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On the Economic Objectives of Spectrum Policy Reforms

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Abstract

Reforms to spectrum management methods have been underway for two decades in several OECD countries. Their aim is to improve the efficiency with which the spectrum is allocated and used through higher reliance on market forces (market pricing, property rights, trading). These reforms have made spectrum-intensive industries more allocatively efficient through improved spectrum valuation and higher investor certainty about long-term spectrum holdings. However, the high degree of resource exclusivity conferred by property rights potentially crowds out access by innovative services, affecting dynamic efficiency and reforms may also undermine technical efficiency if the owner makes scant use of the privatised spectrum. The paper takes stock of action research performed in the regulatory agency of a reforming country to present the trade-offs involved, and suggest a piecemeal approach to reforms based on a flexible licensing system.

Bio

Ben Freyens (PhD Economics, Australian National University - ANU) is Senior Lecturer at the Faculty of Business & Government, University of Canberra and a fellow of the Centre of Law & Economics at the ANU and at the Centre for Social and Human Capital Research (UOW). He has led contracted research projects for the Australian Communications & Media Authority, a collaboration which resulted in the release of several industry reports and the publication of academic papers on spectrum policy, spectrum licensing and radio transmission technologies. Samples of this research have been published in *Information Economics & Policy*, *Telecommunications Policy, Info, Telematics and Informatics*, *Telecommunications Journal of Australia*, several book chapters and in the proceedings of various refereed *IEEE* conferences.

Keywords

Spectrum, efficiency, licensing, property rights

JEL Classification

K23, L96, P14, P28, P32, P41, O56

Disclaimer – This paper is based on a presentation made at the 5th International Telecommunications Society (ITS) AAA conference and draws on material presented at the 1st conference of the Network for Economics Research on Electronic Communications (NEREC) 2009, the Communications and Policy Research Forum (CPRF09) 2009, the 4th International Telecommunications Society (ITS) AAA conference, IEEE DySPAN 2010 and 2011, IEEE VITAE 2011, as well as research reports on radiocommunications licensing prepared for the Australian Communications and Media Authority. The views and interpretations presented here are my own and should not be assumed to represent those of any individuals or institution named in this paper.

Introduction

How efficiently we allocate and licence the radio spectrum to different radio communications services and users is critical to the competitiveness of the information industry and the many beneficiaries of its services. Accordingly, several OECD countries have adopted principles of efficient spectrum management[1]. These principles have been used to guide reforms to spectrum management methods through use of market pricing and assignment of property rights.

Efficiency objectives are a direct response to the economic failings of control and command arrangements that prevailed prior to reforms, when regulatory agencies allocated radio spectrum to wireless services with little or no regard for market forces. The opportunity cost of using control and command arrangements to allocate spectrum frequencies had been criticised by several generations of economists starting with seminal pieces by (Coase (1959); De Vany, Eckert, Meyers, O'Hara and Scott (1969); Herzel (1951); Levin (1966)), and the deregulatory reforms undertaken from the late 1980s onward were primarily motivated by efficiency gains.

However, the new spectrum laws and regulations are generally unclear about the precise nature of the efficiency gains to achieve. The main policy reform of the last two decades was the introduction of spectrum property rights and the assignment of these rights through auction and other market-based pricing mechanisms. These reforms improved the allocative efficiency of spectrum-intensive industries through higher investment certainty and improved spectrum valuation. However, the high exclusivity of property rights potentially crowds out access by innovative services on a secondary user basis, affecting dynamic efficiency and, potentially, affecting technical efficiency if the owner also leaves the spectrum fallow.

Thus, efficiency principles can be a confusing source of guidance for regulatory agencies. Frequency bands differ in physical properties and radio communications services differ in their commercial value and in their contribution to the public interest. The relative importance of technical or dynamic efficiency for the public interest varies with these characteristics. A one size fits all approach to reform may only intensify conflicts between efficiency objectives.

The article builds a case for a more tailored, piecemeal approach to reforming spectrum management methods. Maximising the public interest based on the constrained maximisation of a menu of efficiency criteria is better served by developing the institutional flexibility to craft and select appropriate licensing instruments tailored to achieve selected economic objective for specific bands and services. Few amongst reform countries have developed that capacity, yet increasing the flexibility of spectrum licensing systems is critical at a time of fast-growing spectrum demands for combined voice-data applications. The paper takes stock of action research in the regulatory agency of a reforming country to illustrate these points.

Market pricing and property rights

How far have we really come with economic reforms? With respect to market-based pricing reforms have made significant progress over the last 20 years. Most OECD countries now use market pricing instruments to allocate spectrum to services, which generate high market value

[1] In the US, where the Communications Act 1934 gives the Federal Communications Commission (FCC) the power to make regulations, efficiency principles and objectives were adopted through the recommendations of FCC regulatory papers. In other reform countries, they were legislated (United Kingdom, Australia, and New Zealand).

- such as cellular and broadband networks. Auction pricing and beauty contests[2] have generally proved the preferred method in reform agencies to initially assign spectrum to these services , whereas opportunity cost pricing is increasingly used for licence renewal (Doyle 2010). Spectrum trading (trading licences in 'second hand' markets) has also made significant headway in the United States, and to a lesser extent in the United Kingdom, Australia and a few other reform countries (Xavier and Ypsilanti 2006, ACMA 2008, Crocioni 2009, Akalu 2010).

By contrast, the second stage of these reforms, the endowment of spectrum property rights[3], has seen little development outside a small subset of reform-minded countries, among which, Australia, El Salvador, Guatemala, New Zealand, the UK and the US. But even in these countries, the initial drive for a large scale move towards a system of property rights has slowed or stalled over time. For instance, there have been no new allocations of spectrum licences in Australia or management rights in New Zealand over the last decade (Freyens 2009). The British regulator's (OFCOM) recent experiment with spectrum usage rights (SURs) proved short lived (Webb 2008). In the US, the FCC stopped short of tying property rights to the recently auctioned 700 MHz licences , despite their high degree of exclusivity.

This trend towards a pause in the pace and scope of reforms motivated several agencies and policy analysts to set increased targets for the roll-out of spectrum allocations through property rights. For instance, in 2002, Kwerel and Williams suggested that the US' Federal Communications Commission (FCC) move rapidly towards a system of property rights and spectrum trading (Kwerel and Williams (2002)). Shortly thereafter, Australia's Productivity Commission released its Inquiry Report on Radiocommunications Policy, strongly recommending that the Australian Government adopt a wide-scale privatisation approach to spectrum allocation (Productivity Commission (2002)). Then, the British regulator, OFCOM, concluded its Spectrum Framework Review (SFR) with a well-publicised decision to use market forces (market pricing, service neutrality and trading) to manage over 70% of the United Kingdom's spectrum holdings by 2010 (OFCOM (2005)). Finally, 27 high-profile US economists endorsed reformist positions in a statement recommending the privatisation of the radio spectrum to meet future US need is broadband policy (AEI 2006).

These calls did not lead to further property right allocations in the countries concerned and the current regulatory trend is, instead, toward a status quo in the *number* of property rights licences, and in some areas, towards a decline in the exclusivity of these property rights. To understand the rationale driving this new policy turn, one needs to understand the economic objectives initially set for reforms, particularly the need to improve efficiency in the use and allocation of the radio spectrum.

Spectrum efficiency

Cave et al. (2007, Ch. 11) argue that efficiency in the context of radiocommunications policy should be defined based on the Pareto criteria – i.e. in terms of not being able to improve the

[2] In a beauty contest, applicants submit a business plan to the regulatory authority, which ranks and matches applications against predetermined public interest criteria – deployment speed, employment etc. - to select a licensee, with or without payment of a fee. France, Spain and Sweden used beauty contests to assign 3G licenses in the early 2000s (Gans et al. 2005).

[3] Property rights are here defined as (i) rights to a high degree of usage exclusivity - such as long, uninterrupted leases - and (ii) rights to operate with service and/or technology neutrality – such as the right to change the type of service or technology used on a specific frequency without being required to obtain regulatory consent. Exclusivity and neutrality both greatly improve the degree of certainty to users considering investments in spectrum-reliant infrastructure. Property rights therefore increase the market value of the spectrum.

well-being of one economic agent without harming that of another. They decompose economic efficiency into *productive efficiency* (least cost production of a given output), *allocative efficiency* (producing a mix of services such that that no other mix could improve the overall well being of an economic agent without harming that of another), and *dynamic efficiency* (managing the spectrum in ways that enable long-term productivity improvements such as through innovation and R&D).

Which of these three sub-objectives should have higher priority? Cave and his co-authors emphasise the potential complementarities of these objectives in an ideal world of perfect competition. For instance, they show how a reallocation of spectrum resources between sectors with different marginal benefits from spectrum use can increase both allocative and productive efficiency - by freeing other resources, which prices and quantities can then be used to value the reallocated spectrum. This discussion sets a benchmark to develop pricing mechanisms but the authors are well aware that in practice radiocommunications markets bear little resemblance to any ideal, frictionless environment.

In economic theory, productive efficiency is usually subsumed to the over-arching allocative efficiency concept, that is, productive efficiency is one of several conditions to be met in order to achieve allocative efficiency, and for that reason this paper will assume that productive efficiency is implied by allocative efficiency.

However, one efficiency concept which is not subservient to allocative efficiency is the less commonly used concept of *technical efficiency*. Technical efficiency is achieved when firms produce on their production frontier, i.e. when the maximum output attainable from each input level is achieved (Coelli, Rao, O'Donnell and Battese (2005)). Technical efficiency refers to making full productive use of a given stock of resources, whereas allocative efficiency is more concerned with least cost production, and consumer valuation of the services produced, regardless of whether resources are fully used or not. Legislated objectives of spectrum reforms put considerable emphasis on efficient usage and allocation of the spectrum, but provide little guidance as to which objective should have precedence when objectives of efficiency in usage and in allocation conflict with one another.

In the subsequent sections, we examine these trade-offs and policy roadblocks through an Australian case study, but much of the discussion could extend to cover the issues facing New Zealand's management rights system, or the United States' regulatory debate over white space licensing.

Reforms and conflicting economic objectives

The major aim of spectrum management reforms is to improve efficiency in use and allocation of this key resource. This objective is clearly articulated in the key texts of the relevant regulatory jurisdictions in spectrum-liberalising countries. For instance, in the US, the Spectrum Policy Task Force of the Federal Communications Commission (FCC) has repeatedly stated that 'One of the Commission's key spectrum management goals has been to promote efficient access to and use of the radio spectrum' (FCC 2002 : 4).

Is efficient access assumed to be conducive to efficient use? Or are these two unrelated objectives expected to contribute separately and independently to an overall efficiency goal? To clarify its intentions, the FCC suggested adopting three different definitions of efficiency (FCC 2002 : 5-9): (i) *spectrum* efficiency, a throughput measure; (ii) *technical* efficiency, which qualifies throughput efficiency for the cost of using other resources; (iii) *economic* efficiency, which is the ratio of output value over inputs cost and differs from throughput by measuring value rather than quantity.

Importantly, the FCC emphasises that 'spectrum and technical efficiency feed into and become a component of economic efficiency'. High rates of spectrum and technical efficiency may just be too costly to achieve compared to the benefits they create to society as a whole. A balance must be found between technical and economic considerations, and the FCC seemed to have decided in favour of the latter when it supported an extension of economically efficient governance regimes (FCC 2002 : 32-34) such as (1) more exclusive usage rights (e.g. allowing subdivision, trading and service neutrality) for services with low transaction costs.

In the United Kingdom, the *Communications Act 2003(the Act 2003)* requires that spectrum policy should lead to 'the efficient use in the United Kingdom of the electro-magnetic spectrum for wireless telegraphy' (§152, s.5, HMSO 2003). This act of Parliament does not discriminate amongst specific efficiency objectives, but Cave et al. (2007, Ch. 11) suggest that 'efficiency in this context is usually understood to mean *economic efficiency*' (p. 169, their emphasis) in terms of allocative, productive and dynamic efficiency.

Reforms in Australia started with the enactment of the Radiocommunications Act 1992 (Henceforth 'The Act'), which in its Part 1.2, Section3, buttresses the importance of using efficient spectrum allocation methods: 'The object of this Act is to provide for management of the radiofrequency spectrum in order to (a) maximise, by ensuring the efficient allocation and use of the spectrum, the overall public benefit derived from using the radiofrequency spectrum.

Objective (a), The Act's foremost objective, emphasises goals of allocative and technical efficiency. However, The Act does not stipulate which of 'allocative efficiency' and 'usage - i.e. technical - efficiency' should prevail in situations where these two objectives are mutually exclusive. Neither does The Act suggest how these objectives should be interpreted and how they could be pursued. This ambiguity is of particular importance for assessing the economic success (or otherwise) of the main reform brought about by The Act: the introduction of a spectrum property rights regime through spectrum licences.

Property rights in Australia

Under The Act, Australia assigns and regulates the radio frequency spectrum using three licensing regimes; apparatus, spectrum and class licences, which are broadly representative of command and control, property rights and open access approaches respectively. Except for a few amendments to The Act in 1995 and 1997, which modernised apparatus licences (authorising licence transfer, third party operations and spectrum reallocation processes and other policy novelties), the three basic licensing regimes have seen little change over the years. The last significant alteration was a multi-year consolidation process among class licences started in 2000 and completed in 2008. Table 1 summarises the main characteristics and attributes of Australia's trichotomic licensing regime (a similar table could be designed with relatively minor alterations for New Zealand's trichotomic licensing system and with larger changes for the US and the UK).

The Act sets up a legislative regime where spectrum licenses are regulated as property (leasehold rather than freehold) for the purpose of subsection 51(xxxi) of the Commonwealth of Australia Constitution Act (the Constitution). Consequently, the duty of managing interferences is transferred to the licensee. The spectrum owner is entitled to clear transmissions but conflicts over interfering transmissions have to be resolved through the judicial system rather than through regulatory agencies.

Spectrum licences (the property rights regime) offer a more appropriate approach to the development of spectrum markets than other licensing regimes, such as apparatus licences,

due to higher certainty (tenure and term), exclusivity, sub-dividability and above all, discretion with respect to service and technology selection (service neutrality). To users considering long term investment planning decisions, property rights confer a much higher degree of certainty and control over the licensed spectrum.

Table 1. Main attributes of Australia's trichotomic licensing system

Attributes	Apparatus licences	Spectrum licences	Class licences
Regime focus	Device-centric	Space-centric	Tech-centric
Efficiency objective	Technical	Allocative	Dynamic
Exclusivity	Medium to high	Very high	None
Coordination rules	Administratively set	Proprietary	Self-governed
Flexibility (tech-service)	None to moderate	High	variable
Individually assigned	Yes or No	Yes	No
Assignment by:	Adm. pricing, auction	Auction	Not assigned
Price	fee / market price	Market pricing	Free
Tenure and term	5 years/renewable	15 years / +?	Unlimited
Interference protection	provided	provided	not provided
Tradability	Moderate	High	Not relevant
Sub-division	Not allowed	Allowed	Not relevant
Coordination needed	Low	High	Low
Service neutrality	Usually none	High	variable

Yet, spectrum licences have proved a somewhat rigid instrument for the Australian regulatory agency (the Australian Communications and Media Authority - ACMA). The regulator kept much discretion and flexibility in the design of the apparatus and class licences regimes, but kept none for the spectrum licence regime, which appears monolithic relative to the other two licensing regimes. Indeed, since the 1992 reforms (and subsequent amendments) the ACMA has made full use of its discretion to experiment with both rigid and flexible spectrum licensing arrangements. Hybrid licences of all types have flourished within the control and command and open access approaches, but not so within the property rights approach - where the regulatory discretion to craft dynamically efficient sub-regimes is in practice transferred to the licensee. Other types of property rights regimes could potentially have been crafted to expand the available set of licensing instruments but the discretion to design them is no longer a regulatory matter (Freyens (2009)).

Hence, some of the legal rules embedded in the trichotomic[4] licensing structure of the 1992 reforms have helped deploy a wider array of licensing instruments to fine-tune the needs of users and better respond to the opportunities of new technologies. But at the same time, other legal rules stemming from the same set of legal reforms feed a pool of 'licensing gaps' that detract from the public interest they are meant to serve. That is, these rules prevent the

[4] 'Trichotomy' refers to the division into three parts, classes, categories, etc.

deployment of efficiency-enhancing regimes. Before analysing to what extent legal rules reduce potential efficiency in spectrum allocation, one need to understand the different types of economic efficiency concepts involved and how radiocommunications law discriminates amongst them.

Limitations of the property rights regime

Allocative efficiency refers to the optimal distribution of scarce economic resources, usually through a price mechanism (such as auctions) and supplier discretion in responding to market demand (e.g. by defining property rights over the resource). Technical efficiency refers to maximising input-output ratios on the outer edge of a production possibility set. Dynamic efficiency[5] trades off short-run efficiencies for lifecycle efficiency (e.g. as in R&D projects).

Does the assignment of auctioned property rights to spectrum users help to achieve these three efficiency objectives? An effective regime of property rights consists essentially of three elements; (i) assignment through market pricing mechanism (e.g. auctions), (ii) user/owner discretion with respect to service deployment and/or technology adoption (service- and technological neutrality) and (iii) high exclusivity in usage (regulators cannot claw back rights in the short to medium term). Whereas each of these three characteristics contributes in its own way to efficient spectrum valuation and exchange through 'invisible hand' mechanisms, which generally serve allocative efficiency, they each also present potential drawbacks in terms of specific legislated efficiency objectives[6].

1. Auctions

The process of pursuing allocative efficiency through spectrum auctions has seen further controversies as there have been many instances where spectrum auctions did not deliver public interest outcomes. The claim that regulatory authorities achieve allocative efficiency through auctions rests on very strong assumptions that are too often unrealistic. Auctions provide favourable ground for improvements in allocative efficiency with respect to a government-assigned licensing system, because they elicit key valuation information about the communication markets served by market providers. Yet, these spectrum values may also reflect the presence of economic rents due to barriers to entry[7] in many mobile applications

[5] Note that in spectrum policy, dynamic efficiency has tended to adopt another interpretation in which devices are dynamically efficient if they can detect idle spectrum opportunities and occupy the vacant space on a transitory basis (as in Dynamic Spectrum Access or DSA). Dynamic efficiency in that sense is similar to the FCC's concept of technical efficiency (maximising input usage at least cost) – FCC (2002).

[6] Use of property rights to license radiocommunication services has been criticised by Benkler, Yochai, 2003, Some economics of wireless communications, in L.F. Cranor, and S.S Wildman, eds.: *Rethinking rights and regulations: Institutional responses to new communication technologies* (MIT Press, Cambridge, MA), Reed, David P. , 2001, Why spectrum is not property - the case for an entirely new regime of wireless communications policy, 27 February 2001, Draft paper, Snider, J. H., 2006, Spectrum policy wonderland: A critique of conventional property rights and commons theory in a world of low power wireless devices, (30 September 2006, George Mason University, Arlington, VA), Werbach, Kevin, 2004, Supercommons: Towards a unified theory of wireless communications, *Texas Law Review* 82, 863-973., among others. See also reviews in Freyens, Benoit Pierre, 2009, A policy spectrum for spectrum economics, *Information Economics and Policy* 21, 128-44, Freyens, Benoit Pierre, 2010, Shared or exclusive radio waves? A dilemma gone astray, *Telematics and Informatics* 27, 293-304..

[7] For instance, at the time of 3G auctions in the UK in March 2000, incumbents' sunk infrastructure costs - the pre-existing 2G networks, existing brands and customer basis acted as a deterrent for new entrants (Binmore and Klemperer 2002).

markets and the externalities arising from future collusive behaviour among spectrum users in oligopolistic markets.

A simple example will illustrate this point[8]. Suppose that the status-quo consist of a single incumbent operator (e.g. a broadcaster, or a network carrier) who owns a licence for a specific amount of scarce spectrum, operating the band as a monopoly and deriving monopoly rents from scarcity and exclusivity. Policy makers consider introducing competitive forces through reduction of the incumbent's spectrum endowments and auction of another licence granting usage rights to the same frequencies.

Suppose there are two bidders registered for the auction but neither of them is the incumbent (to rule out any return to the status-quo). One bidder is a very effective competitor, e.g. a start-up, whose main objective is effective entry and carving market share. The start-up bidder would be expected to drive profits significantly lower in that market, but would also expand the scope of market transactions, thus increasing consumer and social welfare. The other bidder is a relatively ineffective competitor, e.g. a niche player, whose main objective is to generate significant profits. The niche player has an interest in preserving the profitability of the industry and would therefore not be expected to restrict or put much pressure on the pricing / output behaviour of the incumbent.

Who will win this auction? In a traditional ascending bid auction, the uncompetitive player is the likely winner because the presence of rents in the duopoly characterised by uncompetitive behaviour generates positive externalities for the less effective bidder. Given their distinct objectives, the start-up is a weaker bidder than the niche player. The future rents from collusive or other behaviour compatible with the status-quo enable the uncompetitive player to bid at higher levels than the competitive player. From the consumer's perspective, one would want the effective player to win the auction but the presence of externalities strongly reduces the likelihood of this outcome - and there are many such externalities in spectrum auctions.

Optimal auction design can, in theory, deal with these externalities. Sealed-bid auctions favour entry by smaller, competitive players[9] but to be effective the efficiency gains from effective competition must outweigh the welfare losses from smaller players lower valuations. To the extent that the start-up's lower willingness to pay is due to barriers to entry, the presence of regulations enabling third party access to established incumbent infrastructure can help remedy the problem. If the start-up's weak bids are due to a lack of scale, or the risks introduced by market fragmentation then sealed bids may not be optimal. Mixing sealed bid and ascending auctions[10] but the failure of so many 3G auctions to attract new entrants to cellular markets do demonstrate the complexity of the task. Hence auctions do not always allocate the radio spectrum to its most efficient user, nor do they necessarily lead to socially optimal industrial organisation, harming rather than serving allocative efficiency.

[8] This illustration was raised and discussed in a presentation made at the first conference of the Network for Economic Research on Electronic Communications NEREC in September 2009. Other inefficiencies from poorly designed auctions are discussed in Klemperer (2002, 2003), and Gans, Joshua S., Stephen P. King, and Julian Wright, 2005, Wireless communications, in Sumit K. Majumdar, Ingo Vogelsang, and Martin Cave, eds.: *Handbook of telecommunications economics ii* (North-Holland, Amsterdam)..

[9] A successful example of new entry with sealed bid is the Danish 3G auction conducted in September 2001.

[10] In the UK's 3G auction, the regulator designed a two-staged mixed auction mechanism, with a larger number of licenses than the number of incumbents (Binmore and Klemperer 2002). Attempts to emulate the British scheme led to several fiascos in Italy, Switzerland and the Netherlands due to various sources of design or regulatory failure (Klemperer 2002).

2. Exclusivity and certainty

Spectrum licences offer the highest degree of exclusivity in usage in Australia. As opposed to other types of licences, which are typically allocated to a service and assigned to an operator for a few years, spectrum licences grant property rights over 15 years, offering a high degree of certainty to their owners. This high degree of certainty favours allocative efficiency by reducing the risk of investing in new infrastructure or in the development of new technologies that are specific to a particular range of frequencies. However, owners may make scant usage of their private spectrum, for reasons ranging from 'wait and see' speculation (when there are expectations the value of the spectrum will increase in the short-run) to 'leapfrogging' (waiting for the next more efficient technology to be available before investing). Speculation can be allocatively efficient when owners make well-informed choices about the best return for their shareholders and consumption benefits for their customers.

However, idle spectrum is problematic because the radio spectrum is a resource in high demand from diverse sectors of the economy, and property rights spectrum consists of some of the most valuable frequencies. If the spectrum is not used by the primary user, ideally, there should be regulatory instrument allowing other users to make a productive usage of it on a secondary basis. This is essentially the way other licensing regimes operate, but under a regime of property rights the degree of exclusivity is such that no other user can access the frequencies without explicit consent by the primary user. Hence, the property rights regime can generally be presumed to be efficient but only in an allocative sense, not necessarily in a technical (maximal usage) sense, because high exclusivity may in some cases prevent full use of the resource, so that the local economy (the spectrum space) is not operating *on* but rather *below* its production frontier.

Freyens and Yerokhin (2011) for instance illustrate this situation with an example of spectrum licences, which remained unused by their owner for years. The unused spectrum was a source of unease for the Australian regulatory agency, which received daily complaints from smaller prospective users keen to use the spectrum as secondary users but unauthorised to do so. Objective (a) of The Act clearly requires an efficient use of the spectrum and this was not the case. Should technical efficiency take precedence over allocative efficiency? A possible consensus could have been to target allocative efficiency for larger standardized services, and productive efficiency for tailored specialist services. However, in a model of investment in technological projects with uncertainty and risk aversion, Freyens and Yerokhin show that adopting this criterion can still lead to a stalemate between the two objectives. Should the regulator force the owner to use the spectrum or relinquish it through so-called use-it-or-lose-it approaches? This solution would in practice severely reduce the justification for using property rights in the first place. Another alternative is to encourage the development of secondary market for spectrum trading, so that owners who keep their spectrum idle temporarily have incentives to let secondary users use their resource against a payment (Freyens and Yerokhin (2011)).

3. Service neutrality

A third and final issue with property rights is the difficulty to deliver service neutrality in practice. Australia defines the service neutrality of its property rights regime through a block edge mask (BEM) model, which rests on the specification of the technical framework. Spectrum licences are 'service-neutral' and 'space-centric', i.e. they permit users to operate any radiocommunications devices in a given 'spectrum space' subject to respecting the

requirements of a technical framework[11]. The degree of service neutrality of the licence varies along a continuum depending on the exact formulation of the technical framework; too much service neutrality weakens the technical framework and may lead to inefficient uses – i.e. there is a fundamental trade-off between flexibility and efficiency, but mostly it will be difficult if not impossible for a spectrum licensee to vary the type of service deployed on her spectrum space without regulatory intervention – required to modify the parameters of the block edge mask. Hence the degree of allocative efficiency achieved by the property rights regime is restricted by technical and regulatory barriers to potential spectrum reallocation by the owner in response to market changes. By contrast the UK's power flux density approach to spectrum property rights (pfd) does not require a fully-specified technical framework. Instead, the property rights are defined in terms of interference allowed, and owners are free to use the licences to provide any service as long as they comply with the way their rights have been defined. However, the pfd approach is still experimental and very few licences have been issued (Webb (2009)).

Conflicting objectives

The property rights regime was crafted to foster market exchange and to provide certainty to operators investing a significant amount of resources in infrastructure of technology development. Yet, whilst this licensing regime would generally be expected to lead to higher allocative efficiency, that will not always be the case. In particular, technical efficiency may be adversely affected by the high degree of exclusivity of the licences. Conversely, licensing arrangements that make intensive (productive) use of a specific frequency band will usually not be allocatively efficient if the deployed service or the adopted technology are prescribed with no regard for market forces (as with most types of administrative licensing).

Yet, it would be mistaken to assume that these orthogonal choices result from a failure of The Act to provide a clear sense of direction. Much of the legislation in this area is influenced (to a degree) by regulatory authorities and if the legal texts have remained imprecise over the overarching concept of 'efficiency', it indicates policy makers' intent to leave some interpretation discretion to implementation agencies. There is no obvious way to resolve these trade-offs between different efficiency objectives, and the task of designing efficiency-enhancing radiocommunications licences depends largely on the judgements and experience of regulatory agencies. A band designated by ITU regulations for mid-range power, narrow channel services used by a high number of users will require a different interpretation of 'spectrum efficiency' than one characterised by a few large operators, transmitting at very high power, with nation-wide coverage and important infrastructure investments to protect.

Hence, the degree of discretion granted to regulatory bodies in recognising the adequate nature of efficiency objectives and in designing appropriately matching licensing regimes effectively contributes to the pursuit of the public interest (if we agree that efficiency is a critical component of the public interest). One would then hope that these decisions are relatively unfettered by political interference, legislative vetoes and other institutional

[11] A spectrum space comes with an underlying population density, incumbent or prospective services and is specified through the development of a technical framework. Only fully specified spectrum spaces are marketable to private or public operators. This approach defines spectrum space over big areas and large bandwidths, and is therefore much more compatible with a higher degree of freedom in usage. It is generally preferred by large operators seeking the deployment of large-scale networks within the boundaries defined by the licence's technical framework.

restraints[12]. If a regulatory authority recognises the need to adopt an allocative efficiency approach for a highly valued service requiring considerable capital expenditure, the public interest is better served if decision makers can freely design a licence based on market instruments and a high degree of legal protection for the investments required, rather than be constrained to prescriptive command and control or open access approaches.

Thus, the public interest may be better served by a versatile set of legal instruments designed to cater for the specific requirements of all possible services, technologies and markets, or at least by providing agencies with the discretion to develop such instruments. To some extent, this is the path that the early reformist nations, New Zealand and Australia, followed. Due to the isolated geographical location of their country (no close neighbouring countries), New Zealand's Ministry of Economic Development (MED) and Australia's ACMA benefitted from significant flexibility with respect to license design relative to other reformers, yet achieving a high degree of licensing flexibility was never an overt objective of legislative acts in these countries (the Radio communications Act 1989 in New Zealand, and The Act in Australia).

Flexibility and efficiency

Achieving efficiency through licensing flexibility would require having the right licensing instrument available to cater for the specific requirements of all possible services, technologies and markets, or at least having developed the discretion to design such instruments. The efficiency gains from developing this approach would result from expanding the set of institutional constraints that restrict efficient licensing policy. In other words, licensing flexibility is concerned with correcting for the degree of efficiency lost by not being able or allowed to design a management regime best fitting the circumstances of an industry or a new technology. Licensing flexibility as a measure of the regulatory flexibility to respond to different needs with different regulatory instruments is not a mainstream term in spectrum parlance, but it has been alluded to by several authors. (Burns (2002)) for instance suggests that we should view efficiency as a broader governance concept:

> 'optimal use of the spectrum requires the needs of users of spectrum to be met in the most efficient and effective manner taking account of the economic, functional and technical constraints that apply to different services. Assessing how well this is achieved in practice requires a large degree of qualitative judgement as well as quantitative measurement – hence measuring efficiency is an art as much as a science'.

Subsequently, (Webb (2008)) observed that:

> 'The SFR [Ofcom's 2005 Spectrum Framework review] then clearly established that only the regulator could decide on the right balance between these three different mechanisms [note: command and control, market forces, and unlicensed approaches]. For example there appears to be no means other than by regulatory decision that spectrum could transition from market forces to licence-exempt. In principle, a user group could try to acquire spectrum from a licence holder and turn it into a 'private commons' but in practice this appears far too complex to occur'.

[12] The degree of political capture varies among reform countries. It is generally considered a bigger issue in the US where senior FCC appointments are political (Webb 2009b). By contrast, Australia's ACMA and the UK's OFCOM are statutory agency, so technically independent from government.

On the other hand, any discretion to craft new management regimes through flexible licensing is costly in administrative terms. As in any production process, diversifying supply may erode economies of scale, make automation more difficult and increase management cost. In Australia, and in the UK, cellular operators with licenses in the 900MHz and 1800MHz Bands are still only able to use this spectrum for 2G GSM systems (the licences are of apparatus type, rather than property rights). Since these users are few, changing licensing conditions on these bands (from an apparatus to a spectrum type of licence) may affect the level playing field among competitors[13]. Webb (2009b) notes that this example illustrates just how much easier it is to devise a new spectrum strategy than to implement it. The benefits of using a flexible licensing system would need to be large enough to compensate for the costs of introducing such a system.

Mappings between licensing and regulatory regimes in Australia

How is Australia performing in terms of new, flexible licensing approaches? Yet, there are many more ways to manage spectrum allocation and coordinate interference control. For instance, several informal hybrid regimes have seen some degree of deployment in Australia. Australia's trichotomic licensing structure does not fully reflect the actual mix of practical approaches unfolding on the ground. These practical experiments with hybrid spectrum management regimes are only authorised under The Act through legal provisions allowing the ACMA a significant degree of discretion in designing apparatus licences, and to some extent in crafting class and spectrum licences.

Are regulatory spectrum management regimes really restricted to three options: command and control, property rights and open access? There is, conceptually, a much wider array of spectrum management approaches available to policy makers (Freyens (2007); Freyens (2009)). There have been earlier attempts by ACMA to suggest legal reforms towards a single licensing regime under The Act, which would allow the regulatory agency to tailor its licences to the needs of users as new services and technologies emerge. In practice there are at least about 20 different ways to manage spectrum allocation and interferences (and potentially many more), and a wider array of approaches contributes to the efficiency and public interest objectives of The Act. In particular, such a discretionary approach (occasionally referred to in the paper as 'the bespoke approach') would allow ACMA to fine tune the flexibility-certainty dilemma present in its current licensing regimes[14].

The bespoke approach was never seriously considered beyond ACMA's policy branches, but Australia's practical approaches on the ground reveal that some of these conceptual approaches have been used in Australia for some time. However Australia's trichotomic licensing structure does not reflect these developments on the ground. Australia's practical experiments with hybrid spectrum management regimes are only authorised under The Act

[13] A referee for this journal also raises the question of geographic scale. For example, a incumbents' holdings of national / state licence may be sufficiently important to deter prospective market entrants, which in turn may affect the mechanisms for the efficient allocation of spectrum. With fewer entrants, the dynamics of spectrum demand could be less suited to some mechanisms such as spectrum licences. With a small pool of players and geographical scale, optimal spectrum licensing mechanisms require considerable (and costly) regulatory oversight to prevent market concentration and spectrum hoarding.

[14] For a recent and fuller discussion of earlier attempts to develop a bespoke licensing approach see Freyens, Benoit Pierre, 2012, Licensing options for digital dividend spectrum, in G. Faulhaber, G. Madden, and J. Petchey, eds.: *Regulation and the economic performance of communication and information networks* (Edward Elgar, Cheltenham)..

through legal provisions allowing ACMA a significant degree of discretion in designing apparatus licences[15].

There is a small subset of apparatus licences, which is fully specified in The Act, such as licences for national broadcast, temporary community broadcasters, and datacasting, but for most apparatus licences ACMA is virtually unconstrained in its approaches. Apparatus licences are generally construed to be the archetype of control and command (C&C) management and most of them are device-specific and entail very prescriptive technical arrangements. However some apparatus licences are actually quite flexible and decentralised command and control approaches have seen some activity in Australia. Not all apparatus licences fit the stereotype of an arch-rigid management regime ruled by government fiat.

There is also no shortage of demand for regimes providing both rights certainty and some degree of service or technological flexibility in Australia and although spectrum licences are one way to meet this need, some versions of the apparatus licensing regime have provided alternatives in some areas. For instance, some flexible apparatus licences, such as the PTS licences issued in the 900 MHz band, could have realistically been converted to spectrum licences long ago, given their high-value use (cellular markets) and underlying technology (GSM). The fact that they were not converted illustrates just how few differences PTS licensees must have perceived in practice between spectrum licensing and flexible apparatus licensing, in terms of running their core operations.

Mapping licences to practical management regimes also reveals gaps between theory and practice. Some of these gaps arise from prescriptive provisions in *The Act*, whilst other gaps stem from an economic incentive problem. The limits of conducting multi-regime policy equipped only with a trichotomic licensing structure constrain ACMA in its quest to allocate spectrum to its highest value while serving the public interest. Spectrum licences are too exclusive and unaffordable for many users, class licences are too much restricted to low power services, and apparatus licences are generally too prescriptive and provide little certainty to licensees. These limitations warrant legislative reforms in some areas of licensing policy: the degree of exclusivity in property rights may need to be adjusted to increase the dynamic efficiency of spectrum-licensed bands, and the degree of certainty in apparatus licences needs to be adjusted in some areas to create conditions favourable to long-term investment decisions.

Conclusions

To a large extent, reforms to spectrum management methods in the United States, in the United Kingdom, in Australia and in New Zealand have succeeded in introducing market forces in a hitherto rigid resource allocation system. But did they achieve their avowed economic objectives? Any attempted answer would be highly contextual. Auctions succeeded and failed. In some bands property rights allocations led to investment and network deployments but in other bands the spectrum simply laid fallow. Spectrum trading rose in the US but less so in other countries. Economists' repeated calls, ten years ago, to expand the use of market forces did not have noticeable effects. In this article it was suggested that addressing goals of spectrum efficiency in usage and in allocation may require more than expanding the scope of auctioned property rights allocations. It would require specific amendments to existing licensing systems. The trichotomic licensing system in use in most reform countries is not ideally suited to address the economic and technological challenges

[15] In practice, ACMA also has some degree of discretion in designing class and spectrum licences, but for various reasons, it has been much less used to define and authorise new spectrum management regimes.

ahead – particularly the exponential demand for wireless communication devices and the need for in-band co-existence arrangements between devices of compatible technology. Command and control licences are too prescriptive and provide no long-term certainty over spectrum holdings. Property rights licences are economically attractive but they are too exclusive to encourage any form of co-existence - and by keeping regulatory oversight at a distance they also guarantee no actual usage of the resource. Open access arrangements are better suited to device co-existence but too exposed to the interference problem and therefore too restricted to short-range low-power applications. An expanded licensing toolkit could therefore better address future and complex issues such as the allocation of the digital dividend, access rights for TV White Space devices, and dealing with the supply of broadband services through heterogeneous networks . Reform legal rules to allow greater activity rates and secondary usage in property rights spectrum spaces, and to increase the level of certainty and flexibility for command and control licences offers a promising way to maximise both mainstream economic efficiency and deal with future challenges in spectrum policy.

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