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Transmitters and receivers' investment to avoid interference: Is there an optimal regime?

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ABSTRACT

The management of interference has been, and still is, the main concern in spectrum policy. Historically, interference has been dealt with by heavy regulation under an administrative control regime. Over the last decades, a new approach has been put forward based on users' property rights, better able to cope with a rapidly changing technological environment. The issue of dealing with interference across bands, however, remains crucial: What obligations should be put on users so as to keep interference at a socially acceptable level? Also, given that some unwanted emissions are bound to occur, how can private parties be provided with the right incentives to invest in high-quality reception technology? This paper assesses how well different regulatory regimes can lead to efficient outcomes. It develops an economic model of spectrum interference and identifies the efficient solution. A regime where spectrum users have the power to enjoin intruding emissions beyond a predefined level (property rights protection) is compared with a regime where users are forced to bear with intruding emissions, but are entitled to economic compensation for the harm suffered (liability rules protection). The analysis suggests that different regimes may perform differently under different circumstances depending on the cause of interference and, critically, on whether the services are organised as an open- or a close-architecture system. This suggests that regulators should pay more attention to the specific features of the different bands, and that the appropriate spectrum management regime should be designed to recognise these differences.

1. Introduction

The central issue in spectrum management is how to best control interference between users. As early as the 1920s, it became clear that radio interference could not be dealt with by standard tort law. Specialised regulatory authorities were set up and the use of spectrum was subjected to prescriptive regulation. As for standard land communication, the solution was found in proper regulation of traffic; users were constrained to suitable lanes (bands), and kept separate from each other in order to minimise accidents (interference). The level of control required was, and in part remains, very high; spectrum regulators have the power to decide what frequencies can be used for the power, location, height and direction of transmitters, the technology to use, etc.

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Since Coase (1959, 1960), economists have long argued in favour of a different approach where users are granted well-defined property rights, and allocation choices are determined by market forces. Drawing an analogy with land ownership, this approach advocates the transition from central planning (i.e. administrative control) to a decentralised regime; spectrum should be partitioned and allocated to private owners. Owners/licensee should be allowed to decide how to use their own frequencies, including buying, selling or partitioning them. Right holders, however, would be required not to trespass upon other parties' frequencies with signal strength beyond a well-defined limit, which is often referred to as *technical parameter* (De Vany, 1998). If they did, this would be treated like a form of infringement, leading to legal action and, possibly, sanctions.

Regarded with scepticism early on, over the years the property rights approach has gained momentum.[2] Reforms in this direction have taken place in a number of countries. Leading examples of property rights licences are those issued by the US Federal Communications Commission (FCC) in mobile services and the Spectrum Usage Rights (SURs) issued by the British regulator Ofcom in the so-called L-band. Defining property rights for spectrum on the basis of core technical parameters has several advantages over standard licences under administrative control. The main one is that the licensee is free to put the frequency to the most profitable use by modifying the type and nature of the service offered, as long as its emissions into neighbouring bands do not exceed the predefined limits.

The problem of how to properly set the emission limits and how to deal with possible interference, however, remains. It is, therefore, important to understand the basic factors that should guide the regulator's decisions regarding admissible emission levels and the measures to be taken when these limits are not respected. This paper provides an economic treatment of these issues, focusing on efficient spectrum use.

In order to ensure the efficient delivery of services via spectrum, both transmitters and receivers have to be properly calibrated. Regimes based on property rights, as well as those based on traditional administrative control, tend to deal with interference from the emission side by constraining transmission power and out-of-band emissions (by setting the *technical parameter*). Contrary to air pollution, however, spectrum interference cannot be reduced to a problem of (socially excessive) emissions. In fact, interference does not arise directly from the unwanted energy dispersed in a channel, but rather from the inability of the receiver to separate it out from the desired signal. Indeed, interference can be mitigated by reducing the power of the undesired signal, by increasing the power of the desired signal, and/or by improving the ability of the receiver to capture the desired signal (by installing better quality filters, by adopting digital processing devices or by modifying the network architecture).[3] A central issue for the regulator is, hence, that of devising a regulatory regime that provides users with the right incentives to select efficient transmission power and, also, adopt efficient reception technologies.

A critical feature that affects the outcome of the analysis in this paper is the open- or close-architecture nature of the system. In closed-architecture systems, such as mobile telephony and (satellite) pay TV, the same party controls the design of both transmitters and receivers. Operators either manufacture their own receivers or dictate the design to independent manufacturers (Goodman, 2004). By contrast, in open-architecture systems, such as Free To Air (FTA) TV and radio broadcasting, the transmitter does not control the specification of receivers used for its service. The decision of which reception technology to adopt is made by a multitude of independent parties, making coordination significantly harder.

The incentives of each party to engage in efficient communication are examined under the most common regulatory regimes. The analysis focuses first on close-architecture systems. The case of the open-architecture systems is considered in Section 4.

The traditional administrative control regime, where emission levels and transmission technologies are set by an omniscient regulator pursuing economic efficiency, is examined first. The conditions for optimal emission levels and the optimal investment in filtering capacity are derived. These conditions are used as a benchmark for an efficient outcome.

Next, under a decentralised set-up, different regimes are considered where admissible emission levels are set by the regulator and parties are free to decide upon spectrum use and communication technologies. Regimes differ, though, in the degree of protection they provide to the victims of interference (Calabresi & Melamed, 1972).

One possibility is to protect spectrum users through a property rule, which assigns to the victim of excessive emissions the faculty to enjoin the interferer by means of a legal action. This action can be backed by administrative or criminal sanctions. In this regime, emission limits are strongly enforced and, as in the case of real property, trespassing is forbidden and punished. Emissions above the limit can only take place with the consent of the victim.

A milder enforcement alternative is to protect spectrum users by means of a liability rule, which allows victims of excessive emissions only to claim damages for the harm they suffered. Damage awards are decided by a third party (the regulator or a court), who identifies the responsible party and quantifies damages. Here, spectrum rights holders are not guaranteed immunity from unwanted emissions, but only the economic recovery of the loss suffered.

One initial observation is that property rights regimes are likely to provide the right incentives to invest in filtering whenever transmission and reception are integrated (i.e. under a closed-architecture system) and parties can effectively

[2] A different approach, supporting open access to spectrum, has also recently gained attention. This is based on the observation that some technological developments like agile radio and mesh networks allow for a drastic reduction in the level of within-band interference. This removes the need for exclusivity as it would allow all users to share the same frequencies. Regulators have been receptive to this so-called "commons" approach (or unlicensed use), when there is no evidence of scarcity and transaction costs are high (see Kwerel & Williams, 2002).

[3] Technically, mitigation can arise both from improved sensitivity and selectivity (Kwerel & Williams, 2002).