The need for a conservative approach to the pricing of radio spectrum and the renewal of radio spectrum licences

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14 December 2010

About Apex Economics

Apex Economics, led by Chris Doyle, provides economic consulting services in the fields of economic regulation and competition policy relevant to the broadcasting, radio spectrum and telecommunications sectors.

In 2003 Chris was a key member of the team retained by the UK regulator Ofcom to review opportunity cost based spectrum pricing methods (known as Administered Incentive Pricing in the UK, similar to the Optimal Deprival Value method of spectrum pricing in New Zealand). More recently he has been advising Ofcom during the course of its on-going review of spectrum pricing.

Chris is a visiting professor in the Department of Economics at the University of Warwick, UK. He has published many academic papers on regulation and competition policy and in 2007 co-authored with Martin Cave and William Webb the book *The Essentials of Modern Spectrum Management* published by Cambridge University Press.

Apex Economics has 20 years of experience in providing economic and business consulting services to numerous corporate and government clients.

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Suggested citation:

Doyle, Chris (2010), *The need for a conservative approach to the pricing of radio spectrum and the renewal of radio spectrum licences*, Apex Economics, prepared for the Australian Mobile Telecommunications Association.

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Key messages in this report:

- **Government has stated that the price to be set for the renewal of spectrum licences in mobile telecommunications in Australia will be based on *scarcity and value*. This may be open to interpretation, but the setting of a price based on scarcity and value has to be in accordance with the ACMA's principles for spectrum management and the Radiocommunications legislative framework. This will ensure consistency with economic efficiency and the attainment of the Total Welfare Standard (TWS) as required by ACMA.**

- **To ensure economic efficiency and the TWS, the correct calculation of the spectrum price should accord with the economic concept of opportunity cost. This is conceptually right and in line with international best practice. Further it was recognised as far back as 2002 by the Productivity Commission in its review on radiocommunications as correct.**

- **Opportunity cost estimates of radio frequency bands used for mobile telecommunications need to take account of valuations not only in mobile applications, but also in the next highest value use. Only when this is done would a proper assessment of scarcity and value consistent with TWS occur.**

- **Calculating opportunity cost values of radio frequency bands is challenging and in practice will generate a wide range of estimates.**

- **Confronted with a range of opportunity cost estimates means government will need to choose the 'best' estimate. If it chooses a licence renewal fee towards the upper end of estimates, this increases the risk of setting the wrong price for the spectrum and would as a consequence jeopardise investment and adversely affect both digital productivity and the public interest.**

- **There is an asymmetric economic impact associated with the selection of an opportunity cost based spectrum licence renewal fee. In terms of efficiency, setting the price too high outweighs the cost from setting the price too low. Given this asymmetry it is prudent to approach the setting of spectrum fees conservatively and err towards lower value estimates of opportunity cost. The best price is that compatible with a conservative approach.**

- **The central message of my report is the need to exercise caution when choosing a spectrum renewal fee and to approach the task conservatively.**

1. Introduction

This report is about pricing of radio spectrum, an increasingly important resource essential to the development of mobile communications and broadband technologies.[1] The significance of radio spectrum was emphasised by the Chairman of the Federal Communications Commission very recently: [2]

"Spectrum is the oxygen of our mobile communications infrastructure and the backbone of a growing percentage of our economy. Spectrum enables wireless innovation that will grow our economy and create jobs of the future."

I present a high level 'scene-setting' discussion of the principles and practicalities around the setting of prices for the renewal of spectrum licences in mobile telecommunications in Australia, focussing on the potential impact for the industry and the public. I emphasise the economic case for setting spectrum prices conservatively.

The Government has indicated that it favours renewing spectrum licences for mobile telecommunications through the application of a fee that reflects "scarcity and value"[3]. This approach, interpreted and implemented correctly, is consistent with the spectrum management legislative framework and the ACMA's spectrum management principles.[4]

Although the method to be applied by the Government to compute the scarcity and value of the spectrum held by the mobile telecommunications operators has yet to be specified in public, spectrum policy discussion by government over the last ten years or so indicates it will be based on the economic concept of *opportunity cost*. In principle this is the correct approach and accords with international best practice.

I begin my report by setting out the value provided by mobile telecommunications services to the Australian economy. This provides a very useful backdrop and illustrates the considerable impact mobile services have on the Australian economy. The discussion also highlights the substantial

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[1] This report was commissioned by the Australian Mobile Telecommunications Association (AMTA) and is concerned with the possible terms to be applied to the renewal of the expiring 15 year spectrum licences as announced by Senator the Hon. Stephen Conroy in March this year.

[2] Extract from speech given by Chairman Julius Genachowski, Federal Communications Commission, at the FCC Spectrum Summit "Unleashing America's Invisible Infrastructure" Washington, D.C. 21 October 2010, available at: http://www.fcc.gov/Daily_Releases/Daily_Business/2010/db1021/DOC-302331A1.pdf.

[3] As stated by Senator the Hon Stephen Conroy, Minister for Broadband, Communications and the Digital Economy in his address to *AMTA Member Networking Forum,* Sydney, 3 March 2010.

[4] *Principles for Spectrum Management*, ACMA, March 2009 available at: http://www.acma.gov.au/WEB/STANDARD.PC/pc=PC_311683.

investments currently planned with regard to Mobile Broadband (MBB) services and emphasises that setting a price for the renewal of the spectrum licences too high will impose a large cost to the economy, denting digital productivity and weakening the competitive status of Australia.

I next describe the principles, laws and organisational structure governing the management of radio spectrum frequency bands in Australia, highlighting the importance attached to efficiency, the TWS and the opportunity cost concept familiar in economics.

Following on from this I discuss in detail the conceptual basis for using opportunity cost based spectrum pricing principles and argue that this is the right approach to assess scarcity and value within the legal framework governing spectrum management in Australia.

I then turn to a discussion on the opportunity cost methods that can be used to estimate spectrum prices and illustrate how estimates typically fall across a wide range. As government will end up choosing one price for a unit of spectrum from the range of estimates it is presented with, it is crucially important it chooses the right price. I present the economic case for choosing a price conservatively. **This leads me to recommend the choice of a price towards the lower end of opportunity cost estimates.** This is the central message of my report.

Having set out the normative case for setting prices conservatively, I overview experience of opportunity cost spectrum pricing in New Zealand and the United Kingdom, two countries that have applied full opportunity cost based spectrum prices rigorously and in my view have set the best practice international benchmark. I note that the approach to opportunity cost spectrum pricing in these countries is consistent with the conservative approach I recommend.

I conclude by summarising my arguments and reiterate the importance of approaching conservatively the setting of the price of spectrum in the renewal of the mobile spectrum licences.

To ensure that mobile telecommunications contributes fully to the future prosperity of the Australian economy, it is essential that the right spectrum price is selected at the moment the spectrum licences are renewed. This is far more likely to be achieved if a conservative approach to price setting is used. It is encouraging to note that ACMA is on record as supporting the conservative approach:[5]

"If there is a price range within which to set a price, setting price too high will result in an under-use of spectrum. Where there is doubt it is generally better for spectrum to be slightly under-priced. This will at least mean that the completely renewable resource will be used and contribute to welfare, rather than not being used at all. Pricing in this fashion [opportunity cost principles and methods] requires judgment because it is difficult to know the exact shape of the marginal benefits curves of the competing uses, and thus it is difficult to know the equilibrium prices for the competing uses. When trying to set a market-clearing price, ***setting a conservative price is recommended.****"*

(emphasis is added)

[5] Page 22 in *Opportunity cost pricing of spectrum: public consultation on administrative pricing for spectrum based on opportunity cost,* ACMA, April 2009 available at http://www.acma.gov.au/. Note a footnote reference is omitted from the quotation.

My report is structured as follows.

Chapter 1 presents an introduction.

Chapter 2 looks at the value of mobile telecommunications to the Australian economy.

Chapter 3 describes the principles and organisational structure of spectrum management in Australia.

Chapter 4 discusses economic efficiency and opportunity cost in relation to radio spectrum frequencies. This chapter provides a theoretical basis for the application of opportunity cost based spectrum prices.

Chapter 5 presents an analysis of methods used to estimate opportunity cost spectrum prices and shows how a range of estimates typically arises in practice. In this chapter I present the economic case for setting spectrum prices conservatively.

Chapter 6 is a brief review of best practice international experience from New Zealand and the United Kingdom on opportunity cost based spectrum pricing.

Chapter 7 concludes my report with the message: a conservative approach to pricing radio spectrum frequency bands should be adopted by government as this is consistent with the radio spectrum management principles, the legislative framework and digital productivity.

2. The value of mobile telecommunications to the Australian economy

Academic studies have shown conclusively that telecommunications, and mobile telecommunications in particular, have a significant economic impact.[6] Estimates of the benefits of mobile telecommunications to the Australian economy were recently published in a report by Access Economics (the '*Access Economics Report*') which concluded:[7]

"This report demonstrates that the mobile telecommunications industry is of large value to the Australian economy."

The Access Economics Report estimated the economic contribution for all mobile telecommunications services on the Australian economy was AUD17.4 billion over the period 2008/09, noting:[8]

"Based upon the estimated Australian population at 30 June 2009 (ABS 2009b), GDP per capita in Australia is $760 higher than would otherwise have been the case."

Developments in mobile telecommunications are increasingly focussed on high-speed data services and it should be borne in mind that the above estimates of value calculated by Access Economics pre-date the current surge in the growth of MBB services.[9]

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[6] For example see Alice Shiua and Pun-Lee Lamb (2010) "Relationships between Economic Growth, Telecommunications Development and Productivity Growth: Evidence around the World", *Telecommunications Policy*, Volume 34, Issue 4 (May 2010) pp.185-199. Draft available at http://www.apeaweb.org/confer/hk10/papers/shiu_alice.pdf (last accessed 22 October 2010).

[7] See page vi in *Economic Contribution of Mobile Telecommunications in Australia* Access Economics report for AMTA, June 2010, available at www.amta.org.au.

[8] Page i-ii *op cit.* ABS 2009b refers to the Australian Bureau of Statistics *Australian Demographic Statistics*, June 2009, Canberra, December.

[9] Recent growth in data usage on modern mobile telecommunication networks has been dramatic and it shows little sign of abating, in Australia and worldwide. This is discussed in *Five-year Spectrum Outlook 2010–2014: The ACMA's spectrum demand analysis and indicative work programs for the next five years*, March 2010 at www.acma.gov.au, in the *ACMA Communications Report 2008-09* at www.acma.gov.au/webwr/_assets/main/lib311252/08-09_comms_report.pdf and in *Mobile Broadband Growth: reports from HSPA operators worldwide* 8 April 2010 a report by the Global Mobile Suppliers Association (GSA) available at http://www.lteportal.com/Files/MarketSpace/Download/267_4-8MBB_Growth_results.pdf?PHPSESSID=dad54db67c40003e84276733b51b0597. Growing demand for MBB services is putting greater pressure on scarce radio spectrum resources. Some policy makers in other advanced economies (such as the European Union) are allocating more frequency bands to mobile telecommunications operators to enable MBB service development. It was reported by Reuters on 17 September 2010 that the European Commission plans to ask EU countries to free up valuable broadband spectrum to mobile operators by 2013 in a bid to spur consumer demand, see http://uk.reuters.com/article/idUKTRE68G3AD20100917.

Substantial additional benefits are likely to be associated with MBB services, as new telecommunication services have consistently delivered considerable benefits as recognised by Eardley *et. al.* (2009): [10]

"There is considerable evidence that new forms of telecommunication can bring both macroeconomic benefits, accruing to national economies, and microeconomic benefits accruing to individuals, both in developed and developing countries."

Investment by mobile network operators facilitating the development of MBB services will be a critical driver unlocking further substantial economic benefits to the Australian economy. A leading academic commentator in the field William Lehr (2009) recently noted in a survey that MBB services:[11]

"will drive growth and provide a stimulus for innovation and investment for broadband infrastructure and the Internet overall."

In a recently published report by Network Strategies (2010) for the AMTA looking at the evidence of the anticipated economic benefits available through mobile broadband, given sufficient spectrum capacity is made available to meet projected demand, it is:[12]

"estimated gross productivity benefits for mobile broadband over the period 2013 to 2020 to be around AUD143 billion. From this total benefit we estimate the cumulative productivity benefit for Long Term Evolution (LTE) to be AUD62 billion over this same period, assuming that commercial launch of LTE over 2.5GHz will occur in 2013, with LTE over 700MHz available one year later."

[10] Page iii in Eardley, T., Bruce, J. and Goggin G. (2009), *Telecommunications and Community Wellbeing: a review of the literature on access and affordability for low-income and disadvantaged groups*, SPRC Report 9/09, prepared for the Telstra Low Income Measures Assessment Committee (LIMAC), Social Policy Research Centre, University of New South Wales, Sydney available at http://www.sprc.unsw.edu.au/media/File/Report9_09_Telecommunications_Community_Wellbeing.pdf.

[11] William Lehr (2009) "Mobile Broadband and Implications for Broadband Competition and Adoption", a white paper prepared on behalf of *Broadband for America*, Massachusetts Institute of Technology, USA available at: http://people.csail.mit.edu/wlehr/Lehr-Papers_files/LehrMobileandBroadbandCompetition%20RELEASED%20Nov%2022%202010.pdf.

[12] Page iii in: *The future deployment of mobile broadband services: 2.5GHz in Australia*, Network Strategies Report Number 29028, 15 June 2010, available at www.amta.org.au.

The forecast expected substantial benefits of MBB to the Australian economy depend critically not only on new spectrum being made available in a timely manner, but on substantial investments being made by licensed network operators. In February of this year the GSMA stated:[13]

"Operators around the world to pledge half of all mobile CAPEX to Mobile Broadband. The GSMA today announced that mobile operators around the world will invest up to [US]$72 billion in Mobile Broadband technologies in 2010. The new operator CAPEX investment data, compiled by global investment firm Deutsche Bank, reflects the continued consumer and enterprise demand for Mobile Broadband services and the need for underlying infrastructure, and comes as global HSPA connections reach the 200 million milestone."

Investment in MBB service development in Australia is already significant and is expected to remain so over the coming years as the network operators build out new higher speed networks, technologies and services. For example:

- Telstra has invested in Next G, a fast network with download speeds of up to a theoretical 42Mbps;[14]

- Optus' has invested $2 billion over the past five years in *The Open Network*, with more than 1,000 new mobile sites launched since 2008[15] and has acquired new spectrum in the 2100MHz band in metro and regional areas to support growth in MBB; and

- Telstra, Optus and VHA are all trialling high speed LTE services.[16]

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[13] See media release Mobile Broadband Investment Set to Soar as HSPA Connections Pass 200 Million, 10 February 2010, London available at the GSMA website; http://www.gsmworld.com/newsroom/press-releases/2010/4621.htm (last accessed 22 October 2010).

[14] Actual user download speed will be up to 20 Mbps maximum in capital city CBDs and associated airports, selected metropolitan hubs and regional centres. For more detail see Telstra Media Release, "World First: Mobile broadband boost puts Australia in top of the world", 30 August 2010, available at http://www.telstra.com.au/abouttelstra/media-centre/announcements/world-first-mobile-broadband-boost-puts-australia-on-top-of-the-world.xml (URL accessed 11 October 2010).

15 'Optus Opens possibilities with new mobile network brand', 10 September 2010, http://www.optus.com.au/aboutoptus/About+Optus/Media+Centre/Media+Releases/2010/Optus+Opens+possibilities+with+new+mobile+network+brand.

[16] On LTE trials by Optus see: http://www.optus.com.au/aboutoptus/About+Optus/Media+Centre/Media+Releases/2010/Optus+successfully+trials+LTE+mobile+technology+with+Nokia+Siemens+Networks+in+metropolitan+Sydney; on LTE trialled by Telstra see: http://www.telstra.com.au/abouttelstra/media-centre/announcements/telstra-and-nokia-siemens-networks-lte-world-first-trial-achieves-100m.xml; and on LTE trials by VHA see the media release dated 21 October 2010 available at http://clients.weblink.com.au/clients/Hutchison2/article.asp?asx=HTA&view=2610130 (last viewed 21 October 2010).

Mobile telecommunications and MBB services have a considerable positive impact on the Australian economy. This will intensify with growth in demand for MBB services. It is crucial that the price set by government for the renewal of the mobile spectrum licences is undertaken carefully so as not to compromise investments in MBB services. If the renewal price is set too high this would impose a considerable cost on the Australian economy, lead to a serious loss in digital productivity and weaken the competitive status of Australia with regard to attracting foreign investments.

3. The principles and organisational structure of spectrum management in Australia

The principles governing spectrum management are laid out in primary legislation in section 3 of the Radiocommunications Act 1992 (RA 1992):

"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;*
- *(b) make adequate provision of the spectrum:*
  - *i. for use by agencies involved in the defence or national security of Australia, law enforcement or the provision of emergency services; and*
  - *ii. for use by other public or community services;*
- *(c) provide a responsive and flexible approach to meeting the needs of users of the spectrum;*
- *(d) encourage the use of **efficient** radiocommunication technologies so that a wide range of services of an adequate quality can be provided;*
- *(e) provide an **efficient**, equitable and transparent system of charging for the use of spectrum, taking account of the value of both commercial and non-commercial use of spectrum;*
- *(f) support the communications policy objectives of the Commonwealth Government;*
- *(g) provide a regulatory environment that maximises opportunities for the Australian communications industry in domestic and international markets;*
- (h) *promote Australia's interests concerning international agreements, treaties and conventions relating to radiocommunications or the radiofrequency spectrum."*

[emphasis is added]

Efficiency in this context is usually taken to mean that radio spectrum frequency bands should be allocated to uses conferring the highest value to society, and assigned to users delivering most value to society. In competitive markets the interaction of demand and supply would work in favour of such efficiency, with those having the highest benefits willing to pay the most.[17]

The organisational structure of the management of spectrum in Australia is overseen by the ACMA which is governed by the Australian Communications and Media Authority Act 2005 (ACMA Act 2005) with new spectrum management principles issued in accordance with the Radiocommunications Act 1992 (RA 1992).[18] The ACMA is responsible for licensing arrangements,

[17] I sidestep the issue of market power here, but note in passing that sometimes high private benefits may derive from an application of market power. In such cases (economic) efficiency (TWS) is compromised. Efficiency is discussed in detail in the next chapter.
[18] Section 9 of the ACMA Act 2005 sets out the ACMA's spectrum management functions and refers to the RA 1992.

enforcing compliance with licensing terms and investigating complaints of interference to services.

Spectrum licences are tradeable, technology neutral (that is, not related to any particular technology, system or service) spectrum access rights. Instead of authorising the use of a specific device, spectrum licences authorise the use of spectrum space and give licensees the freedom to deploy any device from any site within their spectrum space, provided that the device is compatible with the core conditions of the licence and the technical framework for the bands.

Section 82 of the RA 1992 allows for the reissue (the word reissue is used in the Act, though renewal is frequently used in public discourse and is used throughout this report) of spectrum licences by the ACMA to the same licensees where it is in the **public interest**. In this regard public interest would be adjudged by reference to the objectives set out in section 3 of the RA 1992. Section 294 of the RA 1992 allows the ACMA to determine a spectrum access charge on spectrum licences and the Minister may give written directions to the ACMA about the matters dealt with in determinations.

The public interest criteria were proposed by the Department of Broadband, Communications and the Digital Economy during a recent consultation:[19]

- Promoting the highest-value use for spectrum;
- Investment and innovation;
- Competition;
- Consumer convenience; and
- Determining an appropriate rate of return to the community.

On 3 March 2010 Senator the Hon. Stephen Conroy Minister for Broadband, Communications and the Digital Economy, set out a statement on the renewal of the 15 year licences issued for both 2G and 3G bands. The Minister indicated that operators using spectrum licences would be eligible for renewal and stated:[20]

"Licences reissued in accordance with the public interest criteria will be subject to an agreement on price. Accordingly, the Government will seek a fee that reflects the scarcity and value of this important public resource."

As I elaborate in the next chapter, the best measure of scarcity and value is based on the application of the economic concept of opportunity cost. This view was also taken by the ACMA in its 2009 consultation on applying the

[19] DBCDE, *Public Interest Criteria for re-issue of Spectrum Licences*, April 2009, available at http://www.archive.dbcde.gov.au/2010/january/public_interest_criteria_for_re-issue_of_spectrum_licences.
[20] Senator Stephen Conroy address to *AMTA Member Networking Forum,* Sydney, 3 March 2010.

opportunity cost approach to the setting of spectrum prices in which it stated it is:[21]

"expected to result in more efficient allocation of spectrum [and] is also consistent with the Total Welfare Standard ACMA uses to assess the impact of regulatory decisions".

The ACMA has set out five principles for the effective management of radio spectrum frequency bands:[22]

1. Allocate spectrum to the highest value use or uses
2. Enable and encourage spectrum to move to its highest value use or uses
3. Use the least cost and least restrictive approach to achieving policy objectives
4. To the extent possible, promote both certainty and flexibility
5. Balance the cost of interference and the benefits of greater spectrum utilisation

These five principles accord with underlying economic efficiency objectives and in the 2009 consultation on opportunity cost spectrum pricing the ACMA noted such pricing would in particular be:[23]

"expected to promote productive, allocative and dynamic efficiencies in spectrum markets and related downstream markets".

While acknowledging opportunity cost based spectrum pricing applied correctly is desirable for economic efficiency, I am very sceptical in the context of the renewal of mobile spectrum licences that it would have a material effect on downstream retail competition.[24]

This is because competition in downstream retail markets is already working effectively and the absence of intervention by the regulatory and competition authorities in the setting of tariffs in retail markets supports this view. The ACCC has not found failings in the mobile telecommunications retail market (which it sees as increasingly meaning both voice telephony and MBB, see the reference in note 26 below). For example, in his speech to the 2010 Australian Telecommunications Users Group Annual Conference ACCC Chairman Graeme Samuel made the following comments:[25]

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[21] Page ii *op cit.*
[22] *Principles for spectrum management*, *op cit.*
[23] Page ii *op cit*. The components of efficiency mentioned are discussed further in the next chapter.
[24] Effective competition in downstream retail mobile services markets leads to efficiency given the application of the Mobile Terminating Access Service (MTAS) declaration extended by the ACCC until 30 June 2014, see http://www.accc.gov.au/content/index.phtml/itemId/848724.
[25] *Fair call: the ACCC's report card for the telecommunications sector*, 12 March 2010, Sydney, available at http://www.accc.gov.au/content/index.phtml/itemId/918460/fromItemId/8973. It was also

"While the merger of Vodafone and Hutchison last year has reduced the number of mobile networks from 4 to 3, competition in the mobile sector has always been more robust than in fixed voice services because of the number of network operators…. The greater degree of competition in the mobile sector is reflected in the fact that the ACCC currently regulates access to only one mobile service, namely the mobile terminating access service…. More network competition spurred investment in 3G infrastructure and recently all operators have upgraded the speed and coverage of their networks..."

In the past Mr. Samuel has highlighted the benefits of competition in mobile telecommunications:[26]

"These results [lower prices] suggest that carriers continue to compete vigorously in the mobile segment, as you would expect where there are multiple competing infrastructure networks."

The ACCC is clearly comfortable with the proposition that competition is effective in mobile telecommunications retail markets. Thus competitive market pressures drive retail prices towards costs, an outcome consistent with economic efficiency and the TWS.

The laws and principles governing spectrum management in Australia emphasise efficiency. The practice of spectrum management has led to consideration of the application of opportunity cost spectrum prices. In the next chapter I assess in more detail economic efficiency and opportunity cost based spectrum prices.

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stated "On 29 May 2009, the Australian Competition and Consumer Commission (ACCC) announced its decision not to oppose the proposed merger of the Australian mobile operations of Vodafone Group plc and Hutchison 3G Australia Pty Limited (proposed merger). The ACCC was of the view that the proposed merger would not be likely to have the effect of substantially lessening competition in any relevant market in contravention of section 50 of the Trade Practices Act 1974 (the Act).", see the *Public Competition Assessment* 24 June 2009 on the Vodafone Group plc and Hutchison 3G Australia Pty Limited - proposed merger of Australian mobile operations, www.accc.gov.au.

[26] See http://www.accc.gov.au/content/index.phtml/itemId/743663/fromItemId/2332.

4. Economic efficiency, opportunity cost and opportunity cost based spectrum prices

In this chapter I discuss the concepts of economic efficiency and opportunity cost in relation to spectrum management. The purpose is to illustrate that opportunity cost spectrum prices promote efficiency. In the following chapter I will address the estimation of opportunity cost values.

4.1 Economic efficiency

Efficiency in economics is viewed as having three components. When each is satisfied, the public interest criterion in section 3 of the RA 1992 would be satisfied.[27]

The three components necessary for efficiency are:

1. *Productive efficiency*: Production using radio spectrum frequency bands takes place at the lowest unit cost – radio frequency bands are assigned to users and allocated to uses such that production of services (the uses) occurs at the lowest possible unit cost. In other words, the holders of radio spectrum in mobile communications should be operators capable of supplying services to end users at the lowest possible unit cost of production. Competition is good for production efficiency, as less efficient firms are driven out by more efficient (lower cost) rivals.

2. *Allocative efficiency*: Radio spectrum frequency bands are allocated among uses and users to achieve the greatest benefit – the allocation of radio frequency bands between different users and uses should be organised such that any reallocation would be inferior.[28] With rapid growth in demand for MBB services[29] it is increasingly clear that insufficient spectrum is currently allocated to support mobile applications – the current spectrum allocation is inferior and does not meet allocative efficiency. It is well known that

[27] On the definition of efficiency in economics see for example Yew-Kwang Ng (2003) *Welfare Economics: Towards a More Complete Analysis*, Palgrave Macmillan.
[28] This is a specific illustration of the Pareto efficiency principle from economics.
[29] *"Industry analysts generally share the view that mobile network data traffic will continue a significant upward trend. As smartphones, laptops, and other devices become increasingly integral to consumers' mobile experiences, mobile data demand is expected to grow between 25 and 50 times current levels within 5 years."* This quotation is taken from a report analysing demand for mobile data services in the United States, see page 5 in Federal Communications Commission, Omnibus Broadband Initiative Technical Paper Number 6, *Mobile Broadband: The Benefits Of Additional Spectrum*, October 2010 available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-302324A1.doc. It is highly likely a similar growth pattern will feature in Australia and other high income economies.

the amount of radio spectrum made available for mobile communications uses in Australia (as in most countries) is relatively small (that is small relative to scale of use in mobile communications and other uses of radio spectrum). For example, the UK regulator Ofcom notes that only 4% of radio spectrum was allocated to mobile services in 2004.[30] In a recent FCC report a spectrum deficit is identified and it is stated:[31]

"that an additional 275 MHz of spectrum will be required to meet mobile data demand in 2014."

3. *Dynamic efficiency*: Radio frequency bands are priced so that the right signals for future investments are sent to the market – the setting of spectrum licence renewal fees should be done in a way that does not compromise investment in MBB services. If government were to set fees that are too high this will lead to scaled back investment which will undermine dynamic efficiency, and further adversely impact the Australian economy.

4.2 Opportunity cost

The ACMA states:[32]

"The opportunity cost of a part of the radiofrequency spectrum is the value of the spectrum in the highest value alternative use that is denied by granting access to one party rather than to the alternative."

In economics it is well known that prices determined on competitive markets reflect opportunity cost values and the outcomes arising as a consequence tend towards efficiency.[33] I illustrate this using a hypothetical example involving radio spectrum in which there are two radio frequency bands and two uses for the frequency bands.

Figure 1 shows valuations on the vertical axes and radio spectrum frequency band allocations on the horizontal axis. The marginal benefit in each use measures the value to the user of radio spectrum in the frequency band allocated to the use at a given quantum of spectrum. Marginal benefit means how much a user values a small amount of additional (or a small reduction in) the spectrum. This is equivalent to the maximum willingness to pay for a

[30] See page 10 in *Spectrum Framework Review: A consultation on Ofcom's views as to how radio spectrum should be managed*, 13 November 2004.
[31] Page 17 in Federal Communications Commission, *op cit.*
[32] Page ii *op cit.*
[33] See for example chapter 2 in Jha (2010) *Modern Public Economics*, 2nd Edn., Routledge. Efficiency is guaranteed when a number of assumptions are satisfied, including the absence of market power.

small additional amount of radio spectrum in the frequency band.[34] Note marginal benefit is shown as declining in the amount of spectrum allocated to each use. This property (known as *diminishing marginal returns*) is common for many inputs used by firms in production activities and has been observed empirically in studies looking at spectrum pricing.[35]

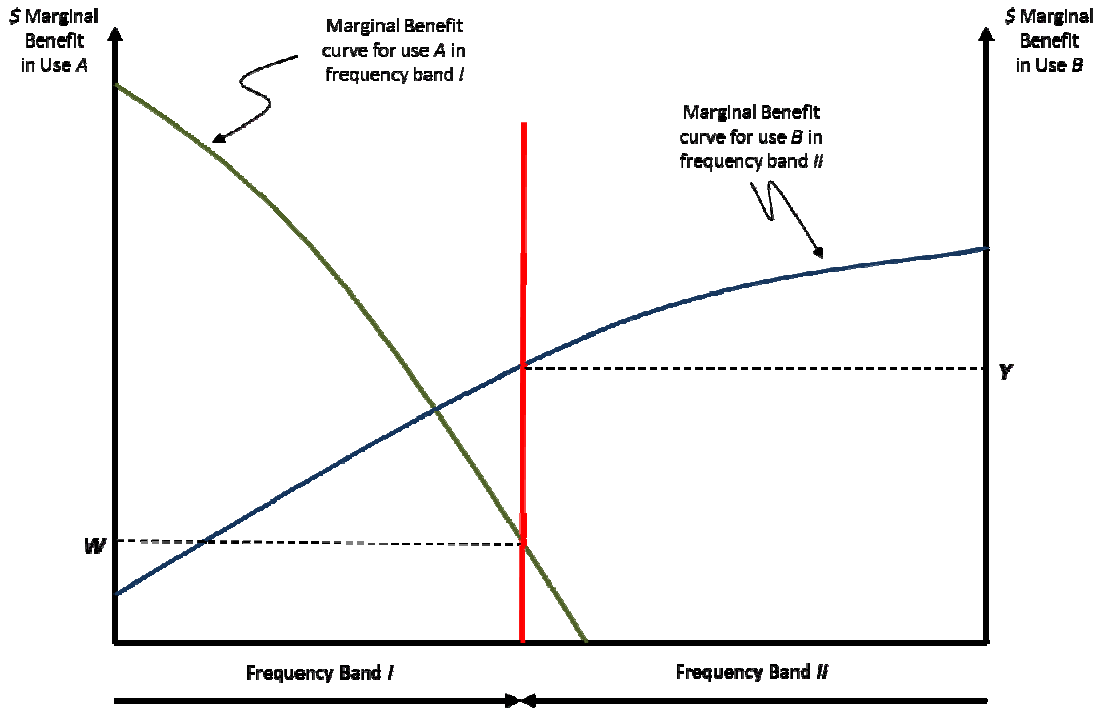

Figure 1. Marginal benefit curves of radio spectrum frequency bands

In frequency band *I* which is allocated to use *A* the marginal benefit at the allocation shown in Figure 1 is $W. In frequency band *II* which is allocated to use *B* the marginal benefit is $Y. Observe in Figure 1 that $Y>$W. A user of frequency band *II* would find it beneficial to offer a user in frequency band *I* slightly more than $W for a unit of spectrum to be transferred from frequency band *I* in use *A* to frequency band *II* in use *B*. A user in frequency band *I* would accept any price above $W offered for a marginal unit of spectrum.

[34] The maximum willingness to pay at the margin reflects opportunity cost. This is because the willingness to pay only makes sense by reference to alternatives available (such as alternative investments).

[35] See *An Economic Study to Review Spectrum Pricing* by Indepen, Aegis Systems and Warwick Business School, February 2004 (Authors: John Burns, Martin Cave, Chris Doyle, Phillipa Marks and Brian Williamson) – the *Indepen Report*. Phillipa Marks and Brian Williamson are now with *Plum Consulting*.

If marginal valuations are not equal across the uses, as shown in Figure 1, there are gains to be made from trading spectrum (alternatively reallocating spectrum) between uses.

In the context of ACMA's statement given above we can measure the opportunity cost of spectrum allocated to use *A* as $Y. By allocating a marginal amount of spectrum to use *A* which delivers a marginal value $W, the spectrum manager is denying the possibility of a higher marginal value $Y in use *B*.

Efficiency occurs when gains from trade (or reallocation of spectrum) across uses is not possible. This occurs at a spectrum allocation where marginal benefits are equal across different uses. This is illustrated in Figure 2 for the case of two uses and two frequency bands.

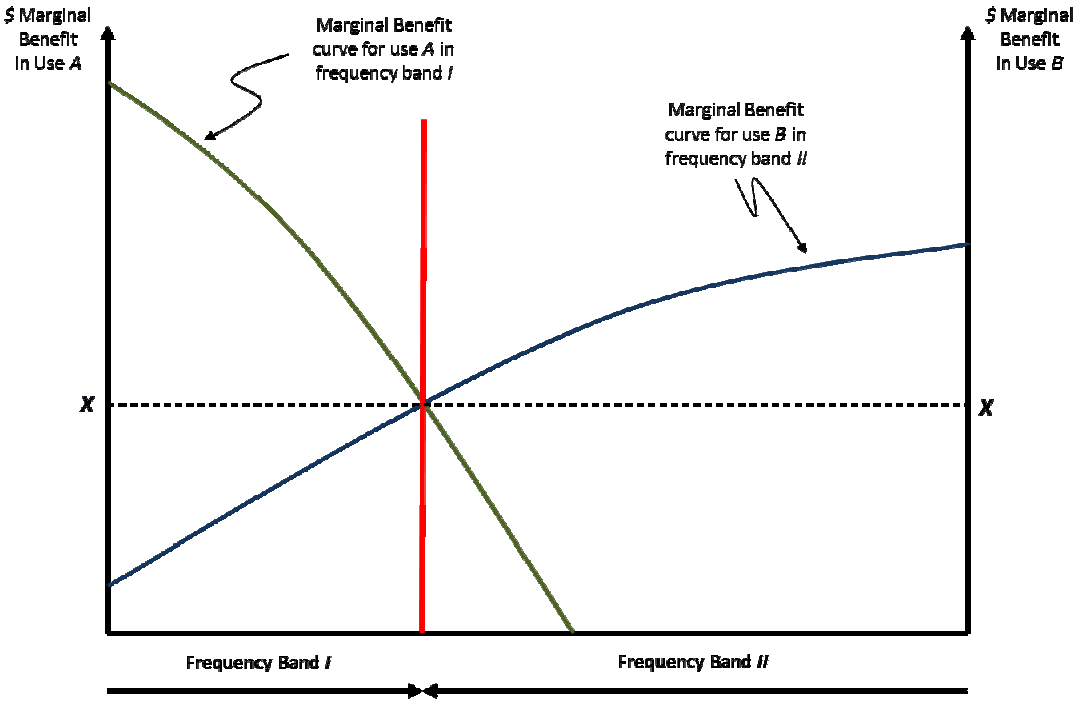

Figure 2. Efficiency occurs where the marginal benefit curves cross

The approach outlined makes clear the need to take account of opportunity cost values associated with alternative uses and across different frequency bands used by different uses. This point was made forcefully by consultants in the *Indepen Report* (see note 35) reviewing opportunity cost spectrum

charges in the UK back in February 2004.[36] As a result of the advice contained in the Indepen Report, the UK communications regulator Ofcom issued a statement in January 2007:[37]

"Ofcom has considered these study recommendations and agrees there is a continuing role for AIP [Administered Incentive Pricing, the name given to the opportunity cost approach to spectrum charges in the UK]. In line with Indepen's recommendations, Ofcom has applied an amended methodology for determining AIP, setting each AIP fee in relation to both the value of the spectrum in existing uses and its value in other potential uses for each band. Thus, AIP will give incentives for spectrum to move to the most valuable uses. Ofcom believes that AIP should continue to be applied despite the introduction of spectrum trading, as AIP can continue to promote greater efficiency."

I have described economic efficiency, opportunity cost, and shown the condition necessary for efficiency to hold for spectrum allocations. In the next section I show that opportunity cost based pricing of radio spectrum is consistent with economic efficiency.

4.3 Opportunity cost based pricing

Opportunity cost based pricing of radio spectrum frequency bands was shown as desirable for economic efficiency in Cave, Doyle and Webb (2007):[38]

"We have shown that a spectrum management agency can use prices [based on the opportunity cost principle] to achieve efficiency in spectrum use."

In Figure 1 the opportunity cost of allocating spectrum to use *A* rather than use *B* is $Y. An opportunity cost based price for a unit of radio spectrum in use *A* should lie above $W and below $Y. A price in this range would lead to a fall in the demand for spectrum in use *A* and the spectrum given up could be reallocated to the higher value use *B*. The correct price for a unit of spectrum in both uses is equal to the value where the marginal benefits for the two uses are equal, shown as $X in Figure 2.

Result 1: Efficiency occurs when marginal benefits (opportunity costs) across uses are equal.

Result 2: In the case of a given spectrum allocation where marginal spectrum valuations differ, for the highest value use (the use with the highest marginal benefit) the opportunity cost based spectrum price is below its marginal

[36] See section 6 on page 4 of the Indepen Report, *op cit.*
[37] Quotation from para. 2.15 in *Modifications to Spectrum Pricing*, Ofcom Statement, 10 January 2007.
[38] Page 184 in *Essentials of Modern Spectrum Management* by Martin Cave, Chris Doyle and William Webb, Cambridge University Press, 2007. The case for opportunity cost based spectrum pricing was also made in the Indepen Report and by the Productivity Commission in 2002.

benefit. Conversely, for the lowest value use (the use with the lowest marginal benefit) the opportunity cost based spectrum price is above its marginal benefit.

Result 2 above is at variance with a recommendation presented on page 3 of the Plum Report[39] presented to ACMA which states:

"If there is no use with a spectrum value higher than the current use of the band then set the AIP at the spectrum value of the current use."

This recommendation is only correct when radio spectrum frequency bands are optimally allocated across uses. As the amount of radio spectrum frequency available for mobile telecommunications is small relative to the scale of use, it is widely perceived that insufficient radio spectrum is allocated to mobile telecommunication uses. Given this, if a radio frequency band has the highest value in mobile telecommunications this reflects two important considerations: (i) the value placed on the services provided in the sector downstream and (ii) the shortage of radio spectrum allocated to mobile telecommunications use. As (ii) is likely to feature, setting a price to reflect the value in the current use and ignoring the next highest value use where the value is lower effectively reinforces a distortion in the market and embeds inefficiency. As is well known in economics a market price is a relative concept, thus the price of a radio spectrum frequency band needs to be assessed not only with regard to other inputs (the direct method) but also in relation to other possible uses of the band and in relation to the value of uses in other frequency bands.

4.4 Opportunity cost pricing of spectrum

The application of the opportunity cost principle to spectrum pricing was recommended as far back as eight years ago in Australia in the review on radiocommunications conducted by the Productivity Commission:[40]

"To achieve efficient outcomes, spectrum charges should be based on opportunity costs, that is, on the value of the best foregone alternative use of that spectrum."

The position taken by the Productivity Commission was reaffirmed more recently by the communications regulator Ofcom in the United Kingdom:[41]

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[39] *Administrative Incentive Pricing of Radiofrequency Spectrum*, Plum Consulting, 23 October 2008 (the *Plum Report*), submitted to and commissioned by ACMA, available at www.acma.gov.au.

[40] Productivity Commission (2002) *Radiocommunications Inquiry Report*, Report no. 22, AusInfo, Canberra, available at: http://www.pc.gov.au/projects/inquiry/radiocomms.

[41] Para 1.12 in *SRSP: The revised Framework for Spectrum Pricing Proposals following a review of our policy and practice of setting spectrum fees*, Ofcom public consultation 29 March 2010.

"[opportunity cost based spectrum pricing] promotes optimal use by ensuring that users face a signal of opportunity cost imposed on society by their use and therefore take it into account in their business and investment decisions, just as they do for other resources that they employ, and so have incentives to use it efficiently in the provision of downstream services."

For efficiency to be achieved and the TWS satisfied, the setting of spectrum renewal prices should be in accordance with opportunity cost measures. This is the correct approach to measuring the scarcity and value of radio spectrum frequency bands.

5. Calculating opportunity cost based spectrum prices

In the previous chapter I noted that prices determined by competitive markets are equivalent to opportunity costs. This suggests that in setting opportunity cost based spectrum prices all that is needed are market data on prices for radio spectrum. Unfortunately spectrum markets tend not to feature high volumes of trade and prices can be influenced by factors beyond spectrum market considerations.[42] As a result the calculation of opportunity cost based spectrum prices has in practice relied more on direct methods rather than market data.[43]

Direct methods are based on information about the demand and supply sides of the market which enable a judgment to be made about the market price or equivalently opportunity cost. Where possible direct methods are supplemented by market data (prices associated with relevant spectrum trades and relevant spectrum auctions) which are used to validate figures calculated using direct methods.

In this chapter the emphasis is on direct methods for calculating opportunity cost based spectrum fees. These methods have already been considered by the government in its consultation addressing spectrum in the 400MHz frequency band and have also been applied in New Zealand and the United Kingdom, countries widely viewed as pioneering their application.

The direct methods applied give rise to a range of estimates, which may be very wide. I argue that government should adopt a conservative approach when selecting from the range of estimates presented. In this chapter I discuss the implications of the conservative approach within the context of direct methods for measuring opportunity cost values.

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[42] Spectrum trades often arise as a consequence of corporate mergers or divestitures, thus many of the reported transactions do not identify asset by asset transfer prices. This was recognized in the ACMA 2008 consultation on spectrum trading: *"Evidence for the thinness of the spectrum market is seen in the variability of the turnover rate. In years where the rate is high, it is often the result of a single trade of a large number of licences from one licensee to another."* Page 11 in *Spectrum Trading: Consultation on trading and third party authorisations of spectrum and apparatus licences*, ACMA, November 2008.

[43] In the Plum Report the methods available to compute opportunity cost spectrum values are described as falling into two categories: (i) market data methods and (ii) direct methods. Market data methods could include the prices observed for spectrum trades (where relevant trading has occurred, including auctions) and may make use of market valuations (usually stock market data and balance sheet data) to estimate indirectly the value of spectrum to a user (indirectly because stock markets value enterprises as a whole). Direct methods assess the value of spectrum by estimating the maximum willingness to pay of a generic (or average) efficient licence holder for an extra marginal unit of spectrum. See chapter 4 of the Plum Report.

5.1 Direct methods to estimate opportunity cost spectrum values

In this section I describe the conceptual foundations underpinning the two direct methods commonly used to estimate opportunity cost spectrum values. The two methods are known as the Least Cost Alternative (LCA) and the incremental Optimal (or Optimised) Deprival Value (ODV).[44]

Consider a mobile telecommunications network operator entering a market. It is well known that for the operator to supply a given output level it faces a trade-off between the amount of spectrum it uses and the number of base stations it deploys. Having more spectrum means that the spectrum re-use pattern can be adjusted and fewer base stations are needed to meet demand. There is an inverse relationship between the amount of spectrum bandwidth and the number of base stations needed to meet demand.

The inverse relationship is illustrated in Figure 3 for two different output levels Q_1 and Q_2, where $Q_2 > Q_1$. The operator requires a minimum A MHz of bandwidth and is not able to obtain more than B MHz of bandwidth.

[44] LCA is the approach pioneered by Ofcom in the UK and the incremental ODV was applied by the Ministry for Economic Development in New Zealand when renewing cellular management rights. See the next chapter for further discussion.

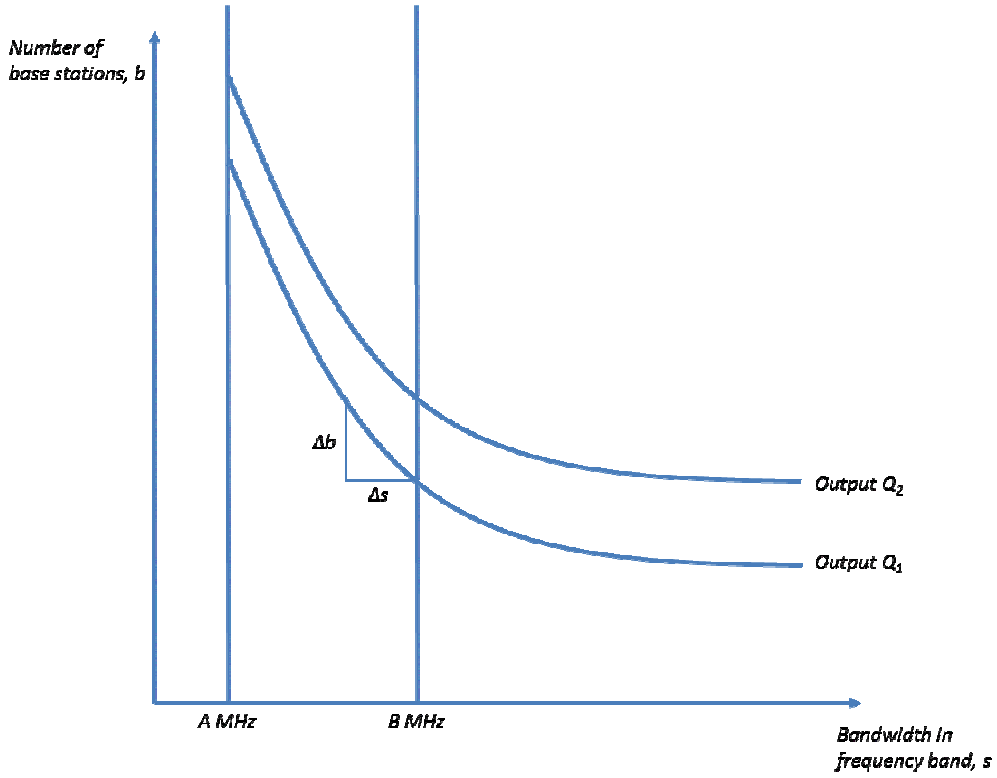

Figure 3. Trade-off between spectrum use and base stations in mobile telecommunications

Assume there is an absence of market data on spectrum prices. In this case it is necessary to apply a direct approach to estimating opportunity cost. This works by asking how much the network operator is willing to pay to retain (or acquire) a marginal unit of spectrum, denoted Δs in Figure 3. To answer this question meaningfully requires further assumptions. In particular it is assumed that output remains unchanged – meaning that the network operator obtains the same revenue.

The amount an operator is willing to pay for the marginal spectrum is equal to the profit it would forego (gain) from losing (acquiring) the marginal spectrum. As total revenue is unchanged, this is measured by the increase (decrease) in costs due to the need to use more (less) base stations to compensate for less (more) radio spectrum, shown as Δb in Figure 3. If we assume $\Delta s=1$ then we can write:[45]

[45] This equation can be interpreted as the opportunity cost of radio spectrum as long as the price of base stations is determined on a competitive market. In practice the market for radio communications equipment is regarded as competitive.

Value of marginal spectrum = Price of a base station x Δb

The calculation of the opportunity cost value of spectrum held by mobile network operators using a direct approach requires information about the factors influencing the price of base stations (and related equipment) and mobile phone network technologies. At a minimum the following information is required:

1. The production technologies of mobile network operators (production functions), current and expected
2. Demand forecasts for the different services supplied over the networks
3. Prices of base stations and related equipment, current and into the future
4. Discount rates (as the exercise is conducted taking account of the licence term)
5. Cost of capital
6. Expected innovations particularly in areas affecting spectral efficiency

The above informational requirements are considerable and involve much judgment about future values. Therefore the opportunity cost value will in practice comprise an expectation, or average, reflecting the range of plausible values for the many variables used in the computations. In practice the opportunity cost value of spectrum is an expectation:

Expected value of marginal spectrum = Expected price of a base station x Expected Δb

In an industry faced with on-going technological changes and changing demand, it will be no surprise that estimates of opportunity costs of spectrum based on a direct method will produce a wide range of values.[46] This uncertainty was highlighted by Plum Consulting (the consultants who advised ACMA on the opportunity cost spectrum pricing consultation) in a report written for the UK communications regulator Ofcom:[47]

"Although it is possible to model cellular spectrum value, the adequate capture of important value drivers requires complex models and a large number of input

[46] In other words the variance of the estimator is high.

[47] Page 7 in "*Estimating the commercial trading value of spectrum*", a report for Ofcom by Phillipa Marks, Ken Pearson, Brian Williamson, Paul Hansell, and John Burns, 2 July 2009 available at: http://www.plumconsulting.co.uk/pdfs/Plum_July09_Commercial_trading_value_of_spectrum.pdf.

assumptions….generic modelling of spectrum values for cellular mobile purposes will remain very uncertain and not indicative of specific circumstances."

Estimating the opportunity cost value of spectrum in this way is as much an art as a science. Considerable judgment needs to be applied regarding many technological and market variables, often stretching over many years into the future. As a result, estimation of opportunity cost spectrum values typically throw up a range of valuations. This was shown strikingly in the Plum Report 2008 for ACMA in an application of the LCA method to estimate the opportunity cost of spectrum in the 400MHz band:[48]

"The least cost alternative is therefore to move to narrowband equipment, implying an opportunity cost in the range $77-$989, with a value of $269 for a "typical" system."

The wide range of values given in the example above is typical and international experience is provided in the next chapter.

Faced with uncertainty over spectrum value, government has to choose a value from a range of estimates. Needless to say, this choice should be undertaken carefully and take full account of static and dynamic efficiency implications. In the next section I present arguments in favour of a conservative approach to the selection of a spectrum price based on a range of estimates derived from direct methods. The argument in favour of a conservative approach is based on efficiency considerations.

5.2 Choosing the right spectrum price: the need for a conservative approach

In the previous section I demonstrated that there is much uncertainty involved when estimating opportunity cost based spectrum prices. This unfortunately places government in a difficult position. If the wrong price is chosen, meaning it is too high or too low, inefficiencies will arise and it will deviate from the TWS. In this section I show the cost of inefficiencies are greater when the price is too high relative to when the price is too low. This leads to the recommendation that a *conservative approach* should be taken when setting opportunity cost based spectrum prices.

I start by showing that even in a simplified (though obviously unrealistic) case with no uses for radio spectrum other than mobile telecommunications; there are grounds for adopting a conservative approach to spectrum pricing. After discussing the simplified case I show the conservative pricing message is reinforced for the more realistic setting of many competing uses for radio spectrum frequency bands. This approach allows us to identify more clearly the different factors at work.

[48] Page 44, The Plum Report, *op cit.*

In Figure 4 I present a diagram with the number of base stations measured on the vertical axis and the per MHz price set for the frequency band in $ on the horizontal axis. In the figure are presented two response functions: these describe the relationship between the number of base stations installed by a mobile network operator and the spectrum price. The unconstrained response function applies to an operator that has previously not installed base stations (it could be a new entrant) and is deciding optimally the number to install given the spectrum price. It can be seen that as the price of spectrum rises the operator would choose to install more base stations, reflecting a substitution away from relatively expensive spectrum into relatively cheaper base stations. As the price of spectrum increases, demand for spectrum falls and demand for base stations rises.

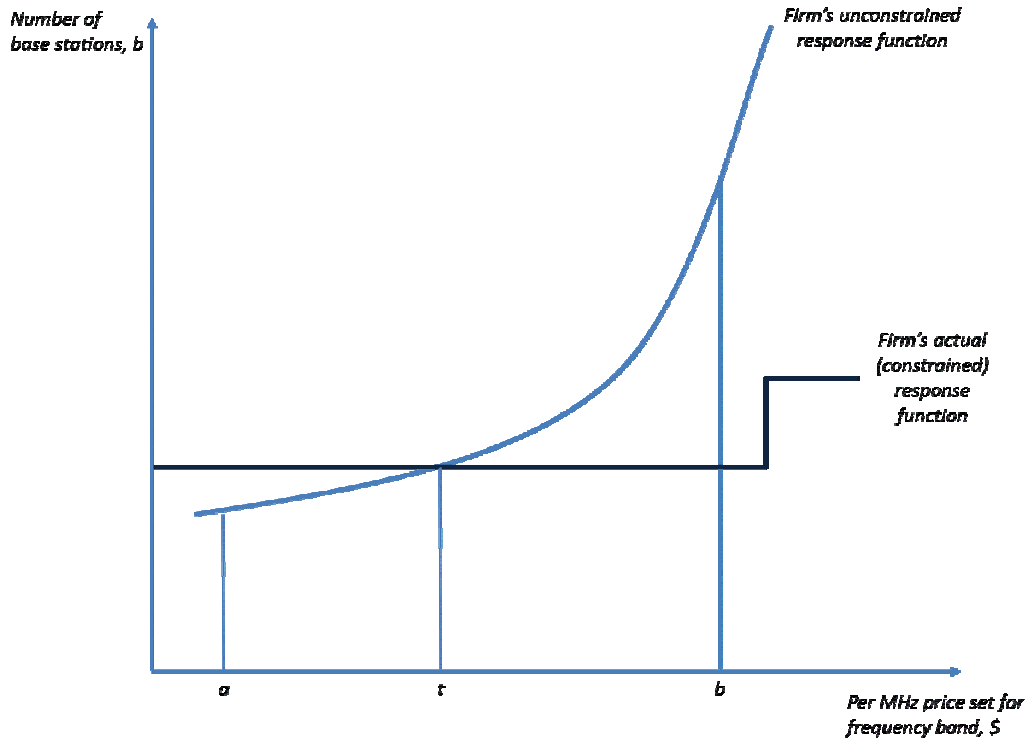

Figure 4. Response functions relating spectrum price and base stations in mobile telecommunications

The constrained response function applies to a mobile operator having an installed network and base stations, where the decisions on how many base stations to install were taken in the past. Having installed a network, the operator is constrained significantly with regard to re-configuring the network architecture and would face considerable adjustment costs. Hence an existing network operator has a response function that is much less

responsive (less elastic) than that for a green field entrant. In the figure the response is completely inelastic except at one relatively high spectrum price, where the firm would re-configure its network and choose to deploy additional base stations and lower its use of spectrum.[49]

In Figure 4 *a* and *b* are the lower and upper values respectively for the range of opportunity cost based spectrum value estimates in the simplified case. The value *t* is the unobservable 'true' opportunity cost value of spectrum. For any price set between *a* and *b* this will not have an effect on an existing firm's choice of inputs (amount of spectrum and number of base stations). The imposition of a spectrum price does have an effect on consumers, as it would raise the cost of production (by increasing the cost of spectrum) and there could be upward pressure applied to retail prices.

The effect is no different to an input tax – the spectrum price for the case of a constrained firm is like a tax and there is a cost-pass through effect tending to lead to higher retail prices. In a recent study looking at the effect of taxation on MBB (mobile broadband) investment it was concluded:[50]

"Private investment in ICT has a strong positive impact on growth and there is robust empirical evidence that suggest that taxation of mobile services appears to have a strong negative impact on the deployment of mobile broadband."

Australian mobile network operators have installed networks and thousands of basestations. Choosing a spectrum price towards the upper end of opportunity cost estimates will have a stronger negative impact on efficiency than choosing a spectrum price towards the lower end of estimates. Setting a price towards the lower end of estimates will tend to favour efficiency by not undermining incentives for investment and it will result in a lower cost-pass through effect on retail prices.

Thus far I have considered the estimation of opportunity cost based spectrum prices for mobile communications without taking explicit account of other possible uses for the spectrum, or of other frequency bands that may be used by mobile telecommunications. As I explained in the previous chapter, the

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[49] In Para 4.18 of *SRSP: The revised Framework for Spectrum Pricing Proposals following a review of our policy and practice of setting spectrum fees*, Ofcom consultation 29 March 2010, it is stated that LCA methods are based on long-term decisions: *"To estimate the opportunity cost of spectrum we currently primarily use the 'least cost alternative' (LCA) method. This involves estimating the value to an average user of a small additional block of spectrum in the band, in terms of avoided cost. This is generally based on a study of the cost of long-term alternative network designs or technology choices that would be made in response to a small reduction in spectrum held by a user. Importantly the LCA method looks at the choices that would be made in long-term, rather than short-term. In the short-term users' responses would usually be more limited and more costly."* The approach taken by Ofcom would appear to suggest that the unconstrained response function is considered – on a forward looking basis.

[50] Dr. Raul L. Katz, Dr. Ernesto Flores-Roux and Dr. Judith Mariscal (2010) "The Impact of Taxation on the Development of the Mobile Broadband Sector" for the GSM Association available at http://www.gsmamobilebroadband.com/upload/news/files/10082010145910.pdf.

correct approach to the calculation of opportunity cost based spectrum prices should take these alternatives into account.

Figure 5 illustrates estimates for the opportunity cost of spectrum in the 900MHz frequency band for two uses: mobile telecommunications and another use. In mobile telecommunications the estimate of opportunity cost is between *c* and *d*, and in the other use the estimate of opportunity cost is between *a* and *b*. Suppose that mobile telecommunications has the highest average value among all possible uses, and assume the other use is the second highest value.

In accordance with the theory presented in chapter 4, the correct spectrum price is between the unobservable true opportunity cost value in mobile telecommunications and the unobservable true opportunity cost value in the other use. Given competition in the output market for mobile telecommunications, this favours a conservative approach to the choice of the spectrum price. In Figure 5 I have suggested that a conservative approach should set a price between the lower estimate for mobile communications and the upper estimate for the other use.[51]

[51] I have considered the case where these two estimates do not overlap. If the upper estimate for the other use *b* were greater than the lower estimate for mobile telecommunications *c*, I recommend that the spectrum price should be set conservatively at *b*.

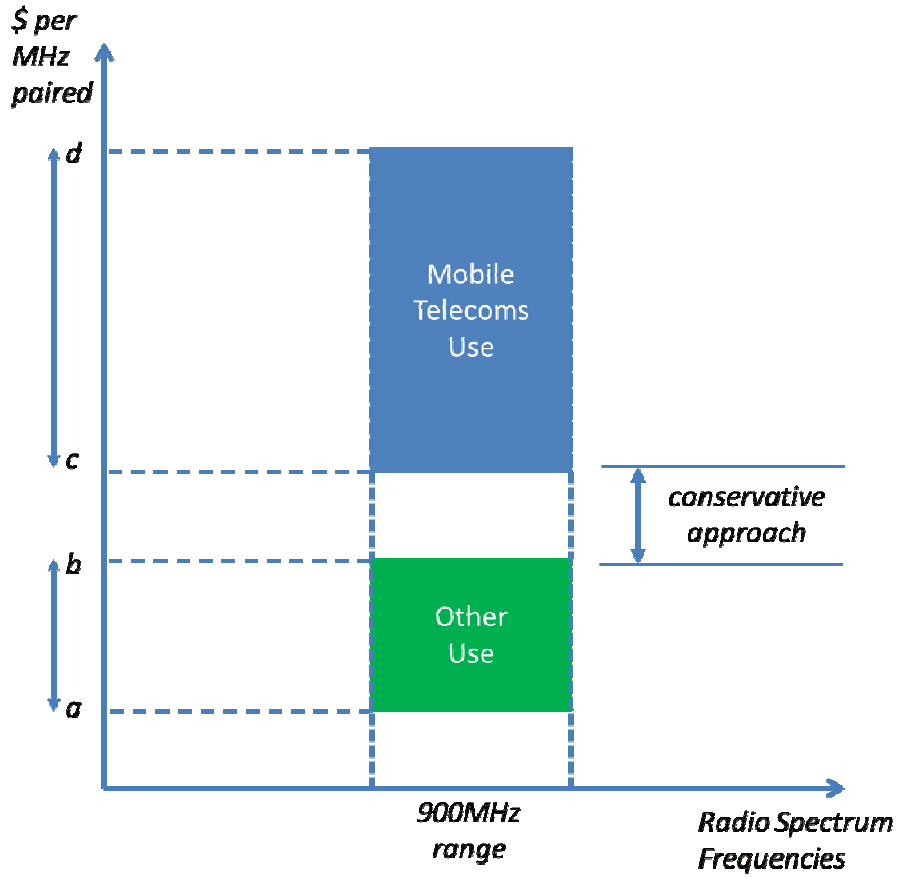

Figure 5. Hypothetical estimates of opportunity cost values for the 900MHz frequency band

In Figure 6 I illustrate a version of the conservative approach taking account of two uses and two frequency bands. Here I suggest that the best approach is to choose a price between the highest estimate of opportunity cost for the other use in the next best frequency band for mobile telecommunications and the lowest estimated value for mobile telecommunications in the same band.

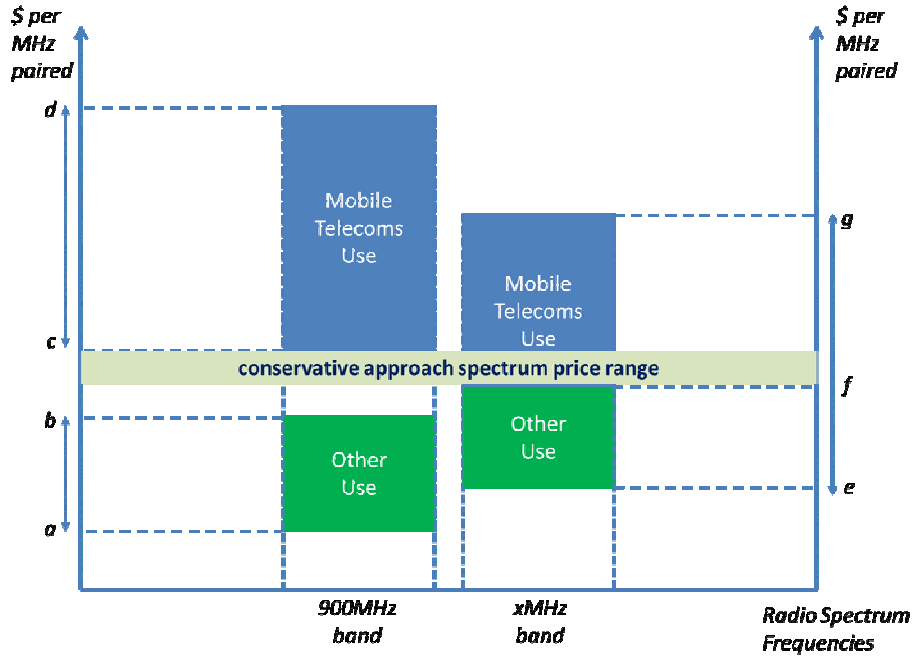

Figure 6. The conservative approach to setting an opportunity cost spectrum price with two uses and two frequency bands

5.3 Conclusion

The economic basis for the conservative approach was asserted in Cave *et al.* (2007):[52]

"Erring on the side of caution and approaching what economists term the socially optimal price(s) (resulting in the equalisation of marginal benefits) from below is better for welfare."

ACMA in its recent public consultation on opportunity cost spectrum pricing acknowledges that a *conservative approach* should apply in Australia:[53]

"If there is a price range within which to set price, setting prices too high will result in under-use of spectrum. Where there is doubt it is generally better for spectrum to be slightly underpriced…When trying to set a market-clearing price, setting a conservative price is recommended."

[52] Page 180 in Cave *et al. op cit.* This was also the message conveyed in the Indepen Report 2004.
[53] Page 22 in ACMA (2009) *op cit*.

In this chapter I have argued that there is an asymmetry in costs between setting the spectrum renewal price too high and setting it too low. Efficiency costs are expected to be greater by setting the price too high rather than too low. This supports the proposition that a conservative approach to setting spectrum prices is desirable.

6. International application of the conservative approach

Opportunity cost based spectrum prices have been applied in New Zealand and the UK and in both countries a conservative approach has been taken. In New Zealand opportunity cost pricing was applied on the renewal of cellular licences due to expire in 2012.[54] The renewal offers made were based on a price that was an estimate of the market value of the rights using an incremental deprival valuation (incremental ODV) approach. This was checked for reasonableness against New Zealand and overseas benchmark market data values.

The method in New Zealand resulted in a wide range of estimates for the value of a MHZ paired spectrum, from NZ$2.1m to NZ$7.8m.[55] The renewal offer price chosen by government was NZ$3.8m (excluding GST) per MHz pair for a 20 year term. This is closer to the lower end of the estimated values of the spectrum and indicates that the government in New Zealand was conservative in its approach.

The communications regulator Ofcom in the United Kingdom has much experience in estimating radio spectrum fees using opportunity cost methods. Ofcom is currently reviewing its opportunity cost radio spectrum fees which it calls AIP. In this review Ofcom makes clear that it has adopted an approach to setting fees based on AIP that errs on the side of caution:[56]

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[54] New Zealand applied what is termed the 'incremental' ODV method, which is very similar to the AIP method used in the UK. ODV is based on an evaluation of foregone value arising from depriving a user of some spectrum. It was first articulated in a report submitted to the New Zealand Ministry of Economic Development by consultants PwC-NZIER (see chapter 4 in Methodology for Pricing the Renewal of Spectrum Rights for Cellular Services) available at: http://www.rsm.govt.nz/cms/policy-and-planning/current-projects/radiocommunications/cellular-rights/past-consultation-and-documents/pwc-report-1. See also p.12 in *Renewal of Management Rights for Cellular Services*, MED Discussion Paper, July 2006 available at http://www.rsm.govt.nz/cms/pdf-library/policy-and-planning/radio-spectrum/rights-at-expiry/renewal-of-management-rights-for-cellular-services-discussion-paper-161-kb-pdf. AIP introduced in the United Kingdom in 1998 is an opportunity cost spectrum pricing technique which has been discussed in many workshops and proceedings internationally, see for example *Towards more flexible spectrum regulation: A Study* commissioned by the German Federal Network Agency (BNetzA) by J. Scott Marcus, WIK-Consult GmbH presented to the ITU New Initiatives Workshop: The Regulatory Environment for Future Mobile Multimedia Services, Mainz, June 21, 2006 available at http://www.itu.int/osg/spu/ni/multimobile/presentations/ITUscottmarcus.pdf.

[55] Consultants (Network Strategies) provided estimates of the cellular spectrum value to the NZ Government and gave a wide range lying between NZ$2.1m and NZ$7.8m for a MHz paired spectrum. See page i in Report for the Ministry of Economic Development *Renewal of Management Rights for Cellular Services (800/900MHz): Calculation of Renewal Prices*, Network Strategies Report 27019,13 November 2007 available at: http://www.rsm.govt.nz/cms/policy-and-planning/current-projects/radiocommunications/cellular-rights.

[56] Para 3.113 in Ofcom (2010) *op cit.*

"Our policy to date has been to err on the side of caution when setting AIP fees. In practice, this means that we have generally set AIP fees below our estimates of spectrum value. This is because we have taken the view that over-estimating the market price is likely to pose a greater risk than under-estimating it."

A conservative approach to the implementation of spectrum fees has featured in the UK ever since opportunity cost methods were introduced. Ofcom also adopts a wider assessment of opportunity cost spectrum values following reviews and consultations on spectrum pricing:[57]

"Ofcom has applied an amended methodology for determining AIP, setting each AIP fee in relation to both the value of the spectrum in existing uses and its value in other potential uses for each band. Thus, AIP will give incentives for spectrum to move to the most valuable uses. Ofcom believes that AIP should continue to be applied despite the introduction of spectrum trading, as AIP can continue to promote greater efficiency. Provided AIP fees are set conservatively, trading should not be impaired."

International practice of direct methods to estimate opportunity cost spectrum prices aimed at promoting efficiency have applied a conservative approach to the choice of price from the wide range of estimates presented. This was done with efficiency criteria in mind.

[57] Para 2.15 in *Modifications to Spectrum Pricing*, Statement, Ofcom 10 January 2007.

7. Conclusion

In February of this year the Minister for Broadband, Communications and the Digital Economy, Senator the Hon Stephen Conroy stated that the Australian Government will set a price for the renewal of spectrum licences currently held by mobile operators in Australia based on *scarcity and value*.

Given the economic principles enshrined in the law and the spectrum management principles, this should lead to the setting of spectrum prices based on the concept of opportunity cost. This has been known by Government since the Productivity Commission report on radiocommunications was published in 2002.

The methods that are used to estimate opportunity cost values of the radio spectrum will result in a wide range of estimates. The biggest challenge for Government will be selecting the best or right price from the range of estimates presented.

In this report I have argued for the adoption of a conservative approach in this selection process.

However, there is a worry in the current fiscal climate that government may be tempted to set a fee at the higher end of estimates. This would run the risk of inefficiency by causing scaled-back investment and higher customer prices for mobile services. The knock-on effect would pose a serious risk to digital productivity objectives.

In a World Bank (2005) publication the danger of setting renewal fees too high has been clearly set out:[58]

"A major concern when renewing a [spectrum] license in determining the renewal fee and the new recurring fees is that the fees do not result in negative impacts on sector development."

Setting a spectrum licence renewal fee for mobile telecommunications based on scarcity and value should be undertaken with economic efficiency as the overriding objective.

[58] "Mobile License Renewal: What are the Issues? What is at Stake?" by Boutheina Guermazi and Isabel Neto, June 2005, Global Information and Communication Technologies Department, The World Bank.

Abbreviations used in this report:

2G:	Second Generation mobile networks
3G:	Third Generation mobile networks
ACCC:	Australian Competition and Consumer Commission
ACMA:	Australian Communications and Media Authority
AMTA:	Australian Mobile Telecommunications Association
AUD:	Australian Dollar
CBD:	Central Business District
DBCDE:	Department of Broadband, Communications and the Digital Economy
EU:	European Union
FCC:	Federal Communications Commission
HSPA:	High Speed Packet Access
ITU:	International Telecommunication Union
LCA:	Least Cost Alternative
LTE:	Long Term Evolution
MBB:	Mobile Broadband
MTAS:	Mobile Terminating Access Service
ODV:	Optimal (or Optimised) Deprival Value
TWS:	Total Welfare Standard