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Article

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Local loop unbundling in the UK does not affect broadband penetration—but it does lead to better service

By **Mattia Nardotto**

Under an open access policy, incumbent broadband providers in all EU countries are required to let new market entrants access their networks through bitstream or local loop unbundling (LLU). This type of regulatory provision aims to increase competition among all broadband providers, and is strongly recommended in markets where the prohibitively high cost of setting up a distribution network means that market power is concentrated in the hands of a few players—or even one single player (such as in the case of telecommunications).

This analysis uses data from the UK to investigate whether such a policy stimulates market entry and broadband penetration and/or leads to an increase in broadband quality. In contrast to what is commonly believed LLU does not increase internet penetration significantly or sustainably. It does, however, stimulate market entry as well as investments that substantially increase service quality. Thus this open access policy does not contribute to a digital divide in access. Although these results are based solely on experiences in the UK, they do point to the general advantages of infrastructure-based competition (based on LLU) over service-based competition (based on bitstream).

As is the case with other communication networks, broadband is a primary driver of economic activity and growth.¹ The potential benefits of broadband are considerable, but so are its roll-out costs. Large, sunk infrastructure investments also create market power, since they enable network owners to deny potential entrants access to the network and thus create a monopoly in the downstream market. For this reason, the telecommunications industry has traditionally been subject to regulation designed to promote competition.

The main trade-off faced by regulators is between static and dynamic efficiency. This trade-off is not peculiar to the telecommunications sector: it can be found in all industries characterized by the presence of a large and costly network. On the one hand, granting new companies access to the network is supposed to increase competition, which will benefit the end user. In the words of regulators, open access should lead to lower prices, and possibly to larger investments that drive innovation, reduce costs, and improve product quality. On the other hand, the possibility of using the existing network dramatically reduces incentives for new entrants to build their own networks with cutting-edge technologies. In a nutshell, the trade-off is between the immediate benefits of stronger competition in the medium term, and the incentives to implement more advanced technologies that could deliver larger benefits in the long term.

The latter point is often stressed by incumbents, which generally oppose open access to their networks, arguing that it amounts to a regulatory taking and reduces incentives for entrants to build their own infrastructure. In response, new entrants argue that they cannot afford to duplicate the existing infrastructure and can only compete if they have access to the incumbent's network.

¹ See, for instance: Czernich, N., Falck, O., Kretschmer, T., and Woessmann, L. (2011), "Broadband infrastructure and economic growth." *The Economic Journal*, 121(552), pp. 505-532. The present report is based on Nardotto, M., Valletti, T., and Verboven, F. (2015), "Unbundling the incumbent: Evidence from UK broadband." *Journal of the European Economic Association*, 13(2), pp. 330-362.

This trade-off is at the core of the debate on regulation in both the European Union and the United States. EU countries require incumbents to open their networks to entrants, with the European Commission also requiring specific regulation of local loop unbundling (LLU) and bitstream access to promote competition within the telecommunications sector. In the late '90s, EU countries did not have to observe any EU regulation when setting rules for LLU or bitstream, and some countries, such as Germany and Denmark, had already introduced LLU in 1996.² The key steps of the EU regulation were established by the *New Regulatory Framework* (NRF) in 2000.³ This set of rules mandated that national regulatory authorities identify the operators with significant market power and mandate these operators to provide access to the local loop at a price that was transparent, non-discriminatory, and fair, clearly requiring a cost-oriented determination of the LLU price.⁴

In stark contrast to the EU approach, the *American Federal Communications Commission* (FCC) eliminated all open access requirements in 2004. This outcome is the result of a process that reversed the initial efforts towards implementing an open access policy in the US, which started with the Telecommunications Act of 1996. Following the introduction of this act, which laid out detailed unbundling requirements for incumbents, a number of judicial cases pushed the FCC to revise the regulation and even overturn some of its requirements.⁵ In response to the decisions of the courts—which included the Supreme Court—the FCC issued several major orders between 1996 and 2004. The final order, which became effective in March 2005, decried the prevailing unbundling framework—a sign that US regulation was shifting away from emphasizing the short-term efficiency produced by swift competitive entry to a more long-term approach based on deep investment and innovation. From this perspective, the respective approaches taken by the EU and the US can be viewed as two extremes of the open access debate.

² See De Bijl, P. and Peitz, M., (2005), "Local Loop Unbundling in Europe: Experiences, Prospects and Policy Challenges." *Communication & Strategies*, 57, pp. 33–57.

³ See Regulation EC 2887/2000 and Directive 2002/19/EC

⁴ According to the EC 2887/2000, "Costing and pricing rules for local loops and related facilities should be transparent, non-discriminatory and objective to ensure fairness. Pricing rules should ensure that the local loop provider is able to cover its appropriate costs in this regard plus a reasonable return, in order to ensure the long term development and upgrade of local access infrastructure. Pricing rules for local loops should foster fair and sustainable competition, bearing in mind the need for investment in alternative infrastructures, and ensure that there is no distortion of competition, in particular no margin squeeze between prices of wholesale and retail services of the notified operator. In this regard, it is considered important that competition authorities be consulted."

⁵ See: Bauer, J. M., (2006), "Local Loop Unbundling and Bitstream Access: Regulatory Practice in Europe and the U.S." DIW Berlin: Politikberatung kompakt, Chapter 7, pp. 150–173.

Technology and market structure

Although the relative desirability of LLU entry⁶ is of key importance to policymakers and market regulators, there exists little reliable empirical scientific analysis on this subject. Due to data limitations, most studies must rely on aggregate cross-country comparisons with limited information on broadband performance indicators, which makes it difficult to identify the causal effects of open access on performance.⁷ This report analyzes the unbundling experience in the UK based on two datasets on investments and subscribers, and another dataset on the speed of internet connections.

Internet services can be provided to end users through several technologies. The most important are DSL, cable, fiber to the home (FTTH), and mobile, with the first two being the most relevant in the years considered for this study.⁸

DSL technology is based on the traditional telephone network. This network is made up of nodes known as *local exchanges* (LE). Each node has a catchment area in which all local households receive both telephone and internet services from that specific LE. The LE is connected to the households through copper wire in a setup referred to as the "last mile". For DSL, the traditional telephone network must be upgraded to facilitate the transmission of digital signals over copper—and the longer the wire (that is, the longer the distance between the end user's house and the LE), the slower the connection speed.⁹

The situation is different for cable internet. Cable TV operators can upgrade their own networks to provide internet access. In this case, the technology is already suited for the transmission of a digital signal—it just needs a return channel—and connection speed is only mildly affected by the length of the cable wire.

FTTH technology delivers the highest internet speeds. Put simply, it entails replacing the traditional telephone networks' copper wires with optical fiber lines, which

⁶ "LLU entry" refers to internet service providers' actual decisions to exploit the open access policy by entering the LEs via LLU and selling internet access to end users.

⁷ See, for instance: Wallsten, S. and Hausladen, S. (2009), "Net neutrality, unbundling, and their effects on international investment in next-generation networks." *Review of Network Economics*, 8(1). Bouckaert, J., Van Dijk, T., and Verboven, F. (2010). "Access regulation, competition, and broadband penetration: An international study." *Telecommunications Policy*, 34(11), pp. 661–671. Gruber, H. and Koutroumpis, P. (2013), "Competition enhancing regulation and diffusion of innovation: the case of broadband networks." *Journal of Regulatory Economics*, 43(2), pp. 168–195.

⁸ For this report, both mobile and FTTH are not relevant options, as the networks for selling broadband had not yet been developed. Both technologies accounted for less than one percent of broadband internet penetration.

⁹ This problem was particularly severe with the early versions of ADSL.

avoids the speed decay that occurs in the last mile. But because FTTH roll-out costs are high, internet service providers have been reluctant to make major investments in this technology.

Regulation in the UK

Open access was implemented in two steps. First, British Telecom (BT)—the incumbent—was regulated and then separated according to function. The BT Group’s most important companies in the broadband internet market became Openreach, BT Wholesale, and BT Retail. Openreach deals with network maintenance and development; BT Wholesale sells network access (through both LLU and bitstream) to competing internet service providers at a regulated price; and BT retail functions as a normal internet service provider, selling internet access directly to end users.¹⁰

Open access regulation required BT to grant telephone network access (at a regulated price) to entrant companies, which could then enter the LE and offer internet services to end users. Entrants have two technological options when entering an LE: bitstream and LLU. The main difference between the two is that LLU requires the entrant to make substantial investments, install machines in the LE known as digital subscriber line access multiplexers (DSLAM), learn how to efficiently manage the data flow within its network, and perform maintenance. From a technical perspective, LLU falls under the category of open access because entrants do not have to build alternative networks; however, it differs from simple reselling (which bitstream is very similar to) due to the substantial financial and managerial requirements mentioned above, which makes LLU relatively close to a facility-based form of competition. With bitstream, on the other hand, the entrant does not take direct control over the line, which is still provided and managed by the incumbent. As our data show, entrants achieved quality improvements only when they entered through LLU—but this, of course, involved a larger investment.

Our dataset covers the LE universe in the UK, in which there are more than 5,500 highly disaggregated geographical areas. The data allow for a deeper understanding of the unbundling process that took place between December 2005 and December 2009, particularly with regard to how entry affected broadband penetration and quality (as measured by speed) throughout the country.

An analysis of the experience in the UK is of particular interest because the country has both a large traditional telephone network (owned by the BT group) that is sub-

ject to open access regulation as well as a well-established cable network that has never been required to open its facilities to competitors. Thus we can analyze both the impact of inter-platform competition (cable vs. traditional providers) and intra-platform competition (in which entrants access BT’s telephone network).

Broadband take-up and LLU entry

Our analysis reveals a complex and interesting picture. The timespan examined, from December 2005 to December 2009, covers the period of rapid broadband internet access diffusion that followed the very early years of broadband take-up (2001 to 2005) for which disaggregated data are not available (Table 1). Although they do not cover these early years, our data are well-suited for studying the development of LLU: the beginning of the sample period—December 2005, when internet penetration via LLU amounted to only 2.2 percent—coincides with the advent of LLU take-up.

In December 2005, total broadband penetration—which is calculated as the fraction of households in a given area with a broadband subscription—stood at 36.5 percent. By December 2009, this figure had reached 62.6 percent. Between 2005 and 2009, the areas with LLU entry nearly tripled, increasing from 695 LEs at the end of 2005 to 2,011 by the end of 2009. At this point, LLU internet access was potentially available to 85 percent of the UK population.¹¹

11 This calculation assumes that all households in the catchment areas of the LEs where LLU operators are active can be served by them. This actually depends on the capacity installed by providers.

Table 1

Subscribers and coverage in the British telecommunications sector

	2005 (Q4)	2007 (Q4)	2009 (Q4)
Number of lines	27,576,261	27,658,092	28,219,684
Number of subscribers	10,052,446	15,624,059	17,664,344
British Telecom	26%	26.3%	24.7%
Bitstream	41%	24.2%	15.3%
LLU	2.2%	25.4%	37.7%
Cable	30.8%	24%	22.4%
Broadband penetration	36.5%	56.5%	62.6%
Number of LEs	5,587	5,587	5,587
Number of LEs with LLU entry	695 (12.4%)	1,733 (31%)	2,011 (36%)
Avg. Num. of LLU operators ^a	1.79	3.44	3.31
Number of LEs with cable coverage ≥ 65%	953 (17%)	844 (15.1%)	829 (14.8%)

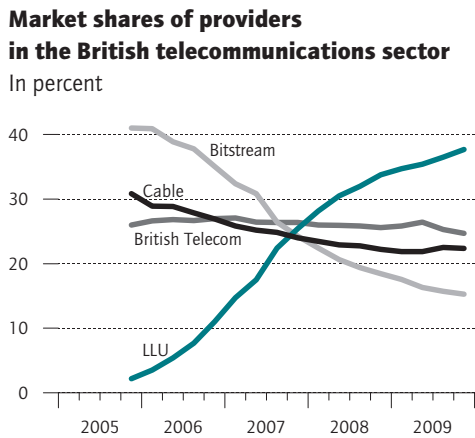
^a: considering the LEs where at least one operator has invested in LLU

^b: average weekly household total income estimate

Source: Nardotto, M., Valletti, T., and Verboven, F. (2015).

10 Since 2013, BT Retail has been divided into BT Consumer and BT Business.

Figure 1



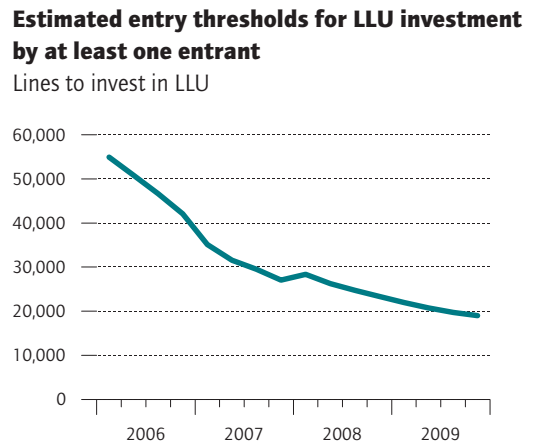
Source: Nardotto, M., Valletti, T., and Verboven, F. (2015).

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LLU and Bitstream experienced opposite growth patterns over time.

LLU's market share (that is, the combined market share of all operators adopting this technology) grew from nearly zero percent at the end of 2005 to almost 40 percent by the end of 2009, mainly at the expense of bitstream's market share (Table 1 and Figure 1). Entrants were progressively moving toward the technological option that allowed them to take full control over the service, which enabled them to improve quality, efficiency, and possibly profit margins as well.

Figure 2



Source: Nardotto, M., Valletti, T., and Verboven, F. (2015).

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Entry thresholds for LLU quickly decreased over time.

But full control over the internet connection through LLU, as discussed above, involves significant investment. A more detailed analysis of the entry process shows that larger markets support a greater number of entrants, thus confirming the importance of investment costs. This is the root of the *digital divide* between urban and rural areas, with the former attracting most, if not all, of the new investment, thus speeding up their internet access. There are considerable differences between LEs that received LLU investments and those without LLU investments (Table 2).

LLU areas are more populous, averaging 12,135 telephone lines compared to 1,243 in non-LLU areas. LLU areas are thus more urbanized on average: indeed, 77.4 percent of them are classified as "urban." Interestingly, individuals living in LLU areas do not necessarily have higher average incomes than do those in non-LLU areas.

An analysis of the entry process indicates that the initial LLU investment is highly sunk, thus generating persistence in firms' entry decisions. Entry is also more likely in locations adjacent to existing LLU areas, which indicates that there are agglomeration advantages or economies of density at play.¹²

¹² This explains the fact that areas with LLU are, on average, poorer than areas without LLU investment. LLU entrant companies are likely to enter in the peripheries of large cities - which are usually relatively poor - after entering the city centers. In fact, the extra cost of unbundling these areas after having entered the city centers is relatively small compared with the cost of unbundling wealthier but more distant towns.

Table 2

Descriptive statistics of the British telecommunications sector

	LEs without LLU		Unbundled LEs		Test	
	Mean	Std. dev	Mean	Std. dev	Stat ^a	P-value
Urban (%)	13	33.6	77.4	41.8	-47.85	< 0.001
Lines	1,243	1,463	12,135	8,444	-57.56	< 0.001
Income	568.8	110.5	514.6	126.4	15.63	< 0.001
Pop. 0-14 years	17.4	2.7	16.8	4.5	0.47	0.64
Pop. 15-60 years	57.6	4.3	60	7.2	-1.51	0.13
Pop. more than 60 years	25	5.7	23.2	7.6	1.32	0.19
Download speed (Mbit/s)	2,846	2,018	3,723	2,624	-126.95	< 0.001

^a: Wilcoxon-Mann-Whitney test is run on continuous variables, proportion test on dummy variables

Source: Nardotto, M., Valletti, T., and Verboven, F. (2015).

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Box

Broadband market in Germany

At the beginning of 2005, broadband penetration in Germany stood at 23 percent, in line with the EU average and below the UK's 32 percent. In 2011, broadband penetration rose to 78 percent, which was above the EU average at the time (67 percent); in the same year, broadband penetration in the UK stood at 80 percent. By 2015, broadband penetration had reached 84 percent in Germany and 90 percent in the UK.¹

Germany was among Europe's first countries to introduce LLU, and it did so within the general framework laid out by the *Telekommunikationsgesetz* (Telecommunications Act) promulgated in 1996. However, although Germany was ahead with respect to LLU, the country's first regulation related to bitstream access arrived quite late: in 2006. The market share of the two technologies – examined below – clearly reflect the evolution of the regulation.

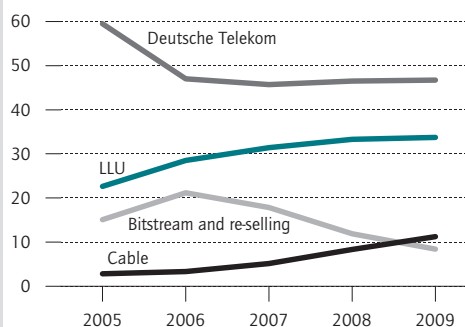
In 2005, the market share of incumbent Deutsche Telekom was very large, starting at 59.5 percent and dropping to 46.7 percent by 2009 (Figure). The share of bitstream and resale-providers in Germany was low (15 percent) in 2005 compared with the 41 percent in the UK. Interestingly, Germany's DSL share² decreased to 8.4 percent in 2009 after a moderate increase in 2006. Germany's LLU share in 2005 was much higher than the UK's because Germany started the unbundling

¹ Sources: Eurostat (see <http://ec.europa.eu/eurostat> – Table tin00089).
² By "DSL market share," we mean the combined market share of re-selling and bitstream.

process much earlier and it grew over the years, although at a much lower rate than the UK's rate. Lastly, cable operators accounted for a much smaller market share in Germany than in the UK, but their market penetration steadily increased over time.

Figure

Market shares of providers in the German telecommunications sector In percent



Source: Dialog Consult/VATM for the 11th Joint Analysis of the telecommunications market 2009.

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LLU and Cable market shares in Germany increased over time, whereas Deutsche Telekom became less dominant.

LLU entrants experienced large efficiency gains over time. This is indicated by the declining trend in the market entry threshold, which is the minimum number of telephone lines needed in an area to induce the entry of one or more providers. This number declined from roughly 55,000 at the end of 2005 to less than 20,000 by the end of 2009 (Figure 2). This decline can be explained by two factors: increasing revenues per line (that is, higher demand) and lower costs per line. According to the model estimates, increased demand alone is not sufficient to explain the substantial decrease in the entry thresholds, and roughly 40 percent of it can be attributed to a decrease in costs.

This strong decline in the market entry threshold explains why LLU quickly reached a large share of the total population and why it is available beyond densely populated areas. Indeed, in the last quarter of 2009, the num-

ber of LEs with an LLU operator amounted to 2,011, up from the initial 695. Importantly, LLU investments were also made in areas without cable, a technology that was available in only 753 LEs.¹³ Thus by the end of 2009, LLU became the only alternative to BT in 1,258 local markets—40.3 percent of the total population.

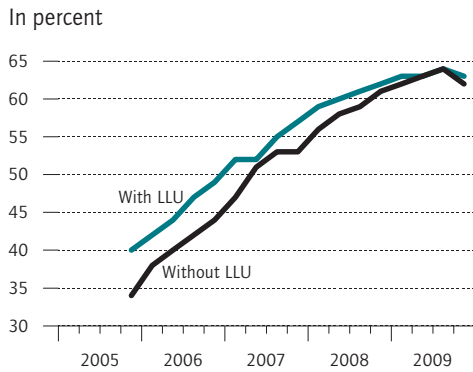
LLU has little effect on broadband penetration ...

During the period in which entrants progressively unbundled local loops, penetration more than doubled in the UK (Figure 3). However, apart from this upward

¹³ This number is based on a 65 percent coverage threshold. Cable is actually available in 1886 LEs, but in many cases it only available for a small fraction of households. Instead, when LLU is introduced in an LE, all households connected to that LE can immediately be served through this technology.

Figure 3

Broadband penetration in local exchanges with and without LLU



Source: Nardotto, M., Valletti, T., and Verboven, F. (2015).

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Broadband internet access in UK diffused rapidly over time.

trend, areas with LLU do not appear to have had higher penetration levels than did those without. In fact, entry grew even more rapidly in non-LLU areas and appears to have caught up with LLU areas.

This is confirmed by an econometric analysis (Table 3). Our estimates of the causal effect of LLU range from a small negative effect of -1.0 percent to a positive ef-

fect of 1.4 percent. Moreover, the effect of LLU seems to be stronger in the early years of broadband take-up. As shown in the second column, LLU initially had a positive impact on broadband penetration, but it decreased over time until it became negative in the second half of the sample period.

Altogether, the data let us compare the following factors' effects on internet penetration: open access through bitstream; open access through LLU; and inter-platform competition from cable. The main finding: compared with bitstream, LLU had little effect on internet penetration. Reconciling this finding with the descriptive evidence on the digital divide (Table 1), we find that although urban and more populated areas received much larger LLU investments, the entry of LLU operators did not cause differences in internet access.

Inter-platform competition (that is, cable) seems to have had a slightly larger effect on broadband internet penetration. The estimated effect ranges from +1.7 percent to +3.4 percent. Although this larger effect confirms the notion that inter-platform competition is more effective in fostering take-up than is intra-platform competition, it was clearly not a decisive factor in the major overall success of broadband services.

Overall, we have no evidence that open-access regulation contributed to a digital divide between areas that experienced LLU entry and areas that did not, at least on the dimension of broadband penetration.

Table 3

Impact of local loop unbundling on broadband diffusion

Dependent variable: total broadband penetration

	Panel FE		Panel FE	GMM
			AR(1)	dynamic
LLU coverage	-0.01*** (0.001)	0.025*** (0.001)	0.005*** (0.002)	0.007*** (0.001)
LLU coverage × time trend		-0.004*** (<0.001)		
Cable coverage	0.019*** (0.002)	0.017*** (0.002)	0.017*** (0.001)	0.018*** (0.005)
<i>Long-run coefficients</i>				
LLU coverage				0.014*** (0.003)
Cable coverage				0.034*** (0.009)

The regressions also includes income as controls (all regressions), fixed effects at the LE level (all regressions) and time effects (first two regressions only). Standard errors in parenthesis, *** indicates statistically significant at the 1% level or higher.

Source: Nardotto, M., Valletti, T., and Verboven, F. (2015).

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... but positively affects broadband speed

Unsurprisingly, the speed test data show that LEs with inter-platform competition (cable) boast the highest average speeds, since cable, being better suited for digital data transmission, is 76 percent faster than BT broadband (Table 4). More notable is that the LEs that experienced LLU entry exhibited higher average broadband speeds than those that did not. LLU operator connections are 18.6 percent faster on average than BT Consumer connections for the same type of broadband product, meaning for the same advertised speed. Moreover, the analysis reveals that the best-performing entrants, thanks to substantial quality improvements, are matching cable operators and offering comparable real connection speeds. At the same time, bitstream internet connections—managed by BT and resold by entrants through open access—turn out to be slower than BT connections by a non-negligible 16.5 percent.

Also notable are incumbents' reactions to new entrants (Table 4). The data show that BT did not increase its connection speed specifically in LLU areas (in this case, the actual speed decreased by a statistically insignificant

0.8 percent) or in those with cable operators (in this case, the actual speed increased by 2.2 percent, also not statistically significant). Instead, the incumbent provided quality uniformly across the country. We can conclude that BT clients living in areas without competition from LLU operators were not treated differently by BT than were clients living in areas with LLU entry and/or cable operators.

Our empirical analysis offers evidence that LLU entrants competed by differentiating their offers “upwards” compared to BT. They focused on the high end of the market, drawing high-speed users away from the incumbent and the cable operators (the market share of the latter decreased from 30.8 percent to 22.4 percent) by offering higher-quality service. This greatly benefited consumers, who could find a range of intermediate qualities in areas where both BT and a cable operator were present, and most importantly, a high-quality alternative to BT in areas where cable was not present (as reported above, the population in such areas amounted to 40.3 percent of the total).

The fact that entry occurred at the high end of the quality spectrum can explain why LLU had little effect on broadband penetration. Indeed, consumers accessing the internet through an LLU connection would have bought it from the incumbent had that been their only option. On the other hand, entrants in non-LLU areas were able use the incumbents’ networks via bitstream—meaning they could not differentiate themselves in terms of service and thus could only compete along the price dimension.

Conclusion

The telecommunications sector is of great importance for the economic development. That is why the evaluation of open access policies is especially interesting. There are different options to open the market for new providers. This report shows that LLU did not raise total broadband penetration compared to bitstream and cable. Open access policy is therefore neither a key of the rapid expansion of internet access nor a cause of digital divide when measured in terms of penetration. However, LLU has substantially increased service quality as meas-

Table 4

Impact of LLU on broadband speed

Dependent variable	Log of download speed		Log of download speed	
	Percentage effect	Std. error	Percentage effect	Std. error
LLU	18.6%***	0.1	-0.8%	1.5
Bitstream	-16.9%***	0.13		
Cable coverage	76%***	0.12	2.2%	1.4

*Based on regression of log of download speed on dummy variables for local loop unbundling, Bitstream and Cable. The regression also includes a constant and the following control variables: urban status of LE, distance between the location of a user and the LE (significant negative effect on speed) and dummy variables for hour and day (much stronger effects during peak hours and days). *** indicates statistically significant at the 1% level or higher.*

Source: Nardotto, M., Valletti, T., and Verboven, F. (2015).

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ured by average broadband speed. Consumers benefited from competitors’ access to LEs, since these entrants were able to take control over the lines, make investments, and ultimately provide a higher-quality product than BT. This was particularly true for consumers in areas where cable was not available, meaning that LLU was the only alternative to the incumbent.

LLU has been strongly advocated by the European Commission as a technology that could simultaneously promote the desirable effects of open access (such as the increased entry of new internet service providers) as well as the innovation gains expected from a truly facility-based competition. The evidence reported in this analysis shows that these goals have been mostly achieved, as LLU proved to have a powerful effect on quality improvements without damaging broadband penetration compared to bitstream and cable. These findings point to the general advantage that infrastructure-based competition can have over service-based competition. Regarding the recent debate on regulating new high-speed access technologies, these advantages should be carefully balanced against regulations focusing mostly on penetration.

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