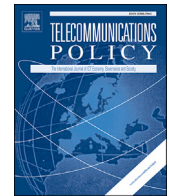


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## Mechanisms to incentivise shared-use of spectrum

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## ABSTRACT

A key concern with the Licensed-shared access (LSA) approach currently being developed by European regulators is that leaving incumbents and secondary users to agree to bilateral arrangements may be insufficient to incentivise an optimal level of sharing.

We propose an efficient auction mechanism to incentivise incumbent users to offer shared access to the spectrum they use. The mechanism consists of two stages. In the first stage, LSA licences are auctioned. In the second stage, the incumbent is provided with a choice of either granting access under an LSA agreement to the winner of the auction or not. If the incumbent accepts, its existing licence fee is reduced, whereas, if it rejects, its existing licence fee is increased. The change in the licence fee is such that a rational incumbent always opts to share when it is efficient to do so, i.e. when the cost of sharing is below the value to the secondary user.

We also explore how this simple mechanism can be extended to situations in which there is more than one incumbent in a band. Our proposed approach involves package (combinatorial) bidding and linear reference prices.

## 1. Introduction

Traditionally, mobile services were provided in bands below 3 GHz, owing to the need for wide area signal propagation; however, with the transition to 5G technology and an increased focus on small cell deployment, in the future it will be viable to utilise much higher frequencies. In anticipation of this transition, leading regulators worldwide are currently searching for ‘new’ bands above 3 GHz that could be repurposed for use by mobile broadband. For example, the National Telecommunications and Information Administration (NTIA) in the United States has developed a ten-year plan to make available 500 MHz of federal and non-federal spectrum available for mobile and fixed wireless broadband below 5 GHz. Similarly, the UK government is aiming to make available 500 MHz of public spectrum below 5 GHz to the mobile industry by 2020. These efforts are running well ahead of the international process, through the International Telecommunications Union (ITU), but are still viewed as too slow by the mobile industry. Such efforts also face resistance from incumbent users, such as satellite, who fear being pushed out of bands that are important to their existing business or public service models, as has happened at lower frequencies.

Looking forward, spectrum sharing may offer an increasingly attractive alternative to the exclusive use model. Although higher bands are extensively used, utilisation of the spectrum across bands varies greatly by time and location. A sharing model would allow incumbents to stay in place, but also open up the frequencies to mobile broadband, and improve the efficiency with which the bands are used. [Kassem and Marina \(2015\)](#) estimate that, going forward in the UK, up to 80% of new spectrum for mobile below 6 GHz could be made available on a shared basis.

Several forms of sharing have been proposed recently:

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1. Unlicensed spectrum, in which users are permitted to access spectrum bands under certain conditions designed to minimise interference, such as low power restrictions.
2. Licenced Shared Access (LSA)—exclusive secondary access to a band already used by an incumbent, on a coordinated basis. This is a suitable basis for providing services at a guaranteed quality of service (QoS).
3. Spectrum Access System (SAS) – proposed by the FCC for the 3.5 GHz band with access split across three tiers: Incumbent (tier 1), Priority Access (tier 2) and General Authorised Access (tier 3). Priority Access licences would be offered in an auction and provide protection from tier-3 users (Cui, Gomez, & Weiss, 2014; Cui & Weiss, 2016; Weiss, Lehr, Acker, & Gomez, 2015).

This paper focuses on the LSA model. To date, regulators have stressed that LSA should be entirely voluntary and agreements would be reached by incumbents and secondary users based on their common best interest. If, however, coordination is left entirely to the market, there is a risk that efficient transactions may fail or be inefficiently structured for reasons including the challenges of making deals in thin markets where one party may have market power or the number of actors on each side of the market varies greatly. This paper explores the opportunity for a regulator to set up a centralised mechanism that helps overcome hurdles for all parties.

The remainder of this paper is structured as follows:

- Section 2 explains why the voluntary approach may not lead to sufficient spectrum being shared and propose a practical mechanism to overcome the hurdles inherent in bilateral trading. The proposed LSA mechanism uses a combination of an auction structure and incentive pricing to encourage efficient trading;
- Section 3 explores the range of auction formats that can be used for an LSA auction, including their strengths and weaknesses depending on the number of incumbents and potential LSA licences; and
- Section 4 summarises the findings of our paper.

## 2. Market-based approach to enable efficient sharing

An LSA arrangement involves a regulator granting a third-party an exclusive licence for shared access to a spectrum band, such that interference is managed bilaterally between the incumbent licensee and the sharing licensee. The licence may be nationwide or geographically limited. This approach limits coordination costs and makes it easier for mobile operators to achieve a minimum QoS from shared access (CEPT, 2014, p. 22).

The ECC identifies three potential use cases for LSA licensing: supplementary, long-term and dynamic (Digital Europe, 2013). Each of these use cases has the potential to bring spectrum to the market quickly without having to clear and repurpose bands.

CEPT (2014) hopes that LSA agreements can be reached voluntarily between the incumbent and the potential secondary user; however, given information asymmetries and thin markets, a *laissez-faire* approach is unlikely to deliver an efficient allocation. As an alternative, a market-based incentive structure should encourage efficient sharing. This mechanism can be applied to multiple market structures but should be tailored to ensure that participants have appropriate incentives to reveal their willingness to share.

### 2.1. Why simple *laissez-faire* may not achieve an efficient allocation

Myerson and Satterthwaite (1983) demonstrate that in situations of asymmetric information, in which a buyer does not know the seller's cost and the seller does not know the buyer's willingness to pay, bilateral trading may be inefficient.

This is directly relevant to bilateral LSA agreements because of the likely presence of thin markets (few buyers or sellers) and high-valuation uncertainty, especially in relation to high frequency bands not hitherto used for mobile broadband. If the incumbent (seller of access to spectrum) and potential secondary user (buyer) are left to negotiate terms on their own, they may fail to agree even though there are gains from trade. This is because each party has an incentive to misrepresent its cost/valuation to achieve a better price. The seller could overstate its cost to achieve a higher price whereas the buyer would aim to understate its willingness to pay to get a lower price. So if left to their own devices, the two parties may fail to agree to terms.

More concretely, Myerson and Satterthwaite (1983) develop an impossibility theorem, which states that, in the presence of informational asymmetries, there is no mechanism which can achieve ex-post efficiency in the presence of individual rationality (i.e., it is optimal for both the buyer and seller to participate in the mechanism given their knowledge of their own willingness to pay and true cost respectively) and the absence of an external source of funds willing to subsidise the trade (budget neutrality).<sup>1</sup>

Rustichini, Satterthwaite, and Williams (1994) demonstrate that if a market is liquid with little or no transaction costs and there are a large number of potential buyers and sellers, this problem disappears. The seller would be in competition with other sellers and his price offer would be driven down to his cost; otherwise he would lose out against another seller. Equally, buyers are now in competition with each other and misrepresenting willingness to pay might mean a buyer loses out against another buyer.

The market for LSA will most likely be characterised by a few sellers—and often a single seller. In most instances, we would expect

<sup>1</sup> Othman and Sandholm (2009) demonstrate that the impossibility theorem holds for settings with gapless continuous valuation priors. However, in situations with discrete valuations the impossibility theorem may not hold. Othman and Sandholm (2009) further argue that even in cases in which it applies, the subsidy required to achieve individual rationality and incentive compatibility is relatively small.

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