

Mariniello, Mario; Salemi, Francesco

**Research Report**

## Addressing fragmentation in EU mobile telecom markets

Bruegel Policy Contribution, No. 2015/13

**Provided in Cooperation with:**

Bruegel, Brussels

*Suggested Citation:* Mariniello, Mario; Salemi, Francesco (2015) : Addressing fragmentation in EU mobile telecom markets, Bruegel Policy Contribution, No. 2015/13, Bruegel, Brussels

This Version is available at:

<http://hdl.handle.net/10419/126690>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

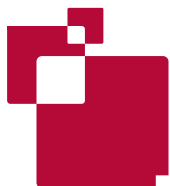
# ADDRESSING FRAGMENTATION IN EU MOBILE TELECOMS MARKETS

MARIO MARINIELLO AND FRANCESCO SALEMI

## Highlights

- Mobile telecommunications markets are an important part of the European Commission's strategy for the completion of the European Union Digital Single Market. The use of mobile telecommunications – particularly mobile data access – is growing and becoming an increasingly important input for the economy.
- The EU currently does not have a unified mobile telecommunications market. The EU compares favourably to the United States in terms of prices and connection speed, but lags behind in terms of coverage of high-speed 4G wireless connections.
- Europe's long-term goal should be to make data access easier by increasing high-speed wireless coverage while keeping prices down for users. An increase in cross-border competition could help to achieve that goal.
- The Commission has two important levers to help stimulate cross-border supply: (a) ensuring competition in intra-country mobile markets in order to provide an incentive for operators to expand into other jurisdictions, and (b) reducing mobile operators' costs of expansion into multiple EU countries. The further development of policies on international roaming and radio spectrum management will be central to this effort.

Mario Mariniello ([mario.mariniello@bruegel.org](mailto:mario.mariniello@bruegel.org)) is a Research Fellow at Bruegel. Francesco Salemi ([francesco.salemi@bruegel.org](mailto:francesco.salemi@bruegel.org)) is a Research Assistant at Bruegel. The authors wish to thank Serafino Abate, Antonios Drossos, Stephen Gardner, J. Scott Marcus and Guntram Wolff for helpful comments. Research assistance by Afrola Plaku is gratefully acknowledged.



# ADDRESSING FRAGMENTATION IN EU MOBILE TELECOMS MARKETS

MARIO MARINIELLO AND FRANCESCO SALEMI, JULY 2015

## 1 INTRODUCTION

The completion of the Digital Single Market (DSM) is one of the top priorities for the European Commission under Jean-Claude Juncker. On 6 May 2015, the Commission published a strategy outlining how it intends to achieve that goal (European Commission, 2015). According to the strategy, the completion of the DSM “could contribute €415 billion per year to [the EU] economy and create 3.8 million jobs”<sup>1</sup>.

A major plank of the strategy is addressing fragmentation in the telecoms sector: access availability, quality and prices vary significantly across the continent, with telecoms markets defined by national borders. Users’ access conditions are largely determined by their place of residence. The Commission’s initial strategy document does not yet offer any concrete solutions to this, but indicates areas for potential future intervention.

In this Policy Contribution we specifically look at EU mobile telecoms markets and analyse potential concrete measures that could contribute to the Commission’s digital strategy goals of improving end-users’ access conditions and addressing EU market fragmentation through the development of cross-border supply of services. There is no apparent structural reason why the supply of mobile services should stop at EU member states’ national borders. For the provision of mobile services, wireless infrastructure is needed. We focus on this for a number of reasons:

- The diffusion of mobile telecommunication has been shown to be a significant factor in improving productivity<sup>2</sup>.
- Mobile data consumption is growing rapidly because of the fast take-up of smartphones and tablets (even though a large part of this traffic is being offloaded to Wi-Fi connections at home or at work) (European Parliament,

2013, pp92-93); the vast majority of mobile traffic will soon be generated by 4G connections (Cisco, 2015).

- Mobile broadband, or wireless internet access, could soon become a valid substitute for wired broadband access for most typical internet users<sup>3</sup>, in particular in low population density areas where building fixed infrastructure might not be economically sustainable.
- Mobile broadband technologies are developing rapidly and although there is still uncertainty about the details of the next generation (5G) wireless standard, the allocation and assignment of dedicated spectrum bands might start as early as 2020.

The fundamental question is how European mobile markets can be improved for the benefit of users. The often-heard answer is that barriers to cross-border competition should be gradually dismantled in order to move towards a pan-European market for mobile services.

Pan-European networks imply lower production and possibly network deployment costs, resulting from economies of scale. This should imply lower prices in the short-term and more investment in the long-term, leading to increased high-speed mobile broadband coverage.

Avoiding the multiplication of networks would also reduce ‘double mark-up’ effects: when more than one network is needed to provide a service, for example in the case of international calls, there is a natural tendency to higher prices. Each network owner chooses how much to charge for terminating calls on its network and wants to maximise only its own profits without considering the negative effect that such choices could impose on the profits of other network owners. The higher the price, the lower the demand will be for a complementary good – in this case the call origination on other networks, which are also needed to make

1. <http://ec.europa.eu/priorities/digital-single-market/>.

2. Lam and Shiu (2010), for example, estimate that the growth in mobile penetration rates significantly affected total factor productivity growth in a number of countries between 1995 and 2004. They also found a two-way relationship between mobile penetration rates and real GDP growth in these countries between 1997 and 2006.

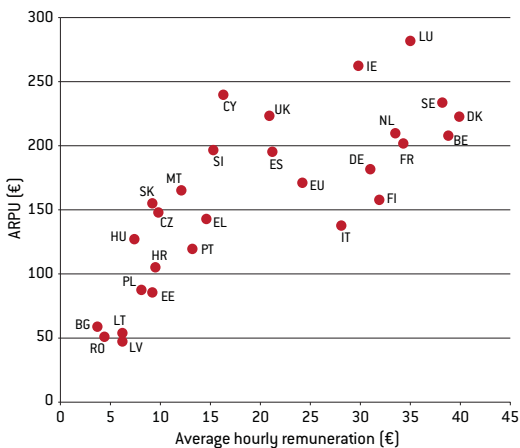
3. Grzybowski and Verboven (2014) note that, especially in recent years, mobile broadband in EU markets has been perceived as a potential substitute for fixed broadband. The UK telecoms regulator Ofcom found that there is a growing positive gap between mobile data revenue and fixed broadband revenue (Ofcom, 2014).

the call. Cross-border networks operated by single operators would limit that phenomenon and ultimately exert a downward pressure on tariffs. Opening the borders would also mean increasing competitive pressure on national markets, with users given access to a wider choice of operators.

This would not necessarily mean that a uniform tariff for all EU users should emerge in such a market, nor that the Commission should impose such a price. As long as significant structural differences between EU countries continue to exist, requiring uniform prices could harm customers with a lower ability to pay, ie customers from lower-income countries<sup>4</sup>. Figure 1 shows the average mobile operator revenue per user (ARPU, a measure commonly used as a proxy for unit price for mobile services) and the average hourly salary per person in 2013 for each EU country (except Austria). The correlation between the two variables is very high. It would be hard to imagine Bulgarian customers paying the same mobile prices as customers from Luxembourg.

To reach its goal, the Commission should aim to ensure that markets are competitive and exposed to a similar level of competition across the continent. Customers from any country could be able to choose from a set of potentially EU-wide service providers and possibly other suppliers with a local or regional focus (a scenario closer to that in the US). In other words, the Commission's objective

Figure 1: Average hourly remuneration and average revenue per user, EU countries, 2013



Source: Bruegel based on Eurostat and Digital Agenda Scoreboard. Note: Austria is missing because the ARPU value is not available. The correlation between the two variables is 0.81 (with 1 indicating a perfect positive correlation).

for mobile telecommunications should be to allow differences in price and quality of service only if they relate strictly to differences in supply (ie costs) and demand characteristics. In the long term, such an approach could be expected to lead to converging tariffs across the continent, insofar as the progressive completion of the single market as a whole (not only the DSM) will imply an increased convergence in the levels of purchasing power and production costs in EU countries.

To identify how the Commission's goal of a single market for mobile services might be achieved, we first look at EU mobile markets in comparison with the US. We then examine how improved wireless access to data by final users, increased fast mobile broadband coverage and lower prices could be stimulated by greater cross-border competition. We then show how policies on international roaming and radio spectrum management could have an impact on cross-border competition.

2 EU MOBILE TELECOMMUNICATIONS MARKETS

Mobile market structure

There are about 40 mobile network operators (MNOs) in the EU. Many operate in just one or two countries. A restricted group of big international

**Table 1: Presence of mobile network operators in EU countries**

MNO(s)	Number of countries
Vodafone	12
Deutsche Telekom	8
Orange, TeliaSonera	7
Hutchison	6
Tele2	5
Telekom Austria, Telenor	4
Telefónica	3
KPN, Belgacom, BITE, Elisa, OTE (40% DT), PPF	2
Bouygues, Bulgaria Telecom, CYTA, DNA, Eircom, Everything Everywhere (50% DT, 50% Orange), Go, Iliad, Luxembourg Online (LOL), Melita, MTN, NOS Comunicações (formerly Optimus), Play, Polkomtel, Portugal Telecom, POST Luxembourg, RCS-RDS, SFR, TDC, Telecom Italia, Teledema, Telekom Slovenije, Tušmobil, VimpelCom, Wind Hellas	1

Source: Bruegel based on Rewheel's Digital Fuel Monitor.

4. Differences in prices would also be expected in more competitive markets, because of differences in the cost of providing mobile services in different countries.  
 5. Even though none has a network that covers the entire land area or population of the US, each covers more than 99 percent of the US population. See FCC (2014), p7.  
 6. FCC (2014), Table II.C.2, p16.

companies (Vodafone, Deutsche Telecom, Teliasonera, Orange, Hutchison) have a larger European footprint, but nowhere near complete EU coverage (Table 1). By comparison, in the US there are four nationwide MNOs<sup>5</sup> (AT&T, Verizon, Sprint and T-Mobile) which accounted for 95.3 percent of US mobile revenues in 2013<sup>6</sup>. The US also has one

multi-regional operator (US Cellular) and several regional and local providers.

Some companies in Europe (eg Tele2, Teliasonera, Telenor) tend to concentrate on specific regions, such as Nordic and eastern European countries. Table 2 shows companies' market shares across

7. While the financial performance of European telecoms operators should not be a primary policy concern in itself, it might be relevant to the extent that worse financial performance might result in poorer services to users, because, for instance, of insufficient investment in the deployment, maintenance or improvement of network infrastructure or reduced investment in new technologies that would allow better utilisation of the available resources (eg spectrum, base stations).

8. Bruegel calculation based on Eurostat and the US Department of Commerce.

9. The European Commission recently opened an in-depth investigation of a proposed merger between Teliasonera and Telenor in Denmark – presented as a joint venture between the Danish operations of the two companies ([http://europa.eu/rapid/press-release\\_IP-15-4749\\_en.htm](http://europa.eu/rapid/press-release_IP-15-4749_en.htm)). Other deals have been either formally announced, pending formal clearance from antitrust authorities, eg the acquisition of O2 (Telefónica) by Hutchison in UK (<http://www.techweek-europe.co.uk/mobility/4g/three-o2-hutchison-whampoa-167859>), or are rumoured, eg the merger between Hutchison and Wind in Italy (<http://telecoms.com/421321/hutchison-and-vimpelcom-in-talks-to-merge-3-italia-and-wind/>) that would further reduce the number of operators in these markets.

Table 2: MNO market shares (% of SIM) in EU countries, Q1 2014

	AT	BE	FR	DE		IE		IT	LU	NL	PT	ES	UK
				Pre*	Post**	Pre*	Post**						
Vodafone				29.5%	29.5%	40.9%	40.9%	26.4%		30.3%	39%	28.8%	25.2%
Telefonica				17%	37.8%	29.2%						42.3%	29.5%
Deutsche Telekom	33.8%			32.6%	32.6%					26.1%			
Everything Everywhere***													33.6%
Orange		27.7%	41.2%						10.6%			22.9%	
Hutchison	22.9%					9.3%	38.5%	11%					11.7%
KPN		28.2%		20.8%							43.6%		
Belgacom		44.1%							37%				
POST Luxembourg									51.7%				
Luxembourg Online (LOL)									0.7%				
Telecom Italia								37.5%					
VimpelCom								25.1%					
Telekom Austria	43.3%												
SFR			32.3%										
Bouygues			17.1%										
Iliad			9.4%										
Teliasonera												6%	
Eircom						20.6%	20.6%						
Portugal Telecom											45.4%		
NOS Comunicações											15.5%		

	BG	HR	CZ	DK	EE	FI	GR	HU	LV	LT	PL	RO	SK	SI	SE
Deutsche Telekom		46.6%	40.3%					44%			28.4%		33.9%		
Teliasonera				22.9%	45.8%	34.3%			41.6%	34.8%					46.2%
Telenor	34.7%			16.6%				32.2%							16.7%
Tele2		13.5%			27.6%				40.3%	42.8%					26.1%
Vodafone			23.7%				30%	23.8%				31.4%			
Telekom Austria	43.5%	40%													30.3%
Orange											27.4%	39.7%	43.2%		
Elisa					26.6%	40.4%									
Hutchison				9.7%											10.9%
OTE (40% DT)							49.2%					23.8%			
PPF			36%											22.9%	
BITE									18.1%	20.4%					
DNA						25.3%									
TDC				50.8%											
Play											18.7%				
Polkomtel											25.6%				
Wind Hellas							20.7%								
Telekom Slovenije															58.2%
Tušmobil															11.5%
RCS-RDS												5.1%			
Teledema										2.1%					
Bulgaria Telecom	21.8%														

Source: Bruegel based on Rewheel's Digital Fuel Monitor. Note: Colours indicate market share rank in each country: red = largest market share, orange = second largest, blue = third largest; green = fourth largest. \* Pre and \*\* Post: data for Germany and Ireland shows the situation both before and after the Hutchison 3G UK/Telefónica Ireland and Telefónica Deutschland/E-Plus mergers. Data for each country might not add up to 100% because of rounding. Malta and Cyprus are not included. \*\*\* 50% DT, 50% Orange.

Europe. Because of different regulatory frameworks, however, even companies that operate multiple networks in neighbouring countries operate the network in each country on a stand-alone basis, so that it is fair to speak about EU national markets rather than a unified EU mobile market in which users can buy mobile access from other operators active on the EU territory. The fragmentation of the EU market – and the resulting smaller scale of operation – has been identified as one of the factors behind the worse financial results of European telecoms companies compared to their US, Japanese and Korean counterparts<sup>7</sup>. It should be noted however, that the absence of a homogeneous regulatory regime is not the only explanation for differences in outcomes, such as user access prices, in Europe. For example, supply and demand conditions vary significantly across Europe, much more than across the US, and differences in prices might be justified even if a homogeneous regulatory framework was sud-

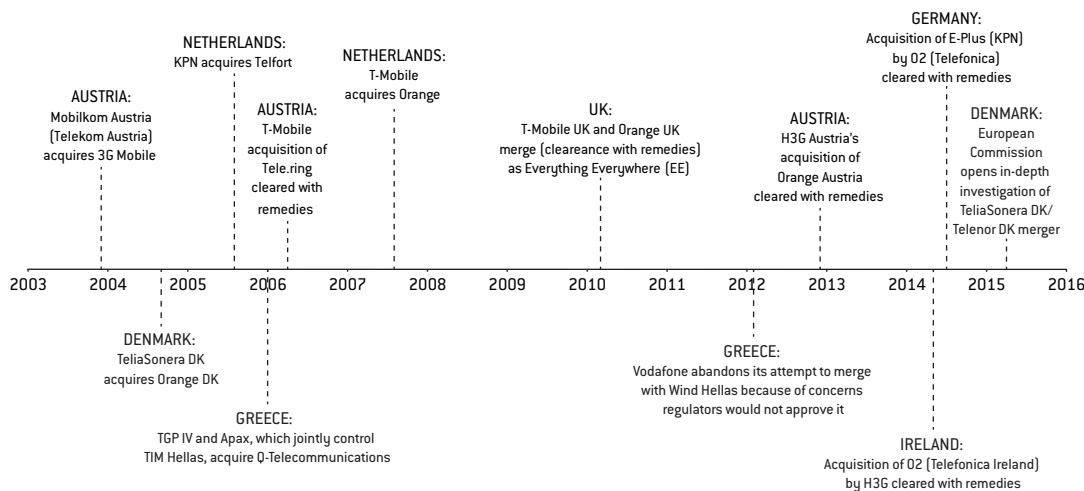
denly adopted. In average real income per capita terms (in purchasing power standard), the ratio between the richest and the poorest US states is 1.73. In Europe, the ratio is 5.71 (or 2.91 excluding Luxembourg)<sup>8</sup>.

In the last two decades, Europe and the US went through broadly similar market restructuring processes, with a series of merger and acquisition deals that significantly increased the level of concentration in the market after the entries of new operators in the mid-1990s and the beginning of 2000s. Figure 2 shows the major merger events in EU mobile markets from 2003 to 2015<sup>9</sup>. Figure 3 shows major merger events in the US mobile industry from 2004 to 2014<sup>10</sup>. Mobile telecommunication markets in EU member states and in the US are now similarly concentrated<sup>11</sup>.

10. In the US, after entries by operators made possible by the spectrum awards determined in the first series of large spectrum auctions (Broadband PCS) during the mid 1990s, and a series of acquisition that gave rise to operators with nationwide footprints, two mergers in 2004 reduced the number of nationwide operators from six to four, and successive mergers eliminated competition from multi-regional operators, eg MetroPCS acquired by T-Mobile in 2013, Leap Wireless acquired by AT&T in 2014. This left US Cellular as the only multi-regional provider of mobile services that has not yet been acquired by a nationwide provider.

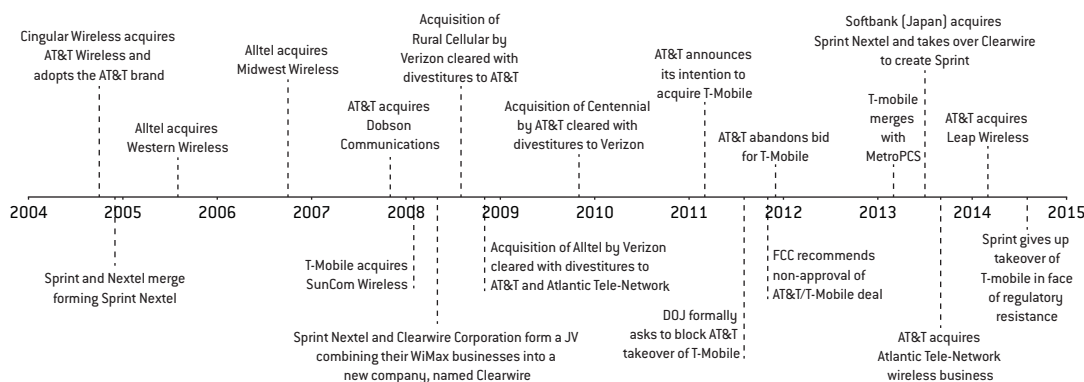
11. According to the standard thresholds based on the Herfindahl-Hirschman Index (HHI), which is commonly used to measure market concentration. In the EU the average HHI (weighted by population) was 3216 in Q1 2014, indicating a high level of concentration (Bruegel based on Rewheel's Digital Fuel Monitor); in the US the average HHI weighted across Economic Areas was 3027 in 2013 (about a 40 percent increase from an HHI of 2151 in 2003). Source for US figures: FCC (2014), Chart II.C.1, p17; for 2003 figures, FCC (2011), Table 9, p47.

Figure 2: Merger events in the EU, 2003-15



Source: Bruegel.

Figure 3: Merger events in the US, 2004-14



Source: Bruegel.

*Mobile end-users' prices*

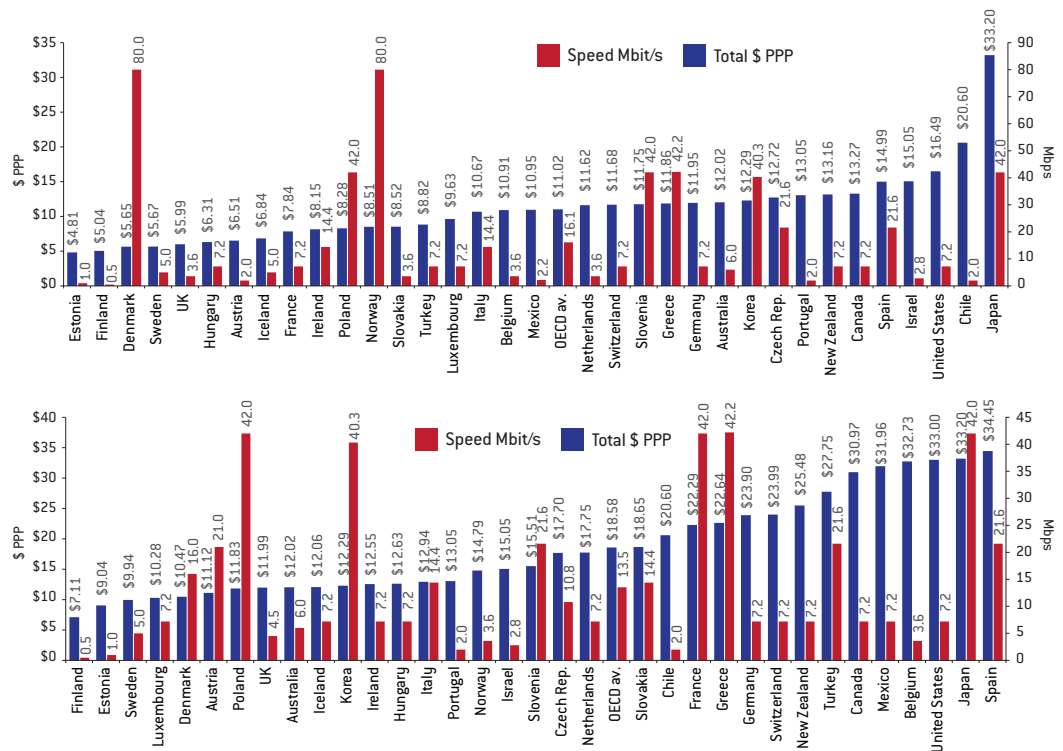
The Organisation for Economic Cooperation and Development publishes every two years data on prices for mobile services. The most recent data was collected between August and September 2012 (OECD, 2013). Several EU countries had lower prices than the US. This was the case in particular in those countries where there exists at least one 'challenger' that does not compete in other EU markets with the very same operators active in that country (eg Finland, Estonia and Poland) or where Hutchinson was present (eg Austria, Denmark, Sweden and the UK). Before it embarked on a series of acquisitions, Hutchinson was a 'challenger' in all countries where it operated, being consistently the smallest operator with market shares well below 20 percent, and often just around 10 percent. The difference in prices between US and Europe is particularly acute when considering services that include data. Figure 4 shows download speed and prices of wireless broadband in OECD countries. It is inter-

esting to note that price differences cannot be explained by higher download speeds.

*Network investment*

Generally speaking, the telecommunications industry is characterised by large fixed costs related to the acquisition of spectrum licenses and the roll-out of networks with sufficient geographic coverage and capacity (bandwidth), and by small variable costs of providing actual services. In absolute and per capita terms, the US invests more than EU countries in telecommunications network infrastructure. EU operators have in the past indicated that their apparent investment underperformance is a consequence of smaller revenue streams compared to US operators. Lower EU mobile telecoms revenues are likely to be partly explained by the greater maturity of EU markets: between 2005 and 2013, mobile cellular subscriptions per 100 people (the penetration rate) increased from 96 to 125 percent in Europe and from 68 to 96 percent in the US (Bruegel

Figure 4: OECD wireless broadband basket, Sept 2012, Tablet 250MB (top) and Tablet 2GB (bottom)

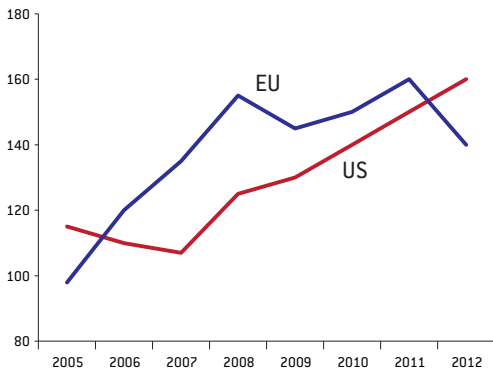


Source: Bruegel based on OECD. The panels show (i) the price of the least costly options in OECD countries for baskets of wireless broadband which include total charges for 250MB (top) and 2GB (bottom) of data for tablet use per month in USD PPP (left axis) and (ii) the broadband speed of the contract in megabits per second (right axis). The correlations between prices and download speeds in the two figures are about 0.09 for the 250MB basket and 0.17 for the 2GB basket, suggesting little relationship between the two variables.



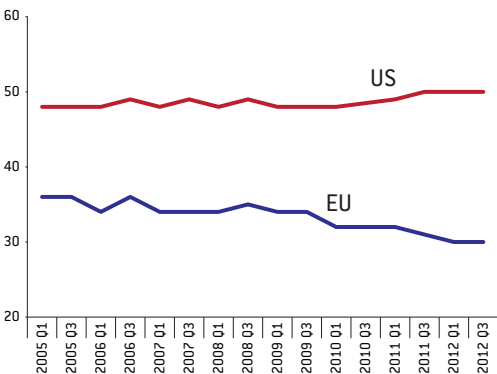
based on World Bank). The increase in revenues in the US is mainly due to the increase in penetration rates, similar to what European operators experienced during the mid-2000s (Figures 5 and 6).

Figure 5: Mobile revenue in the EU and US, € billions, 2005-12



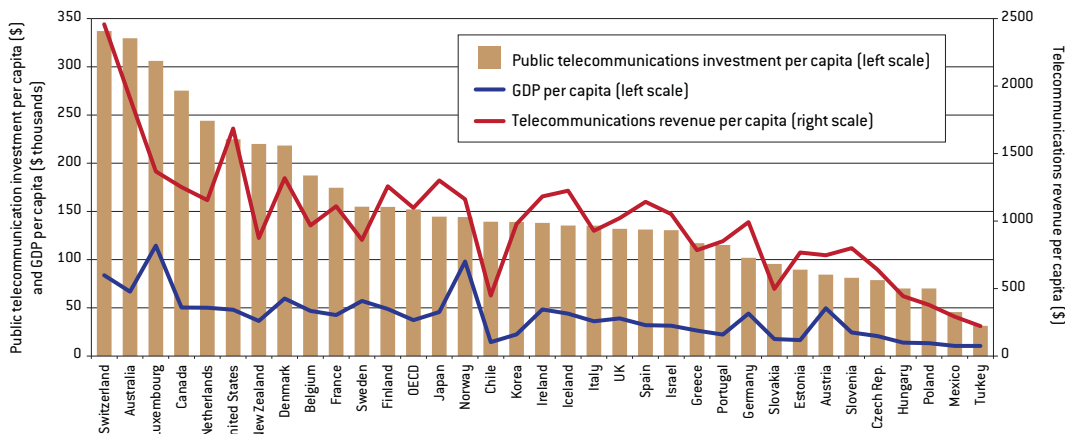
Source: European Commission.

Figure 6: Monthly wireless ARPU in the EU and US, €, 2005-12



Source: European Commission.

Figure 7: Public telecommunication investment per capita, telecommunications revenue per capita and GDP per capita in OECD countries in 2011



Source: Bruegel based on OECD. Note: public telecommunication investment per capita (left axis, in US\$), telecommunication revenue per capita (right axis, in US\$) and GDP per capita (left axis, in thousand US\$). The correlation between revenue per capita and investment per capita is 0.84, while GDP per capita has correlation of about 0.73 with both revenue per capita and investment per capita (with 1 indicating a perfect positive correlation).

An analysis of OECD countries for the latest available year shows a high correlation between mobile revenues and investment in per capita terms (Figure 7). However, the correlation does not say much about the existence or direction of a causal relationship. Both per capita investment and revenue are highly correlated with countries' per capita GDP. Furthermore, different labour costs needed to build base stations or other network infrastructure could significantly affect the monetary amounts invested in different countries, even for similar costs of equipment. Also, the use of different accounting practices means that different companies might compute the same financial items (eg revenues and capital investment) in substantially different ways, implying that simple comparisons of these figures could be misleading.

In general terms, increased revenues can always be a result of lower competitive pressure. Competition stimulates investment by pushing companies to invest and innovate as they seek other potential revenue sources (for an overview, see Motta, 2004; for an application to the telecoms sector, see Nardotto *et al*, 2015). Competition might however reduce the incentive to invest if it implies a reduction of expected profits after an investment is made<sup>12</sup>. The clearest example is with innovation: companies would not invest in innovative projects without a patent system to shield their inventions when their new products

12. This is what is referred in the literature as non-monotonic (inverted-U) relationship between competition and investment/innovation (Aghion *et al*, 2005).



can be imitated so quickly and cheaply that they are not able to earn a sufficient return on their investment<sup>13</sup>. Hence, the contemporaneous correlation between revenue and investment conveys little information about the link between the two variables, if not accompanied with information on the profitability of future new investment by operators.

**Mobile broadband connection (LTE/4G) coverage and speed**

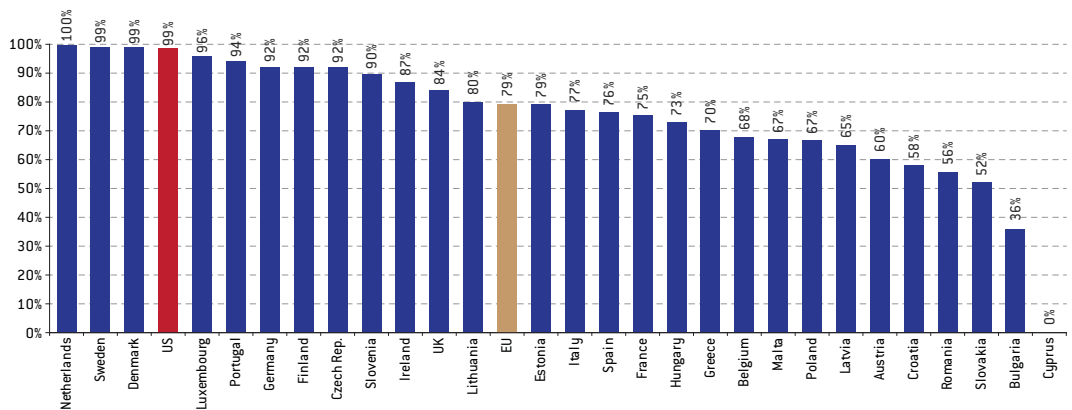
It should be noted that investment in itself might not be that relevant if that does not translate into infrastructure that directly benefits users. A measure of total expenditure on investment does not convey complete information on the benefits delivered. For example, territories with different structural features are likely to require different levels of investment. Less densely populated areas might require higher investment. This does not mean that users from those areas are better off than users from areas where investment levels are lower because the population is geographically more concentrated. For that reason, it is very important to measure the outcome of an investment rather than the investment expenditure in itself.

The core benefit of new infrastructure is increased coverage, speed and reliability of communication. In that context, the ability of users to access fast mobile telecommunications everywhere in Europe now and in the future should be the main concern for EU policymakers, rather than the amount of investment expenditure.

The coverage of Long Term Evolution (LTE) networks – a standardised broadband wireless communication technology usually advertised as 4G – is greater in the US than in the EU. In 2014, US coverage reached 98.5 percent of the population, compared to 79.41 percent of households in the EU (Figure 8). One explanation for such a difference is the delay by many European countries in assigning the radio spectrum necessary to provide 4G services over LTE technology. As Figure 9 shows, the US started to assign spectrum much earlier than EU countries. The first US auction took place in 2006 while the first auction in Europe took place in 2008 in Sweden. For those EU countries that were faster in auctioning off spectrum, a similar, or greater, level of coverage to the US can be observed, while the only two countries with coverage still below 50 percent, Cyprus and Bulgaria, have yet to assign spectrum in the 800 MHz band. Also, some US operators (eg Verizon) had a greater incentive to quickly adopt LTE because their networks, unlike those of their European counterparts, were running on technologies that provided a significantly lower level of service. This also forced the other operators in the US to quickly respond and deploy LTE networks.

In terms of connection quality, download speed is generally faster in Europe than in the US. Figure 10 shows that in several EU countries average download speeds and peak download speeds are faster than speeds in the US, and that the percentage of consumers with a connection that is faster than 4 megabits per second (Mbps) in many European countries is higher than in the US.

Figure 8: LTE coverage in 2014



Source: Bruegel. Note: LTE coverage for European countries is taken from the Digital Agenda Scoreboard and shows the percentage of households living in areas covered by LTE in 2014. The US data shows the percentage of the population living in areas covered by LTE in January 2014, and is from the FCC (2014), Table III.A.2, p31.

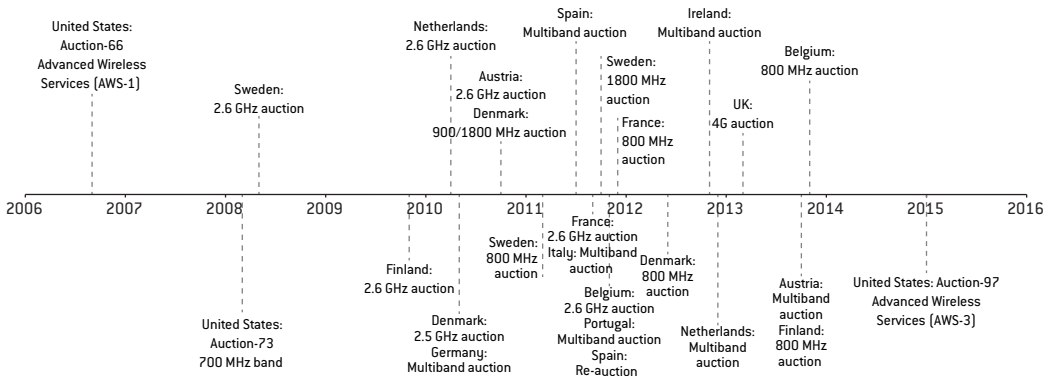
13. However, note that this is not the only effect a patent system might have on incentives to innovate. Especially in cases in which the boundaries of the patents are fuzzy, incumbents can use patents they hold to block potential rivals or to extract rents from innovative firms, reducing their incentives to invest in innovative projects.

3 IMPROVING EU MOBILE MARKETS

The previous section showed that the area in which the EU has the most catching up to do is mobile coverage of 4G connections. This is true even taking into account that Europe is catching

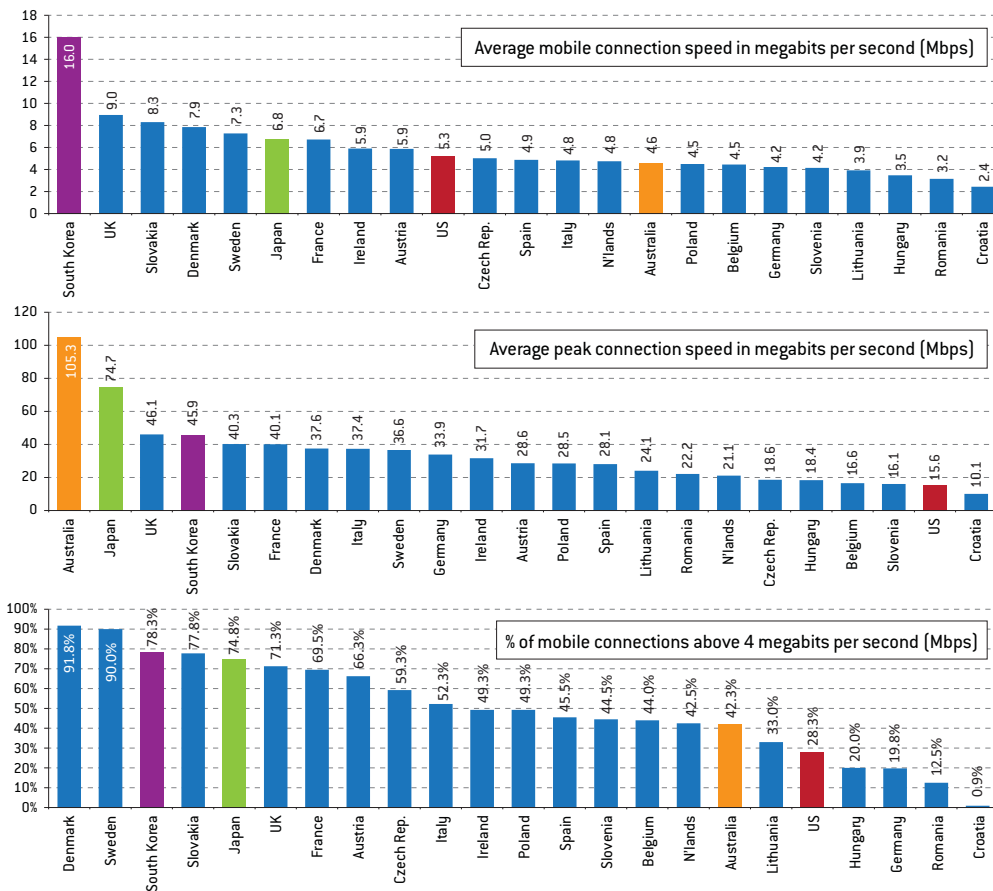
up on LTE thanks to the progressive deployment of networks following spectrum assignments that were late relative to the US. This finding suggests that the European Commission should implement a strategy that helps to increase the coverage and penetration of high-speed mobile broadband while

Figure 9: Major recent US spectrum auctions and major EU 4G spectrum auctions



Source: Bruegel.

Figure 10: Average speed, Average peak speed and percentage of connections above 4 Mbps, 2014



Source: Akamai. Note: Yearly averages were computed using quarterly data published by Akamai in its *State of the Internet* quarterly reports (see <https://www.stateoftheinternet.com>). When data in some quarters for some countries was missing (data for Romania was available only for Q1 and Q2; data for Croatia and South Korea was not available in Q4), the average for those countries was computed using the data in the available quarters. Similar rankings, with several European countries outperforming the US, can be obtained using other speed measurements (eg Ookla/NetIndex and OpenSignal).

guaranteeing access at affordable prices, particularly in view of the adoption in the long-term of new technologies such as 5G, on which the delays experienced with 4G should not be repeated.

A particular emphasis should be placed on data access, rather than voice and text. The recent trend in mobile telecoms has been the increasing importance of data traffic: while voice traffic was basically flat from Q1 2008 to Q4 2014, data traffic increased 54 percent year on year and now greatly exceeds voice traffic (Akamai, 2015) (even though a large part of this traffic is offloaded to Wi-Fi connections at home or at work; see European Parliament, 2013, pp92-93). Data is expected to represent an even a larger share of traffic in the future, especially as voice and text messages are themselves going to be data packets running over shared links. This is already the case with services like WhatsApp, an alternative to SMS, and Voice over IP (VoIP) services such as Skype, which provide an imperfect alternative to traditional telephone call services.

A significant increase in cross-border competition would help Europe to pursue the objectives of greater coverage and affordable access: the expansion of cross-border networks and services would reduce investment costs and increase profitability while preserving the incentive to supply fast and reliable mobile services at affordable prices, for the reasons discussed in the introductory section.

To stimulate cross-border competition the Commission, the European Parliament and the Council of the EU should use their regulatory powers to make it relatively more attractive to operate cross-border networks instead of focusing on domestic markets. Aghion *et al* (2005) explains the theory that we apply to this context: companies are attracted by the prospect of higher profits. Lower costs of entry into cross-border markets and increased competitive pressure in domestic markets should create an incentive to 'escape' domestic competition and seek profits across borders. Conversely, increased domestic profits because of a reduction of competitive pressure might render new investment relatively less attractive. This is particularly true if new investment to expand network reach across borders involves a

risk that significant domestic rents will be lost: expanding supply across borders means imposing a threat to the rents of other operators in other national markets, potentially leading to retaliation. The bigger the domestic profits, the more an operator has to lose from a cross-border service supply 'war' between EU-wide operators.

Following from this, we consider two policies that could have a positive effect on cross-border competition by increasing the relative profitability of a service provided on an EU-wide basis, compared to a service provided to domestic markets only: (1) international roaming and (2) radio spectrum management.

### 3.1 International roaming

To a great extent the debate about the convergence on a single European tariff has overlapped with the debate around international roaming charges. In July 2015, the European Parliament and Council agreed in principle on a draft regulation that would eliminate roaming charges within the EU<sup>14</sup>. The new rules would reduce roaming surcharges on national tariffs to €0.05 per minute for voice calls, €0.02 per SMS, and €0.05 per MB of data downloaded from April 2016. From June 2017, surcharges would be eliminated. 'Fair use' limits would be implemented to prevent exploitation of arbitrage possibilities through permanent roaming (ie customers using SIM cards from low-price countries for domestic use).

Under the regulation, prices would still be different in different countries, but the same price would have to be charged whether customers connect to their provider's home network or a network in another country<sup>15</sup>. By comparison, within the framework currently in force, international roaming services tend to be expensive, especially compared to similar domestic services, and the price difference is not primarily due to differences in the underlying costs. There are three main drivers that make international roaming more expensive than domestic mobile access. First, customers are on average different (occasional roamers might have higher purchasing power than the average domestic user and their need to use mobile communication services might differ when travelling, for example). Second, roaming requires access to

14. <http://www.consilium.europa.eu/en/press/press-releases/2015/07/08-roaming-charges/>.

15. At the time of writing, the provisions have still to be formally adopted. The current text leaves open questions about how the regulation will effectively be implemented.

multiple networks owned by different operators resulting in ‘double mark-up’ effects (ie the increase in price due to lack of coordination between suppliers of two complementary goods, in this case access to separate networks) and, in the case of international roaming, inefficient bargaining processes<sup>16</sup>. Third and most importantly, international roaming services are expensive because they are normally sold in bundles with domestic services. Customers, who predominantly use domestic services, tend to choose an operator on the basis of its domestic offer – hence operators have little incentive to compete and reduce their tariffs in the international roaming market. Furthermore, at least at current prices, price reductions do not seem on average to stimulate demand and generate higher usage of roaming services for voice and text (Marcus *et al*, 2013).

For this reason, the European Commission has previously introduced price caps at the wholesale and retail level and measures aimed at increasing transparency and avoiding bill shocks. The stated ultimate goal of the Commission is a ‘roam like at home’ (RLAH) scenario, in which prices of mobile services do not change “*just because [consumers] have crossed an invisible internal border that is supposed to have disappeared*” (Kroes, 2011). This in practice means equalising roaming and domestic charges in order to allow consumers to replicate their typical domestic consumption patterns while travelling in other EU countries.

RLAH charges could leave operators facing potentially drastic business challenges. For example, an operator from a low-income country might have a domestic retail price that is below the wholesale price the operator would need to pay to get access to a host network in a high-income country, leaving the operators with negative margins on roaming services. The operator could then find it unsustainable to offer roaming services in the EU<sup>17</sup>. Moreover, establishing a direct link between the price charged for domestic use and the price charged to international roamers could introduce distortions in domestic markets, which could lead to price increases<sup>18</sup>.

A better solution would be for users of international roaming services to face conditions similar

to those for customers living in the country they are visiting – sometimes referred to as ‘roam like a local’ (RLAL, see Marcus *et al*, 2013). This would avoid arbitrage effects without the need for a ‘fair use’ limitation clause, while potentially significantly reducing roaming prices. RLAL conditions can be achieved through the design of a regulatory framework so that competition in the roaming market is stimulated (while not preventing companies from charging different prices in different member states, if the economic conditions so require).

The EU Roaming III regulation<sup>19</sup> introduced a number of structural measures, in force since July 2014, with this aim: MNOs were required to unbundle roaming services from their domestic offerings and give the option to “*alternative roaming providers*” to offer these services to their customers.

The implementation of these ‘decoupling’ measures has however been unsuccessful. Very few alternative operators have so far entered the market and it is unlikely that others will enter in the near future. This might be because of the lack of commitment on the part of the Commission to enforce the measures. Even before the entry into force of the decoupling measures, the Commission proposed other regulatory measures in the context of the Telecom Single Market package<sup>20</sup>, overlapping with Roaming III. In particular, MNOs were offered the possibility to escape the unbundling requirement by entering into pan-European alliances with other network operators and making RLAH offers to their own customers. Even though it was unlikely that any MNO would have entered such alliances, the fact that they could use them to escape the structural decoupling measure was enough to destabilise alternative roaming operators’ business plans by making their future profitability uncertain.

The new regulation’s elimination of roaming surcharges suggests that the EU institutions have little intention of credibly pursuing the decoupling solution. However, the RLAH provisions do not address the structural problems that are behind high roaming prices and might have unintended consequences for domestic prices and MNO competitiveness in home and other EU member state markets (BEREC, 2014). The Commission should

16. Since roaming arrangements are usually reciprocal and operators try to have a balanced flow of traffic between themselves, operators do not choose their roaming partners only on the basis of the wholesale price offered, since in this framework roaming is not only a cost but also a source of revenue, and larger operators might be preferred as partners even though another small one was offering a better wholesale price (Shortall, 2010).

17. In order to avoid this problem, the draft regulation allows operators to apply for an authorisation to add a surcharge to the extent necessary to recover costs.

18. This can happen when operators are prevented from price discriminating when supplying a service to two groups of customers with significant differences in the structure of their demand. For a discussion on the welfare effects of price discrimination, see Papandropoulos (2007).

19. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:172:0010:0035:EN:PDF>.

20. [http://ec.europa.eu/information\\_society/news-room/cf/dae/document.cfm?doc\\_id=2734](http://ec.europa.eu/information_society/news-room/cf/dae/document.cfm?doc_id=2734).

therefore commit to seriously enforce decoupling measures, especially in case the RLAH caps result in serious market distortions.

If successfully implemented, structural measures aimed at stimulating competition in the roaming market would imply a reduction of operators' revenues from hosting roamers on domestic networks. International roaming revenue accounts for 5-12 percent of EU MNO revenues – with margins often higher than 60 percent (Wall Street Journal, 2014). The effective implementation of structural measures would therefore not only reduce costs for travellers. It would also expose domestic networks to increased competition, reducing their domestic revenues. Moreover, opening roaming markets to competition would provide MNOs with a concrete incentive to become more competitive internationally, since the measures would create the opportunity for profitable entry into other countries' markets. Effective implementation of structural measures to open up international roaming markets could stimulate operators to expand their service across borders.

### 3.2 Radio spectrum management

Radio spectrum (hereafter spectrum) is a scarce resource that is essential for MNOs to provide wireless communication services. The public management of spectrum can be divided into two phases: allocation and assignment. Allocation refers to decisions over the uses of given bands of spectrum (eg for wireless communications, television or radio broadcasting). Allocation in the EU is done by member states within a framework of international coordination and harmonisation, designed to counter cross-border interference. Harmonised supra-national allocation of spectrum also brings other benefits, such as enabling wireless device manufacturers to produce the same device for use in many countries with associated economies of scale, and enabling users to use the same device in other countries. Assignment refers to the award of rights to use a portion of a specific band of spectrum. In the EU, the right to use spectrum for commercial purposes is currently assigned on a national basis by member states, most commonly through auctions.

Fragmentation in the assignment of spectrum hin-

ders the creation of operators with a larger European footprint for several reasons. Auctions in different countries are run at different times. When bidding in early auctions, bidders willing to operate in multiple countries face aggregation risks (the so-called 'exposure problem')<sup>21</sup>. Bidders that want to operate in multiple countries are likely to calculate their bids for individual lots (ie the rights to use a certain range of frequencies in a given geographic area to provide wireless communication services) on the basis of the value that the whole bundle of licenses they want to obtain will have if ultimately acquired. The bundle value is likely to be higher than the sum of the single licenses. For instance, an operator might find it more profitable because of economies of scale to hold licenses for both France and Spain compared to the average profits that two operators would make if each held one of the licenses. Bidders seeking licenses in multiple countries face the risk of paying too much in early auctions, if they fail to secure other licenses in later auctions whose synergies would have justified the higher price.

Fragmentation in assignment procedures also reduces the ability of bidders to switch to substitute lots in other countries if lots in one country become too expensive. Instead each assignment procedure is a separate exercise with its own participation costs, resulting in less flexibility to switch between lots compared to single EU-wide auctions. Furthermore, an operator would only be able to substitute expensive lots in one country with those in countries where auctions have yet to take place and might regret choices made in early auctions if guesses on the prices in later auctions turn out to be wrong.

Separate assignment procedures therefore require bidders that desire to obtain licenses in more than one country to work on the basis of guesswork about the outcomes of future auctions, which tends to make bidding strategies in sequences of auctions more complex and might push some bidders to bid more conservatively.

To reduce costs for operators and incentivise the deployment of networks with a larger European footprint, there should be a move towards EU-level assignment of spectrum, with a suitable transition period to take into account the variable features

21. This risk is also present for bidders who are willing to buy lots only in one country if they are allowed to buy multiple lots and package bidding (ie the possibility to submit single bids for packages of lots) is not allowed, but is in general mitigated by the possibility to switch to substitute lots if one of the lots they were bidding for became too expensive and by the possibility to withdraw (usually with a penalty or some other mechanism that ensures bids represent commitments from participants) their bid.



of each country's market. For example, countries might differ in terms of their uses of spectrum bands, demand for spectrum<sup>22</sup> or license periods. With that constraint in mind, the harmonisation process should proceed as quickly as possible, so that the Commission and member states are ready for the allocation of frequencies to be used by future electronic communications technologies, such as 5G<sup>23</sup>.

Ideally, the EU should implement a system similar to that in the US, where the Federal Communications Commission (FCC) assigns licenses in different geographical areas through a single auction<sup>24</sup>. This would reduce aggregation risks for bidders willing to purchase spectrum in multiple EU countries by reducing the amount of guesswork needed for their bidding strategies. Since operators would have to participate only in one auction offering the possibility to bid for licenses in the EU or possibly the European Economic Area, participation costs would likely be significantly reduced. Expenditure in terms of public resources would also likely be lower than the cumulative cost of separate auctions in each member state.

From a practical perspective, the Commission should involve national regulatory authorities in the design of the auction, in order to take into account the characteristics of individual national markets and to exploit national regulators' experience with auctions. Lots should be still defined nationally to avoid any sovereignty concern and because markets will remain regulated on a national basis for the foreseeable future. This reform should be coupled with a more harmonised regulatory framework across EU countries that would allow MNOs expanding across Europe to operate the networks in the different countries as a single one. The auction format should be decided on a case-by-case basis to adapt it to the details of the economic scenario and to benefit from future innovations in auction design.

The revenues obtained from the lots in each member state should either be transferred to the respective member state or be subtracted from the sums they have to transfer to the Commission.

One complex issue would be the split of revenues between countries when package bids (ie bids for

a bundle of lots) are allowed. An option would be to allocate revenues on the basis of the expected profitability of licenses<sup>25</sup>. In practice, member states would need to delegate the actual sale of the licenses to the Commission, working alongside national regulators, but would still retain control over the use of spectrum, such as the conditions attached to the license.

Centralised pan-European auctions have so far been resisted by member states concerned about sovereignty issues linked to the loss of control over spectrum and potential revenue losses. In the system we have outlined, member states would retain control over license conditions, while the Commission would just act as a delegate for the sale of spectrum, meaning that loss of control over market structure downstream and sovereignty considerations relating to the use of spectrum should not represent an issue. The main risk would be the possibility of stalemates because of lack of agreement between member states on timing, the details of auction design, harmonisation of license conditions or the mechanism for splitting package bids.

As for revenues, it is important to stress that an efficient and competitive telecoms market rather than revenues should be the main objective of spectrum auctions. An allotment of spectrum rights that enables an efficient and competitive wireless telecoms market is likely to generate benefits for consumers that are much greater than revenues accruing to public finances. Hazlett *et al* (2012) found that a conservative estimate of the annual consumer surplus (\$174 billion) generated by mobile services in the US in 2009 substantially exceeds all auction revenues collected by the FCC from 1994 to 2009 (\$53 billion)<sup>26</sup>. Considering that design choices aimed at increasing revenues are not costless and might have negative impacts on welfare in the downstream market (eg reducing the number of licenses to assign), it seems natural that revenues (as a non-distortionary/lump-sum form of public funding) should be an objective only insofar as that objective is in line with efficient and competitive telecoms markets.

In any case, generally speaking, if efficiently designed, a centralised auction should not leave

22. For instance, in some countries there was no demand for spectrum in the 3.4-3.8 GHz band. See <http://ec.europa.eu/transparency/regdoc/rep/1/2014/EN/1-2014-536-EN-F1-1.pdf>.

23. While it is not yet clear what precisely 5G mobile technologies would be, they are presumed to be technologies offering larger throughput and better spectral efficiency and scalability. It is likely that in order to do this, different technologies and spectrum at very high frequencies (microwaves) should be used. These technologies are supposed, according to those participating in their development, to hit markets between 2020 and 2025. See 5GPP (2014) and GSMA Intelligence (2014).

24. The FCC determines the lots to be sold in these auctions in what is called the band plan, in which the portion of spectrum to be sold through the auction is divided in specific frequency ranges ('blocks') and the US territory is divided according to some geographic partition for each block.

25. For instance, methods based on a proportion of the bidding units assigned to each lot or the information revealed by the bids submitted during the auction (if detailed enough) could be used. However, further study on mechanisms for splitting revenues is surely needed if Europe decides to move in the direction of a centralised auction with package bidding.

26. Furthermore, also the estimated annual profits of mobile operators in 2009 (\$151.7 billion) were much higher than the cumulative revenues.

27. In terms of individual revenues, while it is possible that some of the revenues might decrease, arbitrage between lots in different countries would tend to generate more competitive prices (more reflective of the true value of spectrum). Centralised auctions would represent a sort of insurance for countries that for some reason could otherwise be late in assigning their spectrum, for instance because of some problem freeing frequencies from previous users (see Klemperer 2004, Chapter 5, pp164-166 for reasons why countries auctioning later might see their revenues reduced).

28. Among the reasons why auctions are preferred to comparative hearings (also called 'beauty contests'), in addition to being more transparent methods, is that the regulator managing the spectrum might not have the information necessary to identify who would be the best users for the spectrum on sale. The auction allows the spectrum management agency to let the operators reveal through their bids which among them is best suited to use a certain block of spectrum. However, since the lots sold in these auctions are rights to use an essential resource to operate in a market, spectrum aggregation limits should be used in order to be sure that bids do not contain the value for an incumbent of a less competitive or more concentrated market, or any other incumbency advantage. If properly implemented, spectrum aggregation limits would also ensure that revenue and efficiency of the mobile markets are not conflicting with each other.

member states worse off in terms of auction revenue. This would mostly depend on whether the total revenue from a centralised auction is at least equivalent to the cumulative revenues yielded by national-level auctions.

It is impossible to know whether this would be the case: the number of variables that affect auction revenues and the complexity of players' bidding behaviour make any estimate very speculative (see Milgrom, 2004, or Salant, 2014, on spectrum auction design). However, there are a number of reasons to think that a centralised EU auction would not reduce aggregate revenue, if properly designed<sup>27</sup>.

A hypothetical EU auctioneer would have an interest in maximising the participation of operators in the auctions for the licenses in each country in order to maximise aggregate revenue and achieve a more efficient assignment. National auctioneers, however, would look only at their national revenues and assignments without considering, for example, that imposing a higher reserve price that discourages some bidders from purchasing spectrum in their country could also reduce the willingness of these same bidders to participate in auctions in other countries with potentially complementary licenses. This suggests that an EU auctioneer might be able to achieve higher total revenues and a more efficient assignment.

Furthermore, the reduced aggregation risk and the reduced amount of guesswork for bidders would reduce bidding uncertainty. That reduced cost (or expected cost) and uncertainty could be reflected in more confident bids, increasing the likelihood of obtaining larger revenues.

Ultimately, however, if revenues were the main objective of these auctions – and they should not be, as discussed above – these are still going to be minor details. The elements that are likely to have the greatest influence on auction revenues are design features meant to attract bidders and to discourage collusive and predatory behaviour or other strategic manipulation, ensuring effective and robust competition in the auction and an effective 'revelation mechanism' through which information on bidders' characteristics is disclosed<sup>28</sup>.

Of course, any potential benefit of coordinated spectrum assignment would be undermined if there is no mechanism to preserve or increase competition in the mobile market, for instance by preventing incumbents from hoarding spectrum in order to undermine rivals. Spectrum is both an instrument in the hands of the Commission to reduce costs for operators seeking to expand their European footprints and a tool to introduce or maintain, when needed, competition in national markets. Spectrum aggregation limits, such as set-asides and spectrum caps, have often been used to maintain or introduce competition in the market, avoiding concentration of spectrum in the hands of few operators. When implemented correctly, these measures helped to foster competitive mobile markets<sup>29</sup>.

Furthermore, if the Commission believes that fast deployment of high-speed mobile networks is fundamental, it could try to induce member states to include more stringent roll-out conditions in the spectrum licenses assigned through the centralised auction. This however would translate into reduced revenues, since MNOs would internalise these costs in their bids. More importantly, less-stringent conditions would enable a more cost-efficient roll-out.

#### 4 CONCLUSIONS

Further integration towards a 'single mobile telecoms market' in the EU is certainly desirable. However, integration is not an end in itself; rather, it is important to clarify the goals that integration is meant to achieve. For example, unless income levels converge in the long term, the emergence of mobile tariff plans so that users are charged the same price everywhere in Europe is neither obvious nor necessarily desirable.

Action from the European Commission to improve the functioning of European mobile markets is welcome. The priorities should be increasing coverage of high-speed mobile connections, and measures to support the creation of 'pan-European' networks – networks operated by companies with a wider European footprint. Wider European networks tend to be more efficient: they promote cross-border competition and reduce deployment and operational costs, ultimately



stimulating investment while keeping access prices low. It is particularly important to ease access to mobile data traffic.

The Commission should start in areas where it is easier to appreciate the benefit of intervention: international roaming and spectrum management. By intervening efficiently with clear policy measures in these areas, the Commission could obtain two outcomes: (a) stimulation of competition within national mobile markets; (b) reduction in the cost of cross-country expansion of supply. A compression of profits in domestic markets would increase the incentive to look for profits in international markets, possibly through securing bigger scale and a potentially more efficient production cost structure. A compression of costs for international operations would make such a strategy even more profitable.

On roaming, the Commission should not abandon the idea of seriously pushing structural measures to increase competition in the international roaming market and to move towards a 'roam like a local' scenario. For spectrum, centralised auctions implemented in a way resembling US auctions would make it easier for operators to expand their footprints, and the use of spectrum aggregation limits would ensure that such a shift does not result in less competitive mobile markets.

An important caveat is that international roaming and spectrum management are only two out of a number of policy areas in which the European

Commission could intervene. Policies in other areas might have equally relevant effects, though if inappropriately designed, those policies might undermine the effectiveness of the measures discussed in this paper<sup>30</sup>. Potential areas for intervention include: cross-country regulatory harmonisation, not necessarily limited to the design and the enforcement of telecoms regulation, but also areas such as consumer protection and other policies to reduce the costs of cross-border services delivered through mobile networks; increased coherence of the taxation/VAT framework; and the introduction of measures to support demand, such as measures to increase the security of mobile online transactions. These areas are all listed in the Commission's DSM strategy and measures are expected in the future.

The Commission should also resist any pressure to relax merger control and facilitate domestic consolidation, as this would be likely to have negative short and long-term effects on consumers and on the development of a DSM. If mergers that reduce domestic competition in one or more member states pass through the merger regulation net without proper remedies, the benefits that society enjoys from mobile communications and the speed of the development of the industry might be reduced, and operators would find in domestic markets a profitable alternative to cross-border expansion. In that sense, the Commission should take care of properly enforcing merger rules so that it does not undermine the effects of its pro-DSM policies.

29. In particular, set-asides are very effective tools when credible potential entrants are present. The UK UMTS auction provides one of the most successful examples of competitive mobile markets fostered by set-asides: H3G, the company which entered the UK mobile market thanks to the license set-aside for a new entrant, turned out to be a competitive and innovative force in the UK mobile market. See COMP/M.5650 T-MOBILE/ORANGE, paras. 49 and 107-108. See Cramton (2013a, b) and Cave and Webb (2013) for other successful implementations of spectrum aggregation limits and how these may also stimulate competition in the auction and increase revenues.

30. The provisional rules on net neutrality recently agreed by the Council and Parliament could particularly affect the incentives of operators to provide fast and unconstrained data access. These rules provide that in general providers of internet services are not allowed to discriminate data on their networks, but give them the possibility to manage traffic in times of exceptional network congestion, to offer a differentiated treatment for 'specialised services' needing a quality of service that cannot be assured by standard internet access and to provide sponsored services (zero rating). These exceptions, if not carefully designed, could give the incentive to operators to offer 'standard' internet access offer with low speeds and/or low endowments in order to push more application and content providers to move into specialized or sponsored services (with several potential negative effects on the market).

## REFERENCES

- SPPP (2014) *5G Vision – The 5G Infrastructure Public Private Partnership: the Next Generation of Communication Networks and Services*
- Aghion, P., Bloom, N., Blundell, R., Griffith, R. and Howitt, P. (2005) 'Competition and Innovation: an Inverted-U Relationship', *The Quarterly Journal of Economics*, 120(2): 701-728
- Akamai (2015) *Akamai's State of the Internet: Q4 2014 Report*, available at <https://www.state-of-the-internet.com/resources-connectivity-2014-q4-state-of-the-internet-report.html>
- BEREC (2014) *International Roaming – Analysis of the Impacts of 'Roam Like At Home'* (RLAH)
- Cave, M. and Webb, W. (2013) 'Spectrum Limits and Auction Revenue: the European Experience', available at <http://apps.fcc.gov/ecfs/document/view?id=7520934210>
- Cisco (2015) *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014–2019*, available at [http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white\\_paper\\_c11-520862.pdf](http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.pdf)
- Cramton, P. (2013a) 'The Rationale for Spectrum Limits and Their Impact on Auction Outcomes', available at <http://www.cramton.umd.edu/papers2010-2014/cramton-spectrum-limits-ex-parte.pdf>

- Cramton, P. (2013b) 'The Revenue Impact of Competition Policy in the FCC Incentive Auction', available at <http://www.cramton.umd.edu/papers2010-2014/cramton-revenue-impact-of-competition-policy-in-incentive-auction.pdf>
- European Commission (2015) *A Digital Single Market Strategy for Europe*, COM (2015) 192
- European Parliament (2013) *Entertainment x.0 to Boost Broadband Deployment*, available at <http://www.europarl.europa.eu/document/activities/cont/201310/20131017ATT72946/20131017ATT72946EN.pdf>
- FCC (2011) *Mobile Wireless Competition Report (15th Annual)*, Federal Communications Commission
- FCC (2014) *Mobile Wireless Competition Report (17th Annual)*, Federal Communications Commission
- Grzybowski, L. and Verboven, F. (2014) 'Substitution between Fixed-line and Mobile Access: the Role of Complementarities', *CEPR Discussion Paper DP10045*
- GSMA Intelligence (2014) *Understanding 5G: Perspective on Future Technological Advancements in Mobile*
- Hazlett, T. H., Muñoz, R. E. and Avanzini D. B. (2012) 'What Really Matters in Spectrum Allocation Design', *Northwestern Journal of Technology and Intellectual Property*, 10(3): 93-123
- Klemperer, P. (2004) *Auctions: Theory and Practice*, Princeton University Press
- Kroes, Neelie (2011) 'A better deal for roaming', SPEECH/11/502, available at [http://europa.eu/rapid/press-release\\_SPEECH-11-502\\_en.pdf](http://europa.eu/rapid/press-release_SPEECH-11-502_en.pdf)
- Marcus, J. S., Philbeck, I. and Gries, C.-I. (2013) 'Structural Solutions and the Evolution of International Mobile Roaming (IMR) in Europe: Where are We Headed?', *SSRN Working Paper*, available at [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2342637](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2342637)
- Milgrom, P. (2004) *Putting Auction Theory to Work*, Cambridge University Press
- Motta, M. (2004) *Competition Policy: Theory and Practice*, Cambridge University Press
- Nardotto, M., Valletti, T. and Verboven, F. (2015) 'Unbundling the Incumbent: Evidence from UK Broadband', *Journal of the European Economic Association*, 13(2): 330–362
- OECD (2013), *OECD Communications Outlook 2013*
- Ofcom (2014) *International Communications Market Report*, available at [http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr14/icmr/ICMR\\_2014.pdf](http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr14/icmr/ICMR_2014.pdf)
- Papandropoulos, P. (2007) 'How should price discrimination be dealt with by competition authorities?' *Revue des droits de la concurrence* (3): 34-38
- Salant, D. J. (2014) *A Primer on Auction Design, Management, and Strategy*, MIT Press
- Shortall, T. (2010) 'A structural solution to roaming in Europe', *EUI Working Papers RSCAS 2010/62*, Robert Schuman Centre for Advanced Studies, Florence School of Regulation
- Wall Street Journal (2014) 'European Telecom Firms Retreat on Roaming Fees', 21 February