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The relationship between local loop unbundling and the deployment of alternative broadband networks. An empirical analysis

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Abstract

This paper means to add to empirical research on the impact of local loop unbundling (LLU) on broadband networks. In particular, it focuses on broadband investment made by entrants. Starting from late Nineties telecommunications incumbents of several European Union countries have been required to unbundle their local loops. While there is a general consensus on the negative or null impact of unbundling obligations on incumbents' investment, research on the relationship between LLU and new entrants' investment, albeit growing, has not yet reached a coherent body of results. We have tested two propositions. First, service-based entry, which relies on LLU, paves the way to new entrants' subsequent investment in broadband systems (i.e. ladder of investment theory). Second, the price charged for local loop should increase over time in order to have a significant investment in alternative platforms (i.e. the transitory entry assistance theory). The empirical analysis is carried out on a sample of 27 European countries (2002-2009 period). We have collected country-level data on broadband lines and LLU policy indicators. The preliminary results suggest that service-based entry does not lead entrants to a subsequent facility-based entry, casting some doubts on the ladder of investment theory. The "short ladder" version of the theory has received confirmation instead. At the same time, an increasing price of local loop is not found to stimulate the entrants' investment in alternative broadband networks.

Keywords: investment, competition, access regulation, broadband networks, unbundling local loop

JEL classification code: L50, L51, L96

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1. Introduction

Starting from late Nineties, the telecommunications incumbents of several European Union countries have been required to unbundle their local loops. In 2001 the European Commission issued a regulation to make local loop unbundling (LLU) compulsory in Member States. LLU obligations have been mainly motivated by the view that the importance and complexity of network modernization investments and the dominance of historical operators would have resulted in a slow progress of facility-based competition. In fact, LLU can be seen as a transitory measure. It is expected to help new entrants to increase their customer base, which in turn is regarded as a necessary condition to develop own networks in a second phase. This paper means to add to empirical research on this topic, addressing the impact of LLU on the development of broadband networks by the new entrants.

Broadband networks continue attracting the attention of experts because they are expected to enhance productivity and to facilitate product innovation (Koutroumpis, 2009). E.g. broadband infrastructure plays a relevant role in the stimulus packages that some countries have adopted to bolster recovery after the recent economic crisis (Qiang, 2009). The current issue among regulators and policymakers around the world is how to favor the deployment of high-speed ("superfast") broadband systems, i.e. fiber networks that should progressively replace the current copper telecommunications networks. Indeed, by June 2010, DSL was still the leading broadband technology, accounting for 61% of total broadband subscribers, while cable and fiber customers amounted respectively to 23% and 7% (OECD, 2010). An effective design of measures that can foster the switch to high-speed is a complex task. However, it can be argued that it requires a better understanding of the effects of LLU up to now. In this paper, firstly, we test if a preliminary phase of service-based competition has helped the development of facility-based competition in a subsequent phase. This is what predicts the ladder of investment theory proposed by Cave and Vogelsang (2003), Cave (2006). Secondly, we investigate the relationship between the price of the local loop and

broadband investment. Indeed, as Cave and Vogelsang (2003) point out, in order to spur facility-based competition, "transitory entry assistance" should not be limited to the obligation to lease unbundled network elements, but should encompass access charge increasing over time, i.e. a critical instrument to give the right incentives to invest.

The empirical analysis is carried out on a sample of 27 European countries observed from 2002 to 2009. From reports provided by European Commission, we have collected data on the total numbers of broadband lines that are provided by new entrants as a whole. We have then estimated the relationship between facility-based entry and service-based entry with the price of the local loop as moderator. All the estimations are obtained through dynamic panel data methodologies: Within-Group (WG), Least Squared Dummy Variable corrected (LSDVc) and difference Generalized Method of Moments (GMMd).

The paper is organized as follows. After a description of unbundling measures in telecommunications (Section 2), theoretical and empirical studies on the relationship between unbundling and new entrants' investment are reviewed (Section 3). The empirical strategy is discussed (Section 4) and subsequently the empirical findings are reported (Section 5). Finally, the paper presents some concluding remarks (Section 6).

2. Local loop unbundling as an entry assistance measure

After liberalization (i.e. after 1998 in European countries), competition between incumbents and new entrants has developed in a patchy way. New entrants first entered the long distance and international markets, where prices were well above cost and investment in long distance networks was relatively cheap. With aggressive price strategies, new entrants gained a healthy market share in long distance and international markets. On the contrary, competition in the market of local connections and services did not develop to a significant

degree because, on the basis of existing price levels, the local market was not sufficiently profitable, while the building of a proprietary local network required a huge investment[3].

The lack of competition became a strong concern among regulators with the coming and growing importance of the Internet that made the use of a local network necessary to provide innovative retail services. In order to foster competition in local markets, regulators throughout industrialized countries launched unbundling policies. The aim of unbundling policy is to enable the new entrants to take control of local networks to provide differentiated services and, as a final consequence, to spur competition. The first country that implemented unbundling obligations was the US in 1996 while in European countries it came into force in 2001.

Absent unbundling, a firm can approach the local market through facility-based entry or resale. With facility-based entry, the new entrant has to build its own local network, a particularly slow and costly mode of entry. For this reason, in the last years particularly cable operators have relied upon this entry form and invested to upgrade their own network to provide also telecommunications services[4].

Alternatively, an entrant can buy the incumbent's local services at a discounted wholesale rate and resell these services to its own customers. Resale is generally considered to be an easy way of creating "entry", although the differentiation is limited to the marketing component.

However, under unbundling regime, the entrant's choice set has enlarged. Entry through unbundling is a hybrid of facility-based and resale entry modes. Local loop

[3] In 1999, in OECD countries, the incumbent enjoyed more than a 97% market share in the local market except Australia, Canada, Finland, Japan, New Zealand, UK and US where new entrants had more than a 3% market share (OECD, 2000).

[4] However, Hoffler (2007) casts doubt on the total positive effect of facility-based competition. Indeed, in an empirical analysis, he showed that the welfare gains from the increase of penetration due to infrastructure competition seem not to be sufficiently large to overcompensate for the very high investments into the basically redundant alternative cable infrastructure.

unbundling (LLU) can be classified into three main types (OECD, 2002): full local loop unbundling, shared local loop unbundling and bitstream access.

Full unbundling occurs when the incumbent leases the copper pair that connects a subscriber to the Main Distribution Frame (MDF). The new entrant takes total control of the copper pairs, and provides subscribers with all services, including voice. Line sharing allows the incumbent to maintain control of the copper pair, and continue providing some services to a subscriber, while allowing an access seeker to lease part of the copper pair spectrum and provide services to the same subscriber. Generally, line sharing allows the incumbent to continue providing services, while the competitor provides broadband (xDSL) services on the same copper pair. Finally, bitstream access relies upon the provision of a wholesale xDSL product by the incumbent. Unlike full unbundling and line sharing, the access seekers can only supply the services that the incumbent designates.

With unbundling, regulators provide some entry assistance that could help entrants to gain a larger market share and to build their own networks. The resale and unbundling entries (that we call service-based entry) give access to a different levels to incumbent's network and this could provide a stepping stone to facility-based entry. According to the ladder of investment (LOI) theory that has been proposed by Cave (2006) regulator has to start from resale entry[5] and then has to enable the access to incumbent's network at a higher level, e.g. bitstream access. Then, as the entrants' customer base grows, they are encouraged to invest in the network elements necessary to pass this level. The next rung of the ladder is full or shared local loop unbundling and the last rung is the building of own local network, i.e. facility-based entry. Implementing this approach is critical. An ill-designed action by the regulator could achieve the opposite outcome from the wished one, i.e. a substitution relationship between facility-based and service-based entry instead of a complementary one. Indeed,

[5] The theory suggests to start from the less replicable element of the incumbent's network. Typically, resale entry is a level of access that requires a very little investment to provide services.

lifting up to the next rung requires the existence of such next rung to step on (access to the incumbent's infrastructure at a higher level at reasonable terms) and simultaneously burning up the preceding rung on the ladder (neutralizing the replacement effect created by the current level of access to the incumbent's facility)[6]. When the regulator does not neutralize the replacement effect, an entrant could not lift the rung, and service-based entry become substitute of facility-based entry.

3. Research questions and empirical literature

While empirical research has found a negative or null impact of unbundling obligations on incumbents' investment (see for a review Cambini and Jiang, 2009), the growing literature on the relationship between LLU measures and new entrants' investments in alternative networks has not yet reached a coherent body of results. As far as theories are concerned, according to the "ladder of investment" (LOI) view, service-based entry and facility-based entry are complements in promoting competition and development of broadband networks (Cave and Vogelsang, 2003; Cave, 2006; Avenali et al., 2010; Bourreau et al., 2010). However, Bourreau and Doğan (2005, 2006) showed that unbundling obligations delay the new entrants' investment, due to a replacement effect. Yet, if the prospects of facility-based competition are weak, a transitory period of service-based competition is argued to encourage subsequent facility-based entry, because it allows new entrants to acquire a customer base and to learn about the market demand ("stepping stone effect", Avenali et al., 2010; Bourreau and Drouard, 2010).

[6] Recently, Bourreau *et al*. (2010) reviewing the literature on the ladder of investment approach, pointed out that the key assumptions underlying the LOI approach: service-based entry serves as a stepping stone to facility-based entry if the replacement effect is neutralized and the regulator has the instruments to neutralize the replacement effect.

PROPOSITION 1:

a) The larger the experience cumulated by entrants through unbundling, the more likely their subsequent entry through investment in own alternative platforms (i.e. ladder of investment theory)

b) The larger the experience cumulated by entrants through resale and bitstream access, the more likely their subsequent entry through unbundling (i.e. short ladder of investment theory)

Transitory entry assistance should not be limited to the obligation to lease unbundled network elements. Bourreau and Doğan (2006) and Avenali et al. (2010) have showed that, in order to speed up the roll-out of alternative platforms, the regulator has to neutralize the replacement effect. To this aim an increase in the price charged for leased elements over time is critical. This result is confirmed also in the literature that looks at innovative race in new infrastructure building, i.e. Next Generation Network investment[7] (Hori and Mizuno, 2006, 2009; Vareda and Hoernig, 2010). At the same time, Bourreau and Drouard (2010) point out that an increasing access charge is an effective way to promote investments only when the prospects of facility-based competition are strong enough. Otherwise a decreasing access charge is instead still necessary to strengthen service-based entry and, in the longer run, to encourage facility-based entry.

PROPOSITION 2: If the local loop price increases over time, provided that service-based entry has already occurred to a certain degree, investment by entrants in alternative broadband platforms is more likely (i.e. transitory entry assistance theory).

Some empirical studies have recently analyzed the relationship between different forms of local loop regulation and broadband penetration, and have generally confirmed the

[7] This literature is related to the R&D race (see Katz and Shapiro, 1987).

hypothesis that firms are more likely to use the incumbent's local loops instead of building new platforms if the option is available to them, even if they could potentially deploy their own network systems. Grajek and Röller (2009), based on a sample of 70 firms in 20 European countries during the 1997-2006 period, found that pro-entry regulation through LLU requirements has discouraged industry-level investment. Similarly, Wallsten and Hausladen (2009), using a sample of 27 European countries observed from 2002 through 2007, found that unbundling lines are associated with fewer fiber connections provided by both entrants and incumbents. Bouckaert et al. (2010) have analyzed the evolution of broadband penetration in 20 OECD countries from 2003 to 2008, and have confirmed the view that the promotion of inter-platform competition instead of LLU obligations is likely to be a more effective policy to improve the broadband penetration.

Hazlett and Bazelon (2005) investigated the relationship between service-based entry and facility-based entry, using US state-level data, observed form 1999 to 2004. They found that unbundled lines in a state in one period do not affect the facility-based lines in that state in future periods, providing no empirical support for the stepping stone theory. Moreover, they showed that incumbent's investment declines as mandatory unbundling was enacted, favoring the cable operators' investment.

Crandall and Sidak (2007) tested a "short ladder of investment" theory in European countries, through descriptive yet insightful analysis. For each country, they examined whether LLU lines as a percentage of total new entrants' lines had increased over time, i.e. they considered LLU as the last rang of the ladder. They did not include facility-based competition in the analysis because at that time there has been little investment by entrants in their own last-mile facilities. Using the European Competitive Telecommunication Association (ECTA) data, they found that LLU lines increased as a percentage of new entrants' lines between July 2002 and September 2006 in nine of the fifteen European countries. As far as the remaining six countries are concerned, they concluded that the ladder

of investment approach was not well implemented[8]. For the nine countries that have experienced an increasing LLU lines over time, the authors stated that only France and Italy[9] offered a genuine support to the ladder of investment theory. The two countries had little or no competition by cable operators. With these exceptions, empirical evidence from Europe does not seem to support the stepping-stone hypothesis. A recent paper by Bacache et al. (2011) has used data on 15 European countries, observed from 2002 through 2009 on a semi-annual basis. They have tested the ladder of investment theory and they have found that service-based entry does not affect facility-based entry. This result seems to be stable after some robustness checks[10]. Similarly to Crandall and Sidak (2007), they have assumed that unbundling entry is the last rung of the ladder. For this "short" ladder of investment, they found that a phase of pure service-based entry, i.e. bitstream and resale access, is helpful to spur entry through full or shared access unbundling.

Other papers have tried to assess empirically the validity of the transitory entry assistance theory. A cross-section analysis of Crandall et al. (2004) studied the impact of local loop price on infrastructure investment by Competitive Local Exchange Carriers (CLEC) in the US, through state-level data for the years 2000 and 2001. They found that the share of facility-based CLEC lines is higher in the states where the rental rates for unbundling network elements (UNE) are higher[11].

Waverman et al. (2007) analyzed the relationship between the price of the local loop and investment in 27 European countries observed from 2002 to 2006. They estimated a system of two equations. The first equation used as a dependent variable the market share of

[8] For instance, the implementation of LOI approach in Germany has been a failure, because bitstream and resale access was made available after local loop unbundling. As many successful German entrants were present in the market after the LLU and before the resale and bitstream access, it proved that providing resale as the first rung of the ladder was unnecessary.

[9] For these two countries, LLU lines overtaked the sum of bitstream and resale lines at some point in the sample period. From their analysis, only Iliad, in France, and Tiscali and Wind, in Italy, have moved up the path from bitstream to LLU.

[10] They have estimated the model after controlling for time dummies, the number of rungs available jointly, the regulatory performance, the development of cable modem and the evolution of local loop prices.

[11] However, this analysis does not allow us to draw some conclusions on the relationship between the evolution of the access charge and new entrants' investment, because it's a cross-section analysis.

alternative operators[12]. The second equation used as a the dependent variable the market share of DSL lines offered by competitors. They found that a reduction of the local loop price yields a reduction of the market share of overall alternative lines and an increase of the market share of competitors' DSL lines. In other words, a trade-off seems to be associated with LLU regulation. Intra-platform competition might be achieved at the expense of longer term inter-platform competition.

Distaso et al. (2009) analyzed the regulatory approach adopted in 12 European Countries from 2005 to 2007 and confirmed that only some regulators have adopted policies that have favored the migration from bitstream-based entry to unbundling-based entry. A graphical analysis showed that in France and Spain a decrease of the ratio between wholesale LLU price and bitstream price is associated with an increase of the share of LLU services with respect to the share of bitstream services.

Our empirical analysis wants to improve the previous research along two lines. A first contribution is related to methodology. As the time span of our sample is longer than most part of previous empirical papers, we can estimate dynamic panel models with appropriate estimators. The second contribution that we want to add refers to a deeper analysis on the relationship between the price of the local loop and investments, because with the notable exception of Waverman et al. (2007), little attention has been dedicated to this topic.

4. Methodology and sample

A broad evidence on the relationship between different service-based competition instruments and the diffusion of broadband networks can be obtained through the joint use of bivariate and multivariate dynamic panel models. In order to test the ladder of investment theory (and the short ladder of investment theory) we have specified an equation similar to that proposed by Bacache et al. (2011). The main difference is that our equation has a

[12] The market share of alternative operators is defined as the ratio between the sum of all broadband lines offered through alternative platforms and the total broadband lines in the country.

dynamic specification and thus we have employed dynamic panel data estimators. Moreover, given the dynamic specification of the estimated models, we have tested the potential presence of unit roots in the dependent variables. In order to test the transitory assistance theory (Proposition 2) we have estimated a very similar model modified to include the local loop price and the interaction term between the local loop price and service-based entry variables. Different dynamic panel data estimators have been employed to give robustness of the obtained results (see Section 4.2).

4.1 Data

The two theoretical propositions are tested on a sample of 27 European countries (2002-2009 period on a semi-annual base). We have collected data on the broadband lines of incumbents, on the one hand, and new entrants as a whole, on the other one. We have also built a set of LLU policy indicators (e.g. full unbundled loop price, shared access obligations, and so on). Data have been sourced from the reports of Communication Committee and the EC reviews of communications regulatory package. In the analysis we consider two different modes of service-based entry (as proposed by Bouckaert et al., 2010, and Bacache et al., 2011): a pure service-based entry (Psbe), where entrants are merely reselling the incumbent's services, and therefore incur few investments themselves (bitstream or resale entry); a service-based entry (Sbe), where entrants lease unbundled local loop elements, but have to invest incrementally in own equipment (full or shared access unbundling entry). In addition, a total service-based entry (Tsbe) variable is constructed as the sum of Psbe and Sbe variables. The variable for facility-based entry is Fbe that is the sum of the total broadband lines provided by Wireless Local Loop (WLL), Fiber and Power Line Communications (PLC) technologies. We have excluded cable technology because it is little likely that an entrant that has utilized the incumbent's network to provide retail services later deploys a cable network (Bacache et at., 2011).

Pll represents the local loop price, i.e. is the monthly average total cost of the local loop, as provided by the EC reviews of communications regulatory package. It is defined as the sum of monthly fee and connection fee amortized over three years.

In addition we have collected data on some control variables. Market structure is proxied through IncShare, that is the ratio between broadband lines provided by the incumbent and total broadband lines in the country. Gdpcap, i.e. GDP per capita, is meant to control for the economic growth of the country and the demand for broadband infrastructure. The penetration of personal computers (PcPen) and mobile devices (MobPen) are also used to describe the demand of telecommunication services. Data are sourced from ICT Communications 2010 provided by ITU. Finally, difference in construction costs between countries are taken into account through Dens, i.e. the population density of countries. Table 1 reports the definition and the sources of our variables. Table 2 and 3 report the descriptive statistics and the correlation matrix.

[Table 1]

[Table 2]

[Table 3]

4.2 Models

In order to test Proposition 1a (i.e. ladder of investment theory, Section 3) we have estimated the following model:

$$Fbe_{i,t} = \rho Fbe_{i,t-1} + \alpha Sbe_{i,t-1} + \beta IncShare_{i,t-1} + \gamma MobPen_{i,t-1} +$$

$$+ \delta PcPen_{i,t-1} + \vartheta Dens_{i,t} + \varphi Gdpcap_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where μ_i and λ_t are the unobservable country-specific and time-specific characteristics and $\varepsilon_{i,t}$ is the i.i.d. disturbance term. The lagged dependent variable takes into account the persistence of the facility-based entry. If the coefficient α is found to be positive and

significantly different from 0, it means that service-based entry in one period positively affects facility-based entry in later periods, confirming the ladder of investment theory[13]. We have also added some control variables: IncShare, MobPen, PcPen, Gdpcap and Dens[14]. In addition, we have estimated the equation (1) adding the variable Psbe and replacing Sbe with the variable Tsbe.

Proposition 1b (i.e. short ladder of investment theory, Section 3) is tested by estimating the following model:

$$Sbe_{i,t} = \rho Sbe_{i,t-1} + \alpha Psbe_{i,t-1} + \beta IncShare_{i,t-1} + \gamma MobPen_{i,t-1} +$$

$$+ \delta PcPen_{i,t-1} + \vartheta Dens_{i,t} + \varphi Gdpcap_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (2)$$

where μ_i and λ_t are the unobservable country-specific and time-specific characteristics and $\varepsilon_{i,t}$ is the i.i.d. disturbance term. Model (2) is similar to model (1), with Sbe as dependent variable and Psbe variable as explaining variable. If coefficient α is positive and significant then entry through unbundling is favored by a previous entry through resale or bitstream access.

In order to test Proposition 2 we have estimated the following model:

$$Fbe_{i,t} = \rho Fbe_{i,t-1} + \alpha_1 Pll_{i,t-1} + \alpha_2 Pll_{i,t-1} * Sbe_{i,t-1} + \beta IncShare_{i,t-1} + \gamma MobPen_{i,t-1} +$$

$$+ \delta PcPen_{i,t-1} + \vartheta Dens_{i,t} + \varphi Gdpcap_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (3)$$

where μ_i and λ_t are the unobservable country-specific and time-specific characteristics and $\varepsilon_{i,t}$ is the i.i.d. disturbance term. Model (3) is similar to models (1)-(2) with Fbe as dependent variable and Pll and its interaction with Sbe as key independent variables.

[13] The coefficient α represents the short-run effect of a shock of Sbe variable on Fbe. However, the effect propagates over subsequent period through the autoregressive element of model (1) (i.e. the long-run effect is $\frac{\alpha}{1-\rho}$).

[14] The variable IncShare, MobPen and PcPen could be endogenous to the dependent variable and thus we use the lagged of the variables in the estimated model.

In order to check the robustness of results equations (1), (2) and (3) have been estimated with three different estimators that rely on different assumptions. The Within Group (WG) estimator takes into account the country fixed effects, but it assumes that all the independent variables are exogenous. As the lagged dependent variable is clearly an endogenous variable (see for instance Wooldridge, 2002), we have used two further estimators that control for the endogeneity: the Least Square Dummies Variable corrected (LSDVc), proposed by Bruno (2005) and the Difference Generalized Method of Moments (GMMd), proposed by Arellano and Bond (1991). While the LSDVc estimator takes into account the endogeneity of the lagged dependent variable and it's well suited for small sample, it continues to assume that the other independent variables are exogenous. At the same time, the GMMd estimator enables us to take into account that all the independent variables could be endogenous in the model but it would require a large sample to perform well.

Before estimating models of interest we have verified if the dependent variables are stationary or not. The literature on the test of unit root in a panel data context is recent but abundant (Breitung and Pesaran, 2008). We adopt two different tests, namely those of Levin et al. (2002) and Im et al. (2003)[15]. If the tests accept together the hypothesis of unit root, we will estimate the model using the differenced variable rather than the variable in level.

5. Results

The results of the unit root tests are reported by Table 4[16]. The null hypothesis (i.e. presence of unit root or non-stationarity of the analyzed variable) cannot be rejected when Fbe and Sbe variables are considered. The test statistics are not significantly different from 0

[15] The common feature of all the tests is that the time dimension of the panel data is relatively large compare to the sample dimension. In our study, the panel has a moderate size in terms of time and sample dimensions, and we have applied more than one test to have more stable and robust results.

[16] All the variables are standardized in order to have more comparable coefficients. The same results, in terms of signs and significance, are obtained not standardizing the variables.

(Table 4). Indeed Sbe variable passed the Levin, Lin and Chu test, but it did not pass the Im, Pesaran and Shin test. We have decided to adopt a caution approach and we have concluded that both Fbe and Sbe variables cannot be regarded as stationary. We have then tested the stationarity of Fbe and Sbe differenced variables and tests rejected the null hypothesis. As a result, Fbe and Sbe differenced variables have been used as dependent variables in models (1)-(3).

[Table 4]

We have estimated equation (1) with the differenced variable Fbe as dependent variable (Table 5).

[Table 5]

The coefficient of lagged dependent variable is positive and significantly different from 0, according WG and LSDVc estimators (at 5% and 1% significance levels respectively). Innovations in the facility-based entry variable are persistent. As regards our key independent variable (Sbe) the coefficient has been found not to play a significant role. A similar result is obtained when pure service-based entry or only total service-based entry are also considered (see the Appendix, Table A1). This means that service-based entry does not encourage facility-based entry, casting some doubts on the empirical validity of LOI theory and leading us to reject Proposition 1a. The coefficients related to control variables are not significant.

Table 6 reports our estimates of model (2) with the differenced variable Sbe as a dependent variable, according to the unit root analysis (Table 4).

[Table 6]

As expected, the coefficient of the lagged dependent variable is positive and significantly different from 0 (i.e. WG, GMMd and LSDVc coefficients are significantly different from 0 at 1% significance level). Psbe is found to have a positive and significant impact on ΔSbe (at 1% significance level). A phase of pure service based competition through bitstream and resale entry modes encourages the entrants to switch to offer the services by

renting full or shared unbundled elements. The short ladder of investment theory is thus confirmed by our results and Proposition 1b is accepted on an empirical ground.

The results of empirical analysis do not confirm Proposition 1a: service-based entry does not encourage facility-based entry. By contrast, a first phase of pure service-based entry, i.e. through bitstream access and resale, has been shown to lead to service-based entry in later periods (Proposition 1b). If the regulator aims at the development of full facility-based competition, it will not be through service-based competition that this goal will be reached.

In order to investigate the Proposition 2, we have estimated the model (3) and Table 7 reports the results.

[Table 7]

The coefficient of the lagged dependent variable is positive and significant, with the exception of GMMd estimate, showing a persistence of the series over time. The estimated coefficients of both Pll and its interaction term with Sbe are negative. The local loop price seems to have a negative relationship with the development of alternative platforms, as represented by Fbe, whatever the level of previous service-based entry. We expected that both Pll and its interaction term with Sbe coefficients were positive instead (Proposition 2). However, it should be emphasized that coefficients of linear Pll term and its interaction with Sbe are not significantly different from 0, with the possible exception of GMMd estimate of Pll linear term. The explanation of this result could be, as Bourreau and Drouard (2010) point out, that when facility-based competition is a long-term perspective[17], a decreasing rather than increasing local loop price is necessary to strengthen service-based entry and, in the longer run, to encourage facility-based entry[18].

[17] In our sample, the facility-based lines represent only the 14% of the total broadband lines in 2009.

[18] However, in the Appendix (Table A2) we present the results obtained estimating the model (3) using service-based entry instead of facility-based entry variable as a dependent variable. The coefficient related to the local loop price is negative and not significantly different from 0. We then conclude that the regulated price of leased network elements seems to be an irrelevant factor when competition, whether service or facility based, is the issue.

This result is puzzling from our perspective. On the one hand, it might be argued that facility-based entry is feasible only over a dramatically long time horizon. This view would lead to conclude that any efforts made by the regulatory authority to implement a transitory entry assistance is over optimistic, given the present status of industry and technology. On the other hand, it might be argued that local loop price decisions adopted by the regulator are mainly targeted to favor Sbe, exactly because facility-based entry is assumed not to be feasible in the short-medium term.

6. Conclusions

This paper has analyzed the impact of the unbundling policies on new entrants' broadband investment. Two main research questions have been explored. First, we have investigated the ladder of investment theory, that is, whether an early phase of service-based entry (pure service-based entry) has favored facility-based entry (service-based entry) in later periods. Second, we have examined the transitory nature of entry assistance, i.e. if facility-based entry tracks changes in the price of the local loop.

The empirical analysis is carried out on a sample of 27 European countries observed from 2002 to 2009. The theoretical prepositions have been tested through the use of multivariate dynamic panel models.

As to the first research question, empirical findings suggest that service-based entry does not encourage facility-based entry. These results casts some doubts on the empirical validity of LOI theory. Instead, we have found support for the short-ladder of investment theory. If regulators and policymakers want to have, in the long run, full facility-based competition in the industry, unbundling obligations do not seem to be the best instrument.

Finally, our results do not support the view that an increase in local loop price favor facility-based entry. On the contrary, empirical evidence seems to suggest that local loop price are negatively related to facility-based entry. It could be that facility-based competition in our

sample is a long-term perspective and so a decreasing local loop price entails the deployment of facility-based platforms in the long run (Bourreau and Drouard, 2010).

We are aware of same limitations of our empirical analysis, among which the relatively small size of our sample, particularly in the longitudinal dimension, is the most notable. Nonetheless, we are quite confident that our results, albeit preliminary, are rather robust because of the multiplicity of adopted methodologies. Our final remarks are the followings. It can be argued that competition within the same infrastructure, i.e. service-based entry, has been the dominant market structure so far, at least when entrants have cumulated large experience with resale and bitstream access. Among unbundling policies, obligations to lease local loops can be regarded just as an accompanying measure with respect to pure service-based entry. At this stage of research we are left with the question about motives why we have not found any relationship between local loop regulation and the development of alternative platforms. First, local loop regulation both unbundling obligations and local loop price may be ill-designed or ill-implemented. Second, theories suggesting that these regulations have impact on entrants incentives to invest in own advanced networks rely upon incomplete or partly unrealistic assumptions. For instance, the maturity degree of broadband technologies may still be too small and facility-based entry should be deferred to a very long term or the organization of communications industry may meet difficulties and failures related to indirect network effects and agreements between content providers, service providers and network operators should rather be relied upon. Finally, we cannot exclude that additional accompanying measures may make the difference, as for instance public-private partnership in the financing and the construction of new networks.

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Table 1 – List of variables

Variable	Definition	Source
Sbe	*Total number of Unbundled and Shared lines*	European Commission
Psbe	*Total number of Bitsteam and Resale lines*	European Commission
Tsbe	*Sum of Sbe and Psbe variables*	European Commission
Fbe	*Total number of WLL, Fiber and PLC lines*	European Commission
Pll	*Montly fee + Connection fee amortised over three years*	European Commission
IncShare	*Total broadband incumbent lines over total broadband lines*	European Commission
Gdpcap	*Gross Domestic Product per capita*	ITU
MobPen	*Mobile subscribers per 100 inhabitants*	ITU
PcPen	*Number of Pc per 100 inhabitants*	ITU
Dens	*Population over the area of the country*	OECD

Table 2 – Descriptive statistics on broadband lines by new entrants (country-level data)

Variable	Obs	Mean	Std. Dev.	Min	Max
Fbe	405	75506.7	177810.2	0	1466100
Sbe	405	420686.9	1210634	0	8314000
Psbe	405	319329	841072.7	0	5567158
Pll	405	10.696	5.241	0	26

Table 3 – Correlation matrix

	Fbe	Sbe	Psbe	Pll	IncShare	MobPen	PcPen	Dens	Gdpcap
Fbe	1.00								
Sbe	-0.03	1.00							
Psbe	-0.06	0.72	1.00						
Pll	0.03	-0.01	0.02	1.00					
IncShare	-0.32	-0.12	-0.25	0.12	1.00				
MobPen	0.28	0.16	0.15	0.30	-0.02	1.00			
PcPen	0.03	0.31	0.29	0.38	0.02	0.51	1.00		
Dens	-0.13	0.02	0.03	-0.07	-0.20	-0.10	0.14	1.00	
Gdpcap	-0.12	0.15	0.16	0.43	0.20	0.39	0.68	0.05	1.00

Table 4 – Unit root tests

	Levin, Lin and Chu (2002)	Im, Pesaran and Shin (2003)
Fbe	-0.002	-0.236
ΔFbe	-0.333***	-1.864**
Sbe	-0.047***	-1.336
ΔSbe	-0.220***	-1.772*
Pll	-0.413 ***	-2.389***

Note: The null hypothesis is the presence of unit root. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%.

Table 5 – Facility-based lines of new entrants (ladder of investment theory)

	(WG)	(GMMd)	(LSDVc)
$\Delta Fbe_{i,t-1}$	0.271**	-0.041	0.355***
	(0.117)	(0.223)	(0.066)
$Sbe_{i,t-1}$	-0.005	-0.027	-0.005
	(0.059)	(0.083)	(0.098)
$IncShare_{i,t-1}$	0.060	-0.078	0.062
	(0.059)	(0.074)	(0.094)
$MobPen_{i,t-1}$	0.185	-0.100	0.193
	(0.119)	(0.161)	(0.138)
$PcPen_{i,t-1}$	0.133	-0.378	0.149
	(0.286)	(0.423)	(0.285)
Dens	-5.121*	-5.026	-4.512
	(2.888)	(6.504)	(4.224)
Gdpcap	0.220	-0.438	0.116
	(0.487)	(0.928)	(0.544)
N	349	322	349
ar1		-1.035	
ar1p		0.301	
ar2		-0.905	
ar2p		0.365	
Hansen		3.059	
Hansenp		0.548	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or

second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).

Table 6 – Service-based lines of new entrants (short ladder of investment theory)

	(WG)	(GMMd)	(LSDVc)
$\Delta Sbe_{i,t-1}$	0.550***	0.433***	0.735***
	(0.076)	(0.151)	(0.062)
$Psbe_{i,t-1}$	0.066***	0.083***	0.042***
	(0.016)	(0.020)	(0.008)
$IncShare_{i,t-1}$	0.001	-0.000	0.002
	(0.004)	(0.004)	(0.006)
$MobPen_{i,t-1}$	0.002	0.006	-0.000
	(0.005)	(0.016)	(0.010)
$PcPen_{i,t-1}$	-0.004	-0.005	0.000
	(0.010)	(0.018)	(0.018)
Dens	0.148	0.222	-0.050
	(0.107)	(1.176)	(0.251)
Gdpcap	0.004	0.019	0.005
	(0.013)	(0.083)	(0.029)
N	347	320	347
ar1		-1.014	
ar1p		0.310	
ar2		-0.229	
ar2p		0.819	
Hansen		11.743	
Hansenp		0.962	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).

Table 7 – Price of local loop and facility-based entry

	(WG)	(GMMd)	(LSDVc)	(WG)	(GMMd)	(LSDVc)
$\Delta Fbe_{i,t-1}$	0.273**	0.306	0.362***	0.270**	0.400	0.361***
	(0.116)	(0.231)	(0.066)	(0.118)	(0.331)	(0.066)
$Pll_{i,t-1}$	-0.006	-0.048*	-0.004	-0.020	-0.054**	-0.017
	(0.018)	(0.024)	(0.024)	(0.030)	(0.027)	(0.040)
$Pll_{i,t-1} * Sbe_{i,t-1}$				-0.049	-0.012	-0.046
				(0.067)	(0.056)	(0.109)
$IncShare_{i,t-1}$	0.019	0.016	0.020	0.016	0.030	0.017
	(0.020)	(0.021)	(0.028)	(0.018)	(0.028)	(0.028)
$MobPen_{i,t-1}$	0.050	-0.001	0.051	0.049	0.017	0.050
	(0.032)	(0.029)	(0.037)	(0.032)	(0.046)	(0.038)
$PcPen_{i,t-1}$	0.037	-0.129	0.041	0.041	-0.200*	0.045
	(0.076)	(0.081)	(0.073)	(0.080)	(0.121)	(0.074)
Dens	-1.292*	-19.451	-1.137	-1.346*	-2.452	-1.183
	(0.721)	(22.083)	(1.120)	(0.769)	(1.996)	(1.146)
Gdpcap	0.053	0.158	0.026	0.063	0.263	0.034
	(0.122)	(0.260)	(0.134)	(0.130)	(0.331)	(0.137)
N	349	322	349	349	322	349
ar1		-1.473			-1.240	
ar1p		0.141			0.215	
ar2		0.042			-0.496	
ar2p		0.966			0.620	
Hansen		5.460			0.243	
Hansenp		1.000			0.622	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).

APPENDIX

Table A1 – Facility-based lines of new entrants

	(WG)	(GMMd)	(LSDVc)	(WG)	(GMMd)	(LSDVc)
$\Delta Fbe_{i,t-1}$	0.272**	-0.084	0.365***	0.270**	0.059	0.362***
	(0.116)	(0.306)	(0.064)	(0.116)	(0.199)	(0.062)
$Sbe_{i,t-1}$	-0.116	-0.430	-0.106			
	(0.102)	(0.303)	(0.153)			
$Psbe_{i,t-1}$	-0.076	-0.163	-0.070			
	(0.059)	(0.127)	(0.091)			
$Tsbe_{i,t-1}$				-0.007	-0.035	-0.006
				(0.016)	(0.023)	(0.028)
$IncShare_{i,t-1}$	0.007	-0.001	0.008	0.013	-0.009	0.014
	(0.017)	(0.015)	(0.028)	(0.016)	(0.022)	(0.027)
$MobPen_{i,t-1}$	0.050	0.002	0.053	0.048	0.002	0.050
	(0.031)	(0.043)	(0.044)	(0.031)	(0.043)	(0.044)
$PcPen_{i,t-1}$	0.033	-0.138	0.038	0.032	-0.156	0.037
	(0.074)	(0.100)	(0.075)	(0.075)	(0.108)	(0.074)
Dens	-1.295*	-0.861	-1.086	-1.321*	-1.529	-1.148
	(0.735)	(1.055)	(0.936)	(0.727)	(1.539)	(0.937)
Gdpcap	0.049	0.091	0.022	0.051	-0.001	0.021
	(0.127)	(0.297)	(0.138)	(0.128)	(0.236)	(0.138)
N	349	322	349	347	320	347
ar1		-0.869			-1.186	
ar1p		0.385			0.236	
ar2		-0.967			-0.795	
ar2p		0.333			0.426	
Hansen		8.192			2.188	
Hansenp		0.224			0.701	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).

Table A2 – Local loop price and service-based lines of new entrants

	(WG)	(GMMd)	(LSDVc)
$\Delta Sbe_{i,t-1}$	0.772***	0.597***	0.979***
	(0.070)	(0.128)	(0.070)
$Pll_{i,t-1}$	-0.003	0.003	-0.003
	(0.004)	(0.003)	(0.006)
$IncShare_{i,t-1}$	-0.019	-0.018	0.002
	(0.024)	(0.023)	(0.007)
$MobPen_{i,t-1}$	0.000	0.000	0.001
	(0.000)	(0.001)	(0.010)
$PcPen_{i,t-1}$	-0.000	-0.001	0.009
	(0.001)	(0.001)	(0.021)
Dens	0.167	-0.039	0.154
	(0.123)	(0.971)	(0.319)
Gdpcap	-0.015	0.027	-0.004
	(0.016)	(0.061)	(0.033)
N	349	322	349
ar1		-1.068	
ar1p		0.285	
ar2		-0.121	
ar2p		0.903	
Hansen		14.325	
Hansenp		0.890	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).