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Assessment of spectrum value: The case of a second digital dividend in Europe

Zoraida Frias*, Carlos González-Valderrama, Jorge Pérez Martínez

Universidad Politécnica de Madrid, Spain

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ABSTRACT

This work assesses the perceived value of 700 MHz according to the impact that this spectrum could have in decreasing rollout costs. 700 MHz spectrum, recently allocated to mobile network operators (MNOs), could help increase coverage in rural area, as well as aid capacity-constrained networks. In both cases, the use of this spectrum could reduce the rollout costs of a Radio Access Network (RAN) based on Long Term Evolution (LTE) technology. The perceived value of 700 MHz is presented in this article as the difference in the Total Cost of Ownership (TCO) of deploying the network with and without this spectrum. However, the rollout costs can differ greatly among MNOs if they previously hold different spectrum portfolios that may or may not include sub-1 GHz frequencies. The results of this study reveal that an MNO not holding the additional 2×10 MHz at 800 MHz, would perceive 62% more value of 2×10 MHz at 700 MHz, than an MNO that does hold 2×10 MHz at 800 MHz. In addition, the value of this spectrum comes largely from urban areas, where networks are strongly capacity-constrained. This leads to the conclusion that under current demand forecasts, low-frequency spectrum starts being more valuable for *simply being spectrum*, rather than for being low frequency. Indeed, the results prove that adding spectrum with similar propagation characteristics to a coverage-constrained network is of no value.

1. Introduction

1.1. Motivation

The growing demand for mobile broadband services has dramatically increased the amount of traffic going through mobile networks. This has forced MNOs to expand their network capacity to meet this ever-increasing consumer demand, despite experiencing declining revenues in some cases. Expanding network capacity has historically been addressed via three network expansion techniques including (i) densifying the network, (ii) increasing available spectrum for mobile and/or (iii) using more advanced technologies with higher spectral efficiencies. Network sectorisation or heterogeneous networks have enabled deployment of a greater number of cells while keeping similar costs in some cases. However, in certain environments network densification can be extremely expensive, e.g. in less densely populated areas, or even physically difficult, like in urban zones. On the other hand, the latest mobile technologies, such as LTE, already provide spectral efficiencies close to the Shannon bound, constraining the room for further improvement. Techniques for creating several parallel communications, like MIMO, can still increase spectral efficiency, but the development of more efficient methods (e.g. 4×4 or 8×8 MIMO) is still ongoing. In addition, the implementation of 'high-order' MIMO will probably be restricted to very high frequencies in urban environments, where multipath propagation can be exploited.

* Corresponding author.

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Finally, increasing the amount of spectrum for mobile communications is challenging because it is a valuable but limited resource, and must be shared across a wide variety of uses.

Over the last decade Europe has carried out several spectrum management reform initiatives to facilitate a rapid access to spectrum for new technologies and to promote competitiveness and innovation. The aim has been two-fold. On the one hand, promoting a more efficient use of spectrum by introducing technology and service neutrality in those frequency bands being used by legacy systems (2G, 3G); the so called *refarming* processes. On the other, identifying and harmonising other frequency bands to allocate more spectrum to broadband wireless services. This process started in 2005 with the European Commission's WAPECS (*Wireless Access Policy for Electronics Communications*) initiative. It encompasses: (i) the refarming of 900 MHz and 1800 MHz frequency bands for its use with other technologies different from GSM (European Commission, 2009a, 2009b; European Union, 2009); (ii) the release of 60 MHz from the 'digital dividend' (800 MHz band) primarily for mobile communication services (European Commission, 2010); (iii) the harmonisation of 2600 MHz band for mobile broadband (European Commission, 2008a); (iv) the release of spectrum in 3500 MHz (European Commission, 2008b) and (iv) the introduction of technological neutrality in 2100 MHz to enable its use by other technologies different from UMTS (European Commission, 2012). However, the success of WAPECS has often been questioned, mainly due to the high cost and uncertainty associated with its flexibility (El-Moghazi, Whalley, & Irvine, 2016).

Furthermore, in 2012, the European Commission established a Radio Spectrum Policy Program (RSPP) (European Union, 2012) that urged Member States to have allocated at least 1200 MHz to mobile communication services before 2015. The RSPP envisages the periodic implementation of spectrum inventories to monitor spectrum usage and its evolution. The first of them, carried out in 2014 (European Commission, 2014), revealed that the amount of spectrum effectively available for IMT services did not reach 1000 MHz in any Member State of the European Union.

The high degree of fragmentation within the spectrum allocated for wireless services, which ranges between 800 MHz and 3500 MHz, raises two key issues. Firstly, the potential increasing importance of spectrum bands for rollout and secondly, the relevance of new carrier aggregation techniques for efficiently using all allocated spectrum simultaneously. Spectral efficiency, and thus network performance, is highly dependent not only on the bandwidth but also on the carrier frequency. Sub 1-GHz spectrum exhibits advantageous propagation characteristics, which often result in network deployment cost savings when compared to frequencies above 1 GHz. Hence, the value of spectrum and the prices paid in auctions have historically differed significantly among frequency bands, capturing the opportunity cost of the use of that spectrum.

The switchover of terrestrial television from analogue to digital broadcasting, which is far more spectrally efficient, enabled the release of valuable spectrum in the upper UHF band (800 MHz), the so called 'digital dividend'. This process has allowed the allocation of 2×30 MHz for wireless providers to deploy new generation networks at a frequency band with the best available propagation characteristics, as 900 MHz is still being used for legacy systems. Consequently, the digital dividend is certainly playing a big role in deploying new generation wireless networks, such as LTE, in a more cost-effective way. Providers can enhance network performance without the need to build more sites and, at the same time, this allows enhanced coverage in rural areas, as well as better indoor performance. Due to the positive propagation properties of 800 MHz spectrum, governments increased the spectrum auction price in many EU Member States, even with any associated licence coverage obligations for rural areas.

Given the expected spectrum shortage that operators may encounter in the near future, the World Radiocommunication Conference 2012 (WRC-12) attributed at co-primary level –long with broadcasting services– the frequencies in 694–790 MHz to IMT services in Region 1. This allocation enables a contiguous band ranging from 694 to 960 MHz for mobile communication services, which is very attractive for many MNOs. Some regulators started auctioning 700 MHz spectrum during 2015 (Arcep, 2015; Bundesnetzagentur, 2015), when the final implementation of the decision was finally approved at the WRC15. In the countries where this spectrum has already been actioned, it is expected to be in use for wireless services as soon as broadcasters are able to release the band. However, the legacy terrestrial television infrastructure substantially differs across European countries and so therefore does their capability to clear the 700 MHz band. Indeed, it would require in many cases a new switchover, from DVB-T to DVB-T2, to release the spectrum for wireless broadband without altering the current free-access TV market structure. Unsurprisingly, this has unleashed a new debate on spectrum policy around a 'second digital dividend'.

The European Commission has launched different initiatives to evaluate future uses of the UHF band currently used by terrestrial television networks, including in 2014 the implementation of a High-Level Group on the future of UHF spectrum, led by Pascal Lamy. The purpose of the group was to prepare a multi-stakeholder report recommending next steps to be followed, but the group was unable to submit a proposal due to lack of consensus. Finally, Pascal Lamy issued an opinion document on his own (Lamy, 2014) recommending the 700 MHz attribution for 2020 across Europe, but ensuring stability and integrity of the rest of the UHF band for terrestrial broadcasters up to 2030.

Despite not being a harmonised frequency band in Europe, the 700 MHz spectrum has attracted great attention by MNOs. In addition, governments have already started auctioning this spectrum based on both spectrum efficiency arguments and their additional desire for new sources of revenue. At this point, two key research questions arise. Firstly, is this spectrum equally valuable for all MNOs? Secondly, to what extent are the benefits for MNOs comparable to those provided by the (first) 'digital dividend'?

1.2. Related work

The value of spectrum across bands has been studied thoroughly during the last few years, largely because of the spectrum management reform described above. Many of the studies that can be found in the literature assess how the different propagation properties of spectrum bands influence their value. All of them rely on the fact that if the network is deployed at a band with poorer

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