Economic Impacts of Increased Flexibility and Liberalisation in European Spectrum Management

Report for

A Group of European communications sector companies

Prepared by

London Economics

April 2008

Contents

Page

Tables & Figures

Page

Executive Summary

Introduction

The wide range of uses, and the growing value, of the radio spectrum means that developing the most efficient spectrum management framework is of great economic importance.

Several forward-looking national authorities have already made significant steps towards allowing spectrum users more flexibility over spectrum usage (both in allocation and assignment of spectrum). Within Europe, the European Commission is currently in the process of developing a new regulatory framework based on the extension of the market-based approach.

Against this background, a debate has developed about the relative merits of liberalisation and harmonisation in spectrum management. Whilst this debate was originally stimulated by the work of Professor Martin Cave[1] the public debate has more recently tended to coalesce around two spectrum economics studies – one commissioned by the European Commission[2] and one commissioned by the UMTS Forum[3].

With this in mind, London Economics was commissioned by a group of European communications sector companies to carry out an independent review of the available evidence examining the costs and benefits of greater flexibility in the use of radio spectrum. This report sets out the findings of that review and is based on existing studies that examine the actual and potential impacts of spectrum liberalisation.

Key Findings

Further spectrum liberalisation is likely to be beneficial

Overall, the available evidence clearly suggests that there are potentially large benefits to be realised from further spectrum liberalisation. The evidence supports the proposition that a policy stance based on liberalisation is the most appropriate way forward for spectrum policy.

[1] Cave, M. (2002) "Review of Radio Spectrum Management: An Independent Review for the UK Department of Trade and Industry and HM Treasury", Ofcom, London.

[2] Analysys, DotEcon, Hogan and Hartson (2004) "Study on conditions and options in introducing secondary trading of radio spectrum in the European Community", May.

[3] Booz Allen Hamilton (2006) "Thriving in Harmony Frequency harmonisation: the better choice for Europe", A Study from the UMTS Forum.

A large majority of the existing studies indicates that there are significant benefits from liberalisation. Furthermore, those countries which have already moved to more flexible spectrum management systems have not encountered the negative impacts of harmful interference or spectrum hoarding that critics of spectrum liberalisation have predicted. In one US case, where harmful interference has been reported, it is suggested that this could have been avoided by a clearer allocation of property rights for spectrum.

One study, from the UMTS Forum, has argued that for that part of the spectrum which is used for wide area mobile communications, a harmonised approach is significantly more beneficial than a liberalised approach. However, a number of other studies which consider this part of the spectrum suggest that even here liberalisation is more likely to be beneficial in future.

Liberalisation policies need to be flexible

Whilst the evidence supports a policy based on liberalisation, the diverse nature of the spectrum means that policy needs to be flexible enough to accommodate those circumstances where some degree of harmonisation[4] may be necessary. Examples of this include spectrum for aviation, maritime communications and some military systems, though even in some of these areas harmonisation is becoming less important as technological developments allow more spectrum flexibility.

In addition it is not likely, for example, that the entire spectrum is suitable for license-exempt usage. Equally, the costs of making spectrum allocation service-neutral may outweigh the benefits for some types of use.

There is a need for continuing development of the evidence base

Despite the potential economic significance of spectrum liberalisation, there is remarkably little robust quantitative evidence, particularly ex post evidence, on the costs and benefits of spectrum liberalisation.

This may be because spectrum liberalisation is a relatively recent phenomenon in many countries, though evidence is limited even from countries with a longer track record. We believe that the absence of significant reported problems arising from liberalisation means that it has not attracted analysts' attention. The quantitative evidence that has been produced is based largely on ex ante simulations, with some limited information available with respect to ex post impacts.

[4] Here defined as the rigid coupling of a frequency band with a particular technology standard and market sector.

The Evidence

Costs and benefits of liberalisation and harmonisation

Overall, the existing evidence is supportive of reforms to implement a greater degree of spectrum liberalisation. Studies in those countries that have introduced greater flexibility have indicated benefits in competitiveness and lower consumer prices. These benefits arise because the market is able to more efficiently allocate spectrum resources between competing demands than a regulator.

Greater freedom for innovation is also frequently raised as a potential benefit from liberalisation. It is argued that the greater flexibility allows faster adjustment to consumer trends and product developments and that it enables easier access for firms to trial and launch new products. Opponents argue that harmonisation favours more innovation because it allows for faster diffusion of a particular technology and by creating a larger platform for service innovation. There is little clear evidence with which to resolve this debate. The Analysys study estimated large benefits in Europe from the effects of liberalisation on innovation, though the evidence base for these estimates is limited.

The potential for higher levels of radio interference is frequently cited as a negative effect from introducing technological neutrality, though in many cases in practice it has been controlled at an acceptable level by the clear assignment of property rights to spectrum users. Clear ground rules for limiting interference in radio-regulatory provisions and the development of modern digital signalling systems to reduce interference will also contribute to limiting the relevance of this issue.

Aside from interference, the other argument sometimes presented for the harmonisation of standards is that it allows regulators to pick "technology winners" and thereby achieve technology diffusion and economies of scale in production. As technologies become more and more complex, and as the likely reaction of the market to new technology becomes far less predictable, the task of picking "winners" becomes ever more difficult for regulators. Developments in technology mean that economies of scale arguments are becoming less important as equipment is able to access more than one spectrum band without significant cost penalties. Tri-band and quad-band mobile phone handsets, for example, have been available for some time and many expect software defined radio technologies to increase in importance quite rapidly.

Whilst the available evidence suggests that, in general, spectrum liberalisation will be beneficial, this broad conclusion does not mean that net benefits can be expected from unrestricted liberalisation, or that they are available in every area of the spectrum. The costs of making spectrum allocation service-neutral for some types of use may outweigh the benefits – where the spectrum is already very congested, for example. Equally, it is not likely that the entire spectrum is suitable for licence-exempt usage.

These considerations indicate that the achievement of significant net benefits from further liberalisation is dependent on ensuring that reform occurs in those areas where net benefits are likely to be greatest and by managing systems so as to avoid or minimise any potential harmful effects in other parts of the spectrum.

The evidence in relation to each of the three main elements of spectrum reform is summarised below.

Secondary Trading

There is a strong case in principle for the implementation of spectrum trading. Providing greater flexibility over who can use spectrum should lead to higher efficiency and benefit competition. Further, by liberalising access to spectrum, firms will be given incentives to innovate, and hence support competitiveness and productivity.

Despite the strong theoretical case, quantitative evidence on the effects of spectrum trading is scarce. Countries that have implemented trading, such as Australia and New Zealand, have seen identifiable benefits from trading and there are very few reported problems. Benefits include the creation of new services and the development of downstream competition. In those two countries the number of trades was modest due to local conditions and the specific nature of the trading systems that have been implemented. Levels of trading in the USA and Latin America have been higher. There are no robust ex post evaluations (either quantitative or qualitative) of trading regimes in Europe.

The evidence suggests that benefits from spectrum trading are achievable but that care needs to be taken in the design of trading systems in order to ensure benefits are realised.

Technology and Service Neutrality

The arguments over increasing flexibility of spectrum use are more complex than those over spectrum trading, and are more dependent on particular technologies and markets.

Making spectrum technology and service neutral would have many benefits, and would complement a spectrum trading system by incentivising innovation, reducing barriers to entry, and supporting competition. This is reflected in a number of estimates of the potential positive impacts of allowing more flexible use.

However, in contrast to secondary trading, there are potential downsides. In particular, changes of use could cause interference problems between technologies. These can be difficult to forecast or measure in advance. Nevertheless, experience suggests that a clear allocation of property rights can minimise the significance of this issue, as can technological developments over time. It has also been argued that liberalisation may lead to the loss of scale and network effects in comparison to imposing a technological standard. It seems clear that the mandated implementation of some standards, in particular the GSM standard, have achieved significant results in the past. Nevertheless, this may not be the case in future as new techniques and technology (such as software defined radio) develop and enable the achievement of scale economies by other means.

The evidence on liberalised systems in practice, particularly from South America, indicates that spectrum liberalisation leads to more competitive end product markets, and lower consumer prices. Further, the existing evidence from those countries that have moved towards technology and spectrum neutrality suggests that interference – one of the major concerns when liberalising spectrum – has not been a problem where property rights have been correctly defined. These results show that market-based spectrum management can be successful if carefully implemented.

The residual argument for harmonisation in Europe relies largely upon the example of GSM. However, this is unlikely to be representative of the majority of spectrum markets, which may not be large, international or have the same capability for economies of scale. In the words of one commentator "the myth of the success of GSM has hung over or intruded upon every administrative and commercial decision about spectrum or wireless services taken in Europe in the last fifteen years"(Sutherland, 2007). It is important to look beyond this in developing a management policy that applies across the entire spectrum. This is particularly the case as technologies become increasingly diverse and complex, making regulators' choice of "technological winners" ever more complex. As a result, this runs the risk of "lock-in" to inferior products and dampening innovative activity.

One of the studies we examined during the course of this review stands out from the crowd as it is the only one to provide estimates of significant negative impacts from liberalisation. The study was undertaken for the UMTS Forum (Booz Allen Hamilton, 2006) and focuses on the impacts of introducing technological and service neutrality. The main conclusion of the report can be summarised with the following two quotes from the report:

> *"In the wide area mobile communications scenarios analysed across the EU and worldwide, a harmonised spectrum use proposition provides the greatest overall benefit to consumers and also to industry"*

> *"The analysis is focused on wide area communications scenarios, and does not propose a one size fits all approach to spectrum management, recognising in other contexts different conclusions could be drawn"*

Essentially, the analysis is based on setting a number of assumptions (about losses in economies of scale, increased interference management costs, less competition and a more uncertain investment environment from liberalisation) and using a simulation model to translate those assumptions into negative impacts on consumers.

The evidential base for many of the input assumptions is not at all clear and so it is hard to judge whether they should be given any credence. The study also assumes that innovation is maximised under a policy of harmonisation as it leads to faster implementation and penetration of new technology. This contrasts with the findings of a number of other studies which suggest that mandatory GSM harmonisation is currently impeding the uptake of 3G technology as the spectrum allocated to GSM use cannot, under current harmonisation regulations, be used for 3G. An alternative set of input assumptions would certainly generate very different results from the simulation model.

License-exempt Spectrum

There has been a rapid growth in applications using licence-exempt spectrum. Quantitative assessments of the value of services that use license-exempt spectrum also show the important economic contribution of these services.

However, we are not aware of any quantitative studies that assess the impact of introducing licence-exempt access for spectrum that is currently subject to licensed access. There may well be potential for license-exempt access in other areas, however licensed spectrum is also likely to continue to play a part (particularly in wide area applications) in an optimal spectrum management system due to the problems associated with interference from potential over-entry into some markets.

While we have examined spectrum allocation and assignment decisions separately, some aspects of the two are interlinked. In particular, both act together to determine the impact of the spectrum management system on innovation. For instance, allowing new firms into the market (e.g. spectrum trading, license-exempt usage) will have little impact on innovation, if those firms are heavily constricted in the services they can provide. Similarly, technology and service neutrality alone may not support innovation without the competitive pressure created by opening up the spectrum to new entrants, or allowing incumbent users to move into new bands. As such, it is necessary to take a holistic view when examining any particular reform of spectrum management.

1 Introduction

In this report London Economics provide an independent review of the available evidence on the impacts of the liberalisation of spectrum management systems. The report reviews evidence on the impacts of three types of spectrum reform:

- the introduction of secondary trading of spectrum licenses;
- the removal of license restrictions relating to technology and service use; and
- the widening of license-exempt spectrum.

The review was undertaken in late 2007 and early 2008 under contract to a group of European communications sector companies. We were asked to assess the evidence on the economic benefits of increased flexibility and liberalisation (including unlicensed spectrum) in future European radio spectrum management, drawing both on case studies of countries where novel spectrum management policies have been introduced, and on existing studies that examine the impact of spectrum reform.

In Chapter 2, we review the nature of spectrum management systems and discuss the progress of spectrum reform in Europe and elsewhere.

In Chapter 3 we review the quantitative and qualitative evidence on the impact of spectrum liberalisation.

In Chapter 4 we provide our conclusions with respect to the impacts of spectrum liberalisation.

Annex 1 provides more detail on the path of spectrum reforms in Australia, New Zealand, the USA and the UK.

2 Spectrum Management Systems

2.1 Introduction

Radio spectrum has a wide range of uses, from mass market consumer industries (such as mobile telephony) to industry inputs (e.g. private mobile radios) and many public services (including defence). Within the last decade, demand for radio spectrum has dramatically increased due to new developments in broadcast and mobile communications technology. However, spectrum remains a scarce input, with limited amounts technically suitable for each application. Increasingly, many European countries face excess demand for their spectrum, particularly in areas such as mobile telephony and terrestrial broadcasting (Analysys et al., 2004).[5]

This growth in economic scarcity (where demand for spectrum exceeds the available supply) is due first to the fact that most radio equipment can operate over only a limited range of frequencies. Second, multiple applications cannot indiscriminately use the same bandwidth, as this may cause harmful interference for other spectrum users. As a result of these issues, and the consequent inability of the spectrum to support an unlimited usage, there is a need for management of the spectrum.

2.2 The role of spectrum management

Use of the spectrum generates significant economic benefits. Within the UK, it has been estimated that the net economic benefit amounts to some £42 billion per annum, up from £28 billion in 2002 (Europe Economics, 2006). Similarly, the value of spectrum within Europe has been estimated as representing EUR200 billion, or approaching 2.5% of GDP (Analysys et al., 2004). Consequently, inefficiencies in the management and use of spectrum could impose a significant cost on society. This makes the correct design of spectrum management systems of prime importance.

The finite nature of the spectrum resource means that it needs to be managed to ensure that higher value applications (including those with high public value) have access to spectrum, while preventing services from being overly affected by harmful interference (through separating transmissions sufficiently in terms of frequency, geography or time).

These competing goals can be split into three categories (Cave, 2002):

[5] Analysys and Mason (2005) have estimated that, in the UK, an additional 2.5 GHz of spectrum could be required to support commercial services below 15GHz by 2025.

- Economic efficiency: ensuring that spectrum is allocated to high value uses and users, with minimal transaction costs, both statically and over time;

- Technical efficiency: allowing intensive use of scarce spectrum, with strong interference limits and promoting the development of new spectrum-saving technology; and

- Public policy: Safeguarding the use of spectrum for public services (e.g. defence and emergency services) and ensuring spectrum use is consistent with Government policy goals and international obligations.

In seeking to achieve these aims, spectrum management systems must address two interrelated issues: the allocation of the spectrum, and its assignment. The allocation of the spectrum refers to *what* the spectrum is used for – ensuring the correct amount of spectrum is allocated to particular uses. The assignment of the spectrum refers to *who* the spectrum is used by and ensuring that users have the correct amount of spectrum.

Spectrum management has traditionally taken place at the national level (based on the idea that spectrum is a public resource). However, given that radio waves do not stop at national borders there is need for some international planning or coordination of spectrum usage. Globally this has been carried out by the International Telecommunications Union (ITU). There is also a growing EU level of involvement in spectrum management, through the European Commission (EC) and the European Conference of Postal and Telecommunications Administrations (CEPT).

2.2.1 Spectrum management systems

Spectrum management has generally been undertaken by national regulatory authorities, within the scope of international agreements. Under such a system both allocation and assignment are decided centrally, with little flexibility for spectrum users. The focus of these authorities has generally been technical efficiency, with regulators consisting mainly of engineers looking to optimise the technical use of spectrum.

This *command and control* approach is increasingly being challenged, as it is argued that the central regulatory approach is insufficiently flexible to cope with the vast acceleration in the growth of demand for spectrum seen in recent years. In particular, for optimal management of spectrum regulators require "detailed knowledge of supply and demand trends, technology developments, and the relative value to society of alternative services". This level of information is extremely difficult, if not impossible, to acquire and to maintain (Cave, 2002).

As a result of these problems, it is argued, the command and control approach will lead to a bias in favour of the status quo, reacting inflexibly to innovation and change. This results from incumbent users' tendency to over occupy spectrum (as they have few incentives to use it efficiently), and the difficulty in accurately forecasting either demand, or the potential interference caused by a new service (Cave, 2002).

Given these concerns, there has been increasing pressure in recent years to move towards more flexible systems of spectrum management with a greater emphasis on economic efficiency. In particular, two distinct approaches have been suggested:

- **Market mechanisms:** the spectrum is managed by the market, subject to license terms set by the spectrum regulator; and
- **Commons model**: where nobody controls the use of the spectrum.

Clearly, both approaches involve reducing the powers of the regulator. However, they differ crucially in their treatment of the spectrum as a resource. Market-based approaches assign property rights over use of the spectrum to users (through licenses), whereas the commons model involves no property rights in the use of spectrum. This assignment of property rights allows the development of a secondary market (whereby usage rights can be sold and bought by users).

In addition to these assignment decisions, in each case regulators also have to decide how much freedom to allow users over the choice of services they provide and the equipment they use. Where usage rights contain no restriction on each of these, they are *service neutral* and *technology neutral* respectively.

2.2.2 Liberalising spectrum management

In practice, both market and commons approaches involve a range of potential policies, with varying degrees of control given up to users (from the regulator). Even license-exempt models, for instance, often involve restrictions on the type of service that can be offered or power restrictions on that service. Deciding on how much control to give up in favour of market mechanisms in dealing with these tasks is a complex issue and requires the qualitative and – data permitting – the quantitative assessment of various scenarios.

Clearly, moves away from command and control towards market mechanisms do not occur in leaps, and are based upon several smaller reforms. In particular, three major areas of reform can be identified:

Secondary trading: the development of secondary markets in spectrum licenses, in which spectrum usage rights can be transferred between firms.[6]

Spectrum allocation liberalisation: allowing spectrum users greater freedom over which services to produce and the technologies they use.[7]

License-exempt spectrum: allowing areas of spectrum to be utilised by an unlimited number of users, generally with restrictions over technology and services.

2.3 European spectrum management

European spectrum management resides largely with individual spectrum management authorities at the level of the Member States. However, there is a growing recognition of the role the EU plays in coordinating spectrum management policies. Historically, this has focused on the harmonisation of services within frequency bands, but increasingly, the EU is looking to drive moves towards more flexible use of spectrum across Europe.

2.3.1 European Union legislation

The EU[8] does not itself have any spectrum to manage, but plays an important role in coordinating regulation at Member State level. The Commission's role encompasses four particular goals:

- ensure co-ordination of radio spectrum policy approaches;
- ensure harmonised conditions for the availability and efficient use of radio spectrum in particular to support specific Community policies;
- support the provision of relevant information on spectrum usage; and
- co-ordinate Community interests in international negotiations in relation to existing EU policies such as in electronic communications, transport, R&D or broadcasting.

[6] Note that this is only relevant under a market-based approach to spectrum, as under license-exempt systems there are no property rights to be traded. Spectrum trading can occur in various forms, including "sales", "leases", and "frequency pooling". We do not distinguish between different effects of different forms of trades in this report.

[7] This is in contrast to standardisation, where services and technologies are specified.

[8] Spectrum policy at the EU level is developed by the European Commission with the expert assistance of the CEPT.

Spectrum management at EU level is based upon the electronic communications regulatory framework[9] and the Radio Spectrum Policy Decision (RSD)[10].

The European Union spectrum management infrastructure consists of two major bodies: the Radio Spectrum Committee (RSC) and the Radio Spectrum Policy Group (RSPG). The RSC is a committee of the 27 Member States chaired by the commission, and is primarily concerned with the development of technical implementation measures for the harmonisation of spectrum use.

The role of the RSPG is to develop high-level strategic radio spectrum policy and to assist and advise the Commission on a broader range of policy measures than the technical issues covered by the RSC. The RSPG is composed of representatives from the Member States and the Director General of DG Information Society, and elects its own Chair.

Spectrum management at the European level receives expert assistance from the European Conference of Postal and Telecommunications Administrations (CEPT). CEPT currently has 46 members, including all the EU Member States. The basic aim of CEPT is to strengthen the relations between its members, to promote their cooperation and to contribute to the creation of a dynamic market in the field of European posts and communications.

The Commission and CEPT interact in several ways. The Commission works closely with CEPT's European Communications Committee (ECC) in respect of radio spectrum matters. The Commission also has a close working relationship with ERO (the European Radiocommunications Office) which assists CEPT and supports the work of ECC. CEPT is observer to both the RSPG and the RSC. In particular, the RSD empowers the Commission to mandate CEPT to develop technical solutions for the harmonisation of spectrum use, which can then be made legally binding through technical implementation measures.

The existing regulatory framework includes several principles supporting a move away from the traditional command and control approach, including technology neutrality, allowing exclusive rights to spectrum only as an exception and allowing Member States to introduce spectrum trading. However, although several Member States have made moves towards liberalising their spectrum management systems (discussed further below), the Commission has found that "current practice does not seem to reflect

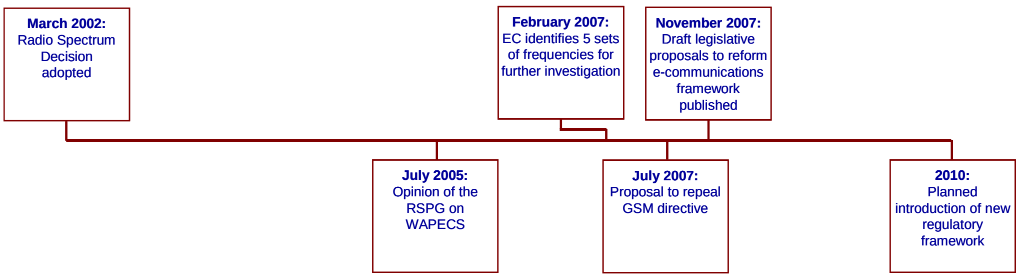
[9] The current framework comprises five directives: the Framework Directive (2002/21/EC), the Access Directive (2002/19/EC), the Authorisation Directive (2002/22/EC), the Universal Service Directive (2002/22/EC) and e-Privacy Directive (2002/58/EC).

[10] Decision No 676/2002/EC of the European Parliament and the Council of 7 March 2002 on regulatory framework for radio spectrum policy in the European Community (Radio Spectrum Decision), L 108/1.

these general principles, no coherent application is ensured and most bands are systematically subject to individual rights”.[11]

In response to these problems, there has been continued discussion about reform of the regulatory set-up, including a combination of legislation, policy documents and planned initiatives. The major recent and planned changes in the EU regulatory framework are summarised in Figure 1.

Figure 1: Timeline of EU spectrum liberalisation



The European Commission has continued to push for a more flexible spectrum management regime, together with greater European coordination of spectrum management approaches. The general principles for further reform were set out in two 2005 communications, and have been embedded in the WAPECS concept.[12] In 2007, the European Parliament responded to these communications in stating that “the European Union needs to adopt a sustainable approach to spectrum which will promote competition and the development of innovative technologies, inhibit the hoarding of frequency rights and the aggregation of monopolies and benefit consumers”. Further, the Parliament also endorsed the need for technology and service neutrality, and welcomes the move to a more market-based approach, alongside unlicensed and administrative spectrum management models.[13]

The Commission has also continued to make practical steps towards liberalising the spectrum, and in February 2007 identified five sets[14] of

[11] Commission Staff Working Document (2007), Impact Assessment, Accompanying document to COM(2007)697, COM(2007)698, COM(2007)699, SEC(2007)1473.

[12] The Wireless Access Policy for Electronic Communications Services (WAPECS) framework seeks to establish a more flexile use of the European spectrum to facilitate economic efficiency.

[13] EP Resolution of 14 February 2007, “Towards a European Policy on the Radio Spectrum”, (P6_TA-PROV(2007)0041).

[14] Including 470-862 MHz; 880-915 MHz / 925-960 MHz as well as 1710-1785 MHz / 1805-1880 MHz; 1900-1980 MHz / 2010-2025 MHz / 2110-2170 MHz; 2500-2690 MHz (the 2.6 GHz band); and 3.4-3.8 GHz.

frequency bands to be investigated further with a view to allowing more flexibility of use.[15] This has led to the proposal, made in July 2007, to repeal the GSM directive. This ongoing programme is incorporated in the Commission's draft legislative proposals regarding reforms to the e-communications framework, adopted in November 2007. Several proposed amendments have been made in relation to spectrum management, including:

- **Unlicensed use:** to require clear justification for the granting of exclusive spectrum license rights (i.e. that interference management could not occur in any other way);

- **Reinforce the principle of technology neutrality, and introduce service neutrality:** Owners of usage rights would have the ability to operate in any usage band and operate any service, subject to certain justifications (such as interference management);

- **Progressive introduction of spectrum trading in specified bands:** Allow buying and selling of spectrum licenses in certain bands across the EU; and

- **EU coordination:** the three areas above will be implemented through strengthened co-ordination mechanisms, as opposed to voluntary co-ordination under the existing framework.

These proposals will now be considered by the relevant European institutions, with the Commission hopeful that the revised framework could be in force by 2010.

2.3.2 National spectrum management

Although the EU is looking to impose greater coordination on Member States, currently a wide range of policies are being pursued across Europe. In general, spectrum management within the EU has been slowly moving towards a more flexible strategy, but the pace at which this has occurred has varied widely.

Following the implementation of the EU regulatory framework in 2003 several Member States have moved towards introducing secondary trading. By 2004, 10 Member States had included trading in their national legislation, while a further 3 felt it was likely that they would do so (Analysys et al., 2004). Those countries considering allowing spectrum liberalisation and

[15] COM (2007) 50 "Rapid Access To Spectrum For Wireless Electronic Communications Services Through More Flexibility".

trading include the Czech Republic, Denmark, France, Netherlands and Sweden (Ovum et al., 2006).

Although this indicates that Member States are moving towards more flexible forms of spectrum management, the extent of reform varies widely. For instance, although secondary trading in spectrum rights is fully permitted in the Netherlands, the national regulatory authority must give permission for any transfer (although in principle these will always be granted). Spectrum license conditions are imposed, and remain in place upon transfer; with license holders able to submit a request to change the conditions.[16]

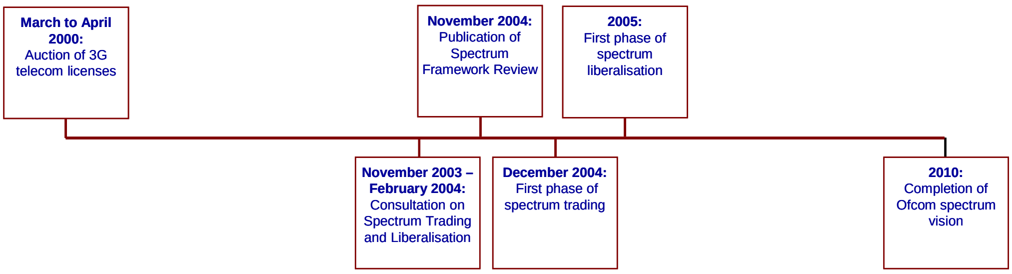
In the UK, on the other hand, there has been an emphasis on the formulation of detailed regulations, following extensive consultation. Trading was implemented in December 2004, with all applicable licenses to be tradable by 2007. In total, it is intended that up to 72% of the spectrum will be liberalised, in addition to 7% license-exempt. A timeline of progress within the UK is produced below.

The UK is currently undergoing a consultation on a wide range of proposals to change arrangements for license-exemption. These include measures to permit the use of a range of new technologies and novel applications of radio (including building material analysis devices and high density application in the Fixed Satellite Service) as well as measures to harmonise with Europe, and to simplify the regulatory process.[17]

[16] Based on the Netherlands' response to the European Commission's proposals for reviewing the EU regulatory framework for electronic communications. Available at http://ec.europa.eu/information_society/policy/ecomm/doc/info_centre/public_consult/review_2/comments.

[17] Further information on spectrum management in the UK is provided in Annex 1.

Figure 2: Timeline of UK spectrum liberalisation



In addition to these formal systems, Analysys et al. (2004) report that several European regulators have allowed informal license trades.[18] In some countries (Malta, Norway and the UK) requests were extremely frequent (up to thousands per year). Similarly, change of use requests were sometimes granted, although less frequently than transfers.

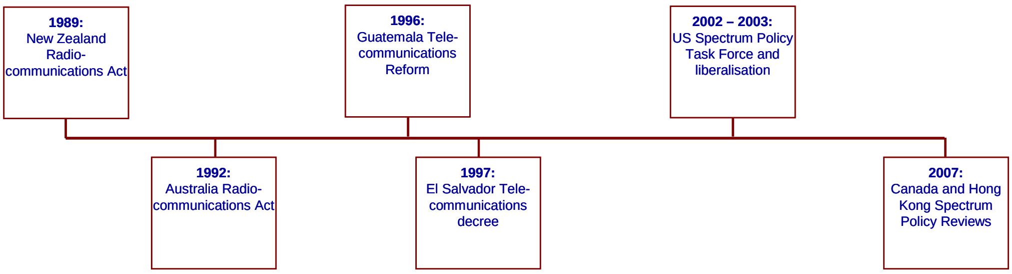
2.4 Spectrum management outside Europe

Until recently, spectrum trading and liberalisation has largely occurred outside of Europe, although only in a very few countries. Having been pioneered by Australia and New Zealand in the early 1990s, spectrum reform has since been taken up elsewhere, notably in the US and Guatemala. More countries are in the process of implementing market based systems, with both Canada and Hong Kong recently undergoing reviews of their spectrum policy. Figure 3 summarises the major developments outside of the EU.[19]

[18] Although rights cannot be directly be transferred between users, management authorities have reassigned rights based on requests of the initial and new users, with (generally) no knowledge of whether a payment has occurred.

[19] Further information about spectrum management in New Zealand, Australia and the USA is provided in Annex 1.

Figure 3: Timeline of spectrum liberalisation outside the EU



The policies followed by different countries have varied significantly, according to the type of licenses issued, the area they cover, the time period assigned to them, and the degree of spectrum liberalised.

New Zealand

New Zealand was the first country to implement secondary trading of licenses, following the 1989 Radiocommunications Act. Around 30% of spectrum is fully tradable, which is currently unlikely to increase significantly (Marcus et al., 2005).

Tradable spectrum rights in New Zealand are split into two tiers:

- *Spectrum Management Rights* (the upper tier) provides unrestricted uses over a nationwide block of spectrum. This can either be government held, or transferred to private entities. Managers have the sole authority to assign *spectrum licenses* within that block; and

- *Spectrum Licenses* (lower tier) are fully tradable, but may specify conditions of use (determined by the manager).

As of February 2004, 91 management rights existed, 15 of which were retained by the government (DotEcon et al., 2006). Interference between different bands is managed through limits on emissions on adjacent bands.

Collective use in New Zealand is operated around General User Licenses (GULs). GULs are available for certain applications, including low power FM broadcasting, cordless telephones, Wireless LANs (WLANs), radio frequency identification devices, medical telemetry, low power audio senders and ultra wideband applications.

Australia

Following reforms in the early 1990s, all spectrum licenses in Australia became tradable.[20] Individual licenses are split into two types:

- *Spectrum licenses:* these are tradable, technology and service neutral (within the scope of international agreements and emissions limits) with a non-renewable term of 15 years. Spectrum is split into commodity blocks based on geographical area and bandwidth, and can be "stacked" horizontally or vertically.

- *Apparatus licenses:* Apparatus licenses correspond to the old "command and control" licenses, with restrictions on site, service and technology. However, they are tradable, although this relies upon regulatory approval. The majority (around 70% of spectrum) is covered by apparatus licenses.

Collective use spectrum in Australia is managed through class licenses, which provide "public parks" for the authorised use of various low powered devices. Examples include garage door openers, remote car door locks and intruder alarms, wireless microphones, automatic tollway systems and tag security systems. Class licensing has also been used to implement WLANs and expand other computing applications.

United States

Trading in spectrum licenses has been allowed in the US for several years but, prior to recent reforms, required Federal Communications Commission (FCC) approval. Since 2002, the FCC has been promoting secondary markets, speeding up processes, authorising spectrum-leasing arrangements for most users and seeking advice on further improvements. In addition, there is an increasing movement towards the use of license-exempt spectrum (Hazlett and Spitzer, 2006).

Licenses are valid for ten years and allow users to lease some or all of their spectrum, but without losing legal or working control over the spectrum. Service and technology in each bandwidth is decided on a case by case basis.

The US has a variety of collective use regimes, with a number of levels of restrictions on usage and technology. There is continued support for the growth of unlicensed spectrum in the US and, in 2006 the FCC proposed allowing low power devices to operate in unused areas of the broadcast television spectrum, subject to testing.

[20] With the exception of *class licenses* which are not issued to individual users, but set out the conditions for use of unlicensed spectrum.

Guatemala

Spectrum management in Guatemala is extremely liberal, with the whole spectrum allocated according to a tradable property right system (with the exception of frequencies reserved for government and amateurs) since the reforms of 1996. Any individual is able to request a TUF (usage title) for any unallocated frequency, with any clashes settled through auctions. TUFs operate as security certificates, with specifications over the frequency, hours of operation, maximum power (total and at the border of other frequencies) and geographic coverage. Over 5,000 TUFs were issued between 1996 and 2002. Licenses are generally issued for fifteen years, with the potential to renew for a further fifteen (without any fee).

There appear to be no license-exempt bands for low power transmitters in Guatemala (Marcus et al., 2005) and relative concentrations of ownership mean that it is likely to be difficult for the State to buy back the relevant bands, if it wishes.

El Salvador

Spectrum management within El Salvador is also strongly based on property rights, with few limitations on what spectrum owners can do.[21] The current system is based on the 1997 Ley General de Telecomunicaciones. Under the existing framework, concessions are granted for 20 years, and are transferable and sub-dividable (according to frequency, geography and time dimensions) without any need for regulatory approval. Similarly, rights holders have the right to choose technologies, and can deviate from the National Table of Frequency Allocation (NTFA) without any penalty.

The process for resolving interference is not as well-defined in El Salvador as it is in Guatemala and there is no specification of how users may bring a complaint (Hazlett et al., 2006a). The regulatory authority has responsibility and severe fines are levied for the unauthorised use of "regulated" (i.e., commercial) or official spectrum bands. Despite this lack of infrastructure, little or no illegal interference problems have been experienced in the mobile telephony sector (Hazlett et al., 2006a).

[21] The overview of the El Salvador system is drawn largely from Hazlett and Munoz (2006b).

3 The Benefits from Liberalisation

3.1 Introduction

In this section we provide an overview and categorisation of the existing evidence relating to the costs and benefits of each of the most common spectrum management reforms:

- secondary trading;
- introducing technology and service neutrality; and
- license-exempt spectrum.

For ease of exposition, we have analysed each of these potential reforms separately. This helps identify the key drivers of costs and benefits, and helps avoid the confusion over different policies that is often found in analyses of spectrum management systems. The analysis in this section is provided within the context that these reforms are not independent, and act together in shaping spectrum management outcomes.

We have categorised costs and benefits for each reform into four areas: efficiency, technology/innovation, competition and regulation. For each reform we provide a qualitative discussion of the costs and benefits of liberalisation that have been identified, followed by an overview of the existing evidence about the extent to which these effects have been observed in practice.

Table 1 summarises the major studies that have estimated the economic costs and benefits of liberalisation across the spectrum.

Table 1: Major studies investigating the costs and benefits of spectrum liberalisation

Study	Description	Key results
Analysys et al. (2004)	Estimates the costs and benefits of 3 spectrum management approaches across the EEA against the status quo: trading only, trading and liberalisation, restrict liberalisation	- Net benefits of EUR8-9 billion p.a. from trading + liberalisation - Compares to net benefits of EUR 900 million from trading only - 30%-40% of benefits derived from pan-European coordination
Booz Allen Hamilton (2006)	Investigates harmonisation vs. liberalisation in the EU-15 wide area mobile communications sector using a simulation model	- Liberalisation leads to: - cumulative loss of consumer welfare of EUR 244 billion over 15 years - lower market penetration and higher consumer revenue
Indepen and Aegis (2004)	Examines impact of European standardisation in the UK through a series of case studies	- GSM harmonisation provided benefits of £876-5,774m - In future GSM standard may be harmful if it slows 3G rollout
Hazlett and Munoz (2006a)	Econometric analysis of increasing amount of spectrum allocated to mobile telephony in 29 wireless telephone markets	- Greater spectrum allocation associated with lower retail prices
Pratt and Bellis (2006)	Estimate potential benefits from refarming the 2G spectrum to 3G at EU level	- Annual consumer benefit of EUR 2.9 billion p.a. - Equivalent to EUR 6 per capita
Farge et al. (2007)	Compare economic impact of using digital dividend for broadcasting or mobile sector	- Allocating spectrum to mobile telephony could bring additional GDP growth of 0.6% p.a. by 2020
SCF Associates (2006)	Econometric model of 3 different options for EU spectrum management: secondary trading with bands of unlicensed use; secondary trading without unlicensed use; no European coordination	- Incorporating unlicensed bands leads to higher GDP growth and higher GDP/head development - Based on opening up market and creating competition
Ofcom (2007b)	Analyse effects of liberalising the mobile telephony spectrum in the UK	- Cost-saving per operator of £1.25 billion from allowing 3G in 2G spectrum - Costs of reduced competition: – total welfare cost of £1.1 billion in allocative inefficiency - £570 million loss from dynamic inefficiency

3.2 Secondary trading

3.2.1 Costs and benefits

Efficiency gains / market failure

The most frequently cited argument in support of spectrum trading is that it will result in substantial efficiency gains. This can be split into two distinct (although interlinked) categories: the efficient assignment of spectrum and the efficient use of spectrum (encompassing both static and dynamic efficiencies).

Secondary trading will allow the optimal assignment of spectrum by allowing the most efficient firms access to the amount of spectrum they require. Firms have more information over the value they place on spectrum than the regulator and under a market system those with the highest value will be able to outbid and hence displace other firms. In a market that is also technology / service neutral, this will allow the highest value services to displace lower value ones – this is discussed further below.

Markets will lead to the efficient use of spectrum, in a static sense, as the ability to sell usage rights exposes firms to the opportunity costs of holding spectrum rights. As a result, firms will either operate efficiently, or sell to a firm that can. Static efficiency will also be enabled by increased transparency within a market system – firms (both existing and potential competitors) will be able to see how valuable spectrum is, and design their activities appropriately.

As well as these static gains, spectrum trading can also provide the opportunity for dynamic benefits both through increased innovation (discussed below) and more rapid adjustments to shifts in market demand and technology. Again, these effects are based upon the assumption that firms possess greater knowledge of market developments than regulators and are able to adjust accordingly. Further, in a market system, those firms that are unable to adjust will be able to sell to newer, more up-to-date companies without waiting for regulatory approval, as under command and control.

There is a potential for market failure in secondary trading. In particular, if the market is unrestricted, issues of social concern may not be priced into trades. For instance, public service broadcasters may be outbid in the market although they may have greater social value than other users. Similarly, as pointed out by Valletti (2001) several existing licenses contain "rollout" obligations which may be lost with the development of trading. One alternative would be to attempt to disentangle many of these requirements from licenses – for instance through explicit subsidies (Valletti, 2001).

Once it is accepted that unrestricted trading is inappropriate for the entire spectrum – to protect public services such as defence, a further problem is to correctly assign spectrum to such purposes. Without a market, correctly assessing the value that should be placed on such uses is difficult. Administrative Incentive Pricing (AIP) is used by some regulators as an instrument to promote efficient spectrum use where markets are not introduced.

Technology / Innovation

Spectrum trading systems are expected to lead to faster development of new technologies, as innovative firms find it easier to access the spectrum than under a command and control system. With a trading system in place, innovators will be able to access the market if they have sufficient funds. This certainty creates incentives for innovation whereas, by contrast, under a command and control system regulators may refuse to let new products/firms on to the spectrum.[22]

Competition

The introduction of secondary trading is anticipated to act as a stimulant to competition. Introducing trading reduces barriers to entry, and allows new entrants into markets for applications using spectrum. The increased competitive pressure will force incumbents to reduce costs and pass the savings onto consumers.

These positive effects may be constrained if spectrum users have the opportunity to "hoard" spectrum, and hence gain market power. The incentives to hoard spectrum are reduced if spectrum is liberalised since liberalisation provides companies with a wider range of opportunities to profitably use spectrum. Thus combining secondary trading and wider liberalisation increases the potential for competition benefits from secondary trading.

[22] Clearly these benefits are also linked to the degree of liberalisation in the spectrum (discussed further below). If technologies and services are severely restricted then these effects may not apply even with secondary trading in place.

Regulatory

It is difficult to assess the effect of secondary trading on regulatory costs. Clearly, the creation of spectrum trading will have costs for regulators due to the need to set up, and administer, the associated system. In particular, there will be a need for a detailed register of trades and other information to ensure that the market is transparent, as well as to prevent spectrum hoarding. However, where the spectrum is liberalised, the regulatory burden may be reduced, as government no longer has responsibility for making complex decisions over optimal allocation and assignment of spectrum – these will be made by the market instead (Lichtenberger, 2003).

3.2.2 Existing evidence

The qualitative discussion above suggests that the overall effects of developing secondary trading in spectrum are likely to be positive. Large benefits could be achieved through the development of new technology as well as improvements in static efficiency. The major costs are likely to be regulatory and the fact that certain valuable services (e.g. public sector broadcasting) may be eroded, as their true value is not represented in the market.

However, there is little evidence on whether these predicted effects have occurred in practice. Although several spectrum trading schemes have existed for a number of years (as outlined in the previous section), there have been no major ex post evaluations.

Given the lack of evaluation evidence, existing studies can be split into three categories: ex ante assessments of the potential value of implementing secondary trading, existing evidence on the operation of current secondary trading systems and some indication of benefits, and evidence on the effectiveness of trading systems in other sectors (particularly pollution).

Ex ante quantitative assessments

Several studies have estimated the potential impacts of allowing secondary trading of spectrum, based on the anticipated efficiency, competition, and (in one case) innovation gains, as well as the potential increase in regulatory and interference management costs. These have all indicated that spectrum trading would bring net benefits.

The major existing study, commissioned by the European Commission, assesses the impact of imposing secondary trading throughout the European Economic Area for the areas of spectrum trading most suitable for secondary trading.[23] (Analysys et al., 2004). This estimates the costs and benefits from spectrum trading in four ways:

- **Static Efficiency:** The welfare gains are estimated based on the expected number of trades under a trading system.
- **Competition:** Net change in consumer surplus based on estimated price decrease of 4%.
- **Innovation:** Increase in consumer surplus from faster diffusion of new technology.
- **Costs:** Includes administrative and interference management costs, based on the expected number of trades.

The study considers three different options for European spectrum management: "trading only", "trading and liberalisation" and "restrict liberalisation". The estimated net benefits for the "trading only" case are significant, as indicated in Figure 4.[24]

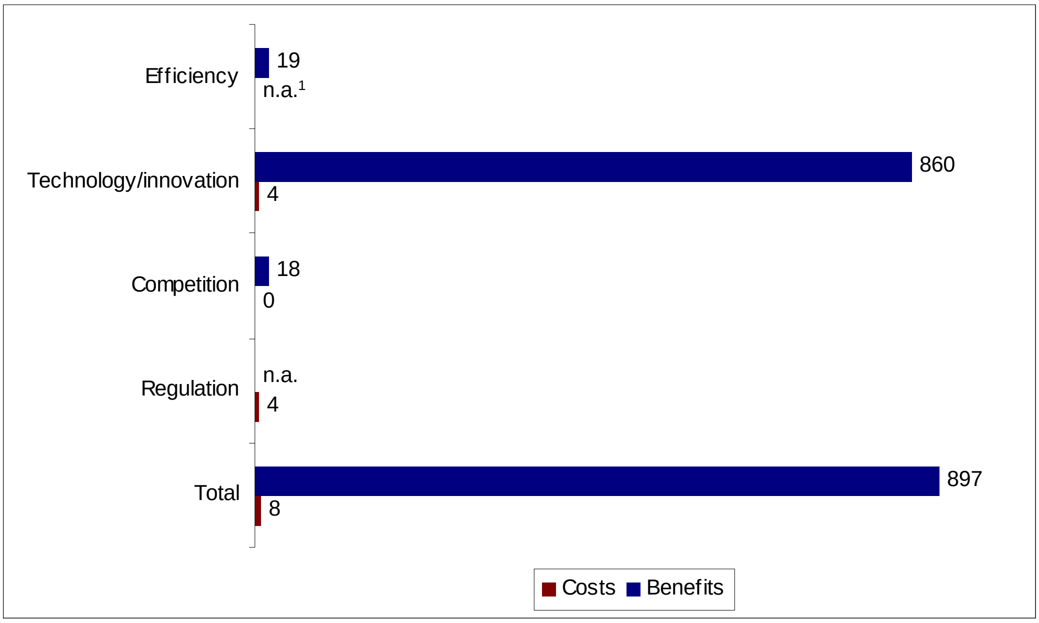
While these results are based on a series of "inevitably speculative" assumptions, and so should be treated as indicative assessments, they provide a useful indication of the likely sources of benefits from trading. Interestingly, by far the largest predicted benefit from spectrum trading system is estimated to result from greater innovation, rather than the initial static efficiency gains.

Notably also, the estimates are relative to the status quo in Europe at the time of the study (rather than a situation in which no trading was in place), and hence assumes that imposing spectrum trading on the entire European Community would lead to only a few additional Member States (accounting for only 10.7% of European GDP) being subject to a trading regime.

[23] The bands include: land mobile PMR, fixed links, fixed wireless access, land mobile public and broadcasting terrestrial.

[24] The results for the other two cases are discussed in section 3.2 below

Figure 4: Costs and benefits of spectrum trading in the EEA (EUR million per annum)



[1] These include "other national policy goals", which are unquantifiable due to their largely political nature. For instance, a desire to assign spectrum free-of-charge, or support a particular industry.

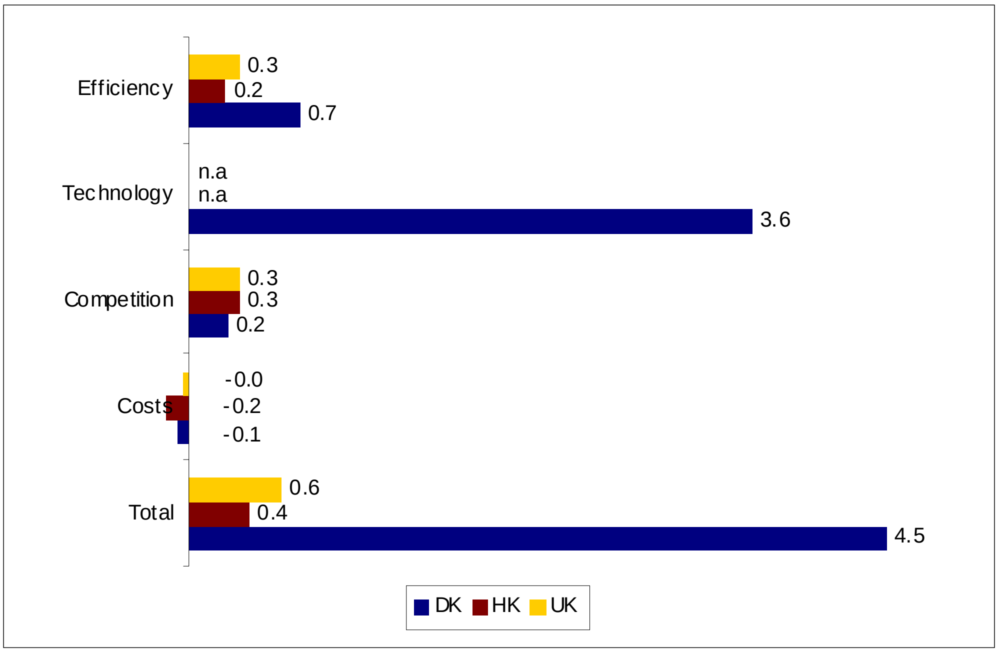
Source: Analysys et al. (2004)

In addition to this estimate based on the impact of secondary trading across the EEA, a number of similar studies have focused on individual countries. The results of these are reported in Figure 5.

Each of the results indicates positive net effects from the introduction of a spectrum trading system, similarly to Analysys et al. (2004). This is not surprising however, as each of the studies are based not only on similar methodologies, but also similar assumptions.[25] The main difference between the studies is that only the Danish estimate (which is based on the same methodology as Analysys et al. (2004)) incorporates any estimate of the size of innovation benefits, which constitutes the major portion of the estimated benefits.

[25] The Hong Kong study, in particular, is a rescaling of the UK results (based on the ratio of GDP and the value of spectrum).

Figure 5: Net benefits of spectrum trading in Denmark, Hong Kong and UK (% GDP * 100,000)



Note: Excludes initial set-up costs. Case for Denmark acting unilaterally. If coordinated with other European countries, total net benefits are estimated to increase to EUR 17 million per annum. Costs include administration and interference management costs.
Source: DotEcon et al. (2006), Ofcom (2004d), Ovum et al. (2006). GDP estimates from World Bank

These estimates suggest that introducing spectrum trading could have a large positive impact. It should be noted that these estimates are based on the effects of 'restricted' trading, i.e. where trading is limited to certain areas of the spectrum. They do not show the potential effect of *unrestricted* trading.

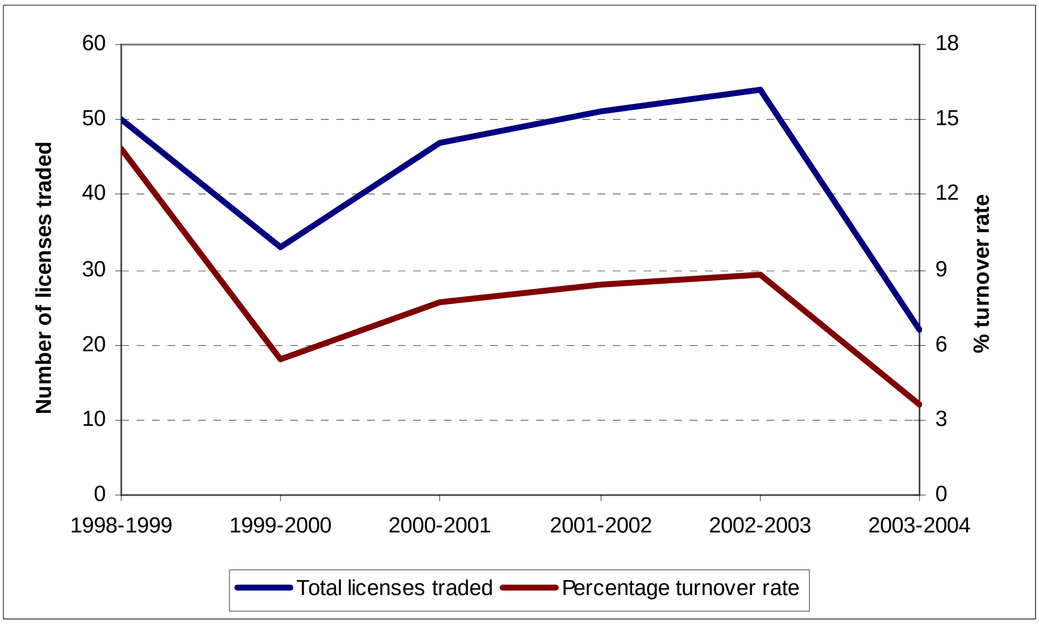
Spectrum trading in practice

Despite many countries having introduced spectrum trading systems there have not been any full ex post cost-benefit evaluations and there is only limited evidence available on how spectrum trading markets have operated to date.

The only available quantitative measure for assessing the performance of spectrum markets has been the number of trades. However, this is extremely crude – the *number* of trades does not take into account the size or value of spectrum traded. Furthermore, the extent of trading is not an aim in itself. It is one indication that the market is working, but if the initial allocation of usage rights is efficient there will be no need for trading. Further, some of the gains from trading (particularly pressure on firms to operate efficiently) could occur in the absence of actual trading (i.e. the threat of new entry is sufficient).

The most detailed information available is for Australia, and is reproduced in Figure 6 and Table 2. This indicates that, as a percentage the total of number of licenses, trade occurred at between 3.6% and 13.8% of the total number of spectrum licenses between 1998 and 2004.

Figure 6: Spectrum license trading in Australia 1998-2004



Note: Turnover rate = number of licenses traded each year/total number of spectrum licenses in issue.
Source: Marcus et al. (2005)

Table 2: Spectrum license trading in Australia 1998-2004

Year	Number of licenses traded	Percentage turnover rate
1998-1999	50	13.8
1999-2000	33	5.4
2000-2001	47	7.7
2001-2002	51	8.4
2002-2003	54	8.8
2003-2004	22	3.6
Total trades	**246**	**n.a.**

Note: Turnover rate = number of licenses traded each year/total number of spectrum licenses in issue.
Source: Marcus et al. (2005)

Elsewhere, the extent to which trading has occurred has varied. Trades in New Zealand have been very few (Radiocommunications Agency, 2002). Within the UK (where trading has not yet been fully implemented) there were 5 trades in assignments[26] independent of other commercial activity (i.e. mergers and acquisitions) in 2005 and 11 in 2006 (Ofcom, 2007). On the other hand, numbers of trades in the US and Guatemala seem to have been higher. Thousands of trades occur each year in the US, although this should be seen in the context of high numbers of actual licenses (DotEcon et al., 2006). The secondary market in Guatemala has been relatively vibrant, with 26% of licenses changing hands since 1995. In all cases other than the UK however, the numbers are likely to be overestimated due to a number of licenses being transferred between companies under the same financial control, or as part of mergers.

In practice, assessing the significance of these numbers is difficult; while some commentators see them as low (e.g. Marcus et al., 2005), others believe that the levels are unsurprising and should be seen as significant (Analysys et al., 2004).

The differences in the level of trade between countries are probably largely explained by domestic factors. For instance, in Australia and New Zealand some areas of spectrum are not overly scarce, reducing the need for market mechanisms. In New Zealand, the use of national licenses (rather than regional, as in Australia) may have further decreased the number of potential buyers.

[26] An assignment is the authorisation given by Ofcom for a station to operate using a specific radio frequency channel in a defined location under specific conditions, and a license may be comprised of a large number of assignments.

The design of spectrum trading systems may also be important. In New Zealand, a large proportion of management rights[27] were issued to State authorities, who have tended to issue licenses on a use-by-use basis, making trade more difficult. A further problem, which has also been identified in Australia, is that licenses have finite periods, meaning that their value diminishes over time, reducing the attractiveness of trades.

However, despite some concern over the limited number of trades, some benefits resulting from spectrum trading have been observable. First, there have been some, although few, large trades – notably the Telstra-Bell South transaction in New Zealand and Nextel's development of a mobile telephony network in the US.[28] These have created substantial benefits for consumers (Analysys et al., 2004).

There are also examples of benefits from smaller transactions. In New Zealand, trade in FM licenses appears to have encouraged new entry, and hence helped downstream competition and later consolidation (Analysys et al., 2004). Similarly, the conversion of television bands into tradable spectrum rights in 1995 allowed the creation of a fourth television channel covering 70% of the population (Radiocommunications Agency, 2002). Within Australia, spectrum trading led to the creation of a new public network and freed up spectrum for the 2000 Olympic Games (Radiocommunications Agency, 2002).

Overall, this suggests that implementing spectrum trading has produced benefits in the creation of new services, and the development of downstream competition. However, although the small number of trades may not be a sign of inefficiency, it does suggest that the benefits may not be large in size – particularly given the limited number of large trades. Further, the lack of quantitative evidence makes it impossible to assess these benefits relative to implementation costs.

In addition, it is likely that the limited number of trades in these countries may be due to local conditions and trading systems. In Australia and New Zealand spectrum scarcity is less of a problem than in Europe. Similarly, the limited number of large players is likely to have reduced the extent of market activity. Most importantly however, this is an indication that the "success of any system depends very much on its details" (Cave, 2002). This is a crucial

[27] As of 2004, 15 of 91 Management Rights were allocated to the government (DotEcon et al., 2006). However, in January 2001, 15 of 41 Management Rights were government owned (Radiocommunications Agency, 2002).

[28] In 1991, Nextel aggregated local area specialised mobile radio (SMR) licenses, and was allowed to change use only after a prolonged lobbying process (Analysys et al., 2004).

factor to bear in mind when assessing the potential benefits of spectrum reform in Europe.

Trading systems in pollution markets

Although there have been no *ex post* evaluations of spectrum trading markets, there have been studies analysing the impact of creating secondary permit markets in other sectors, particularly relating to pollution. While these are clearly not directly comparable, they provide an additional indication that markets in permits can work (i.e. buyers and sellers are able to find each other and complete transactions) and also that efficiency benefits can be found.

The Acid Rain Programme, one of the first large-scale tradable permit programmes, was introduced in the US in 1990 and sought to reduced Sulphur Dioxide (SO_2) and Nitrous Oxide (N_2O) emissions from power stations. A recent study found that the programme "is on track to achieve the expected reductions in SO_2 and N_2O emissions from the electric power sector by 2010 for a cost that is substantially lower than originally estimated", with estimated benefits of $122 billion per annum in 2010 (compared to costs of $3 billion) (Chestnut and Mills, 2005). Cost savings attributable to emissions trading were estimated at between $225 billion and $375 billion in 1995 (implying costs would have been one-third to one-half as costly again in the absence of trading) (Ellerman et al., 1997).

Similar positive effects have been found for the RECLAIM programme in Los Angeles. The programme achieved its environmental goals, and saw a large number of trades suggesting that the cost-savings were achieved. Further, the market acted "correctly" in response to shifts in demand and supply (Harrison, 2003).

A review of the international experience in tradable water pollution rights (Kraemer et al., 2004) also illustrates that tradable permit markets can work. For instance, salt pollution trading in Hunter River, Australia has generally reached salinity targets and reduced water storage and treatment costs. However, in some cases (such as Fox River, Wisconsin, USA) systems have been less successful, with administrative charges seemingly inhibiting potentially advantageous trades. In addition, the authors point out that the pre-conditions within each country are crucial in assessing the potential impact of trading schemes.

These studies indicate that market-based systems can work effectively, and produce efficiency gains (for instance through lower costs to produce a particular level of pollution). However, it is important to note the lessons from water pollution markets, that an understanding of pre-conditions in the relevant markets is critical to the design of a market system.

3.3 Technology and service neutrality

Above we have discussed the impact of introducing secondary trading of spectrum usage rights, which is one method of liberalising the assignment of spectrum. A second key issue is the extent to which the *allocation* of spectrum is liberalised. In particular, advocates of reform argue that licenses to use spectrum should be both technology and service neutral – that is that spectrum users can choose the technology used to produce services, and provide whichever services they wish.

To assess the impact of a move toward technology and service neutrality, it is important to understand the "unreformed" system, which we refer to as standardisation[29]. In particular, restrictions are imposed based on two distinct rationales.

First, standardisation has been used to prevent harmful interference between competing technologies. Tight control over the services that operate within a band and the equipment that it can use are one method for achieving this.

Second, standardisation has occurred as regulators have sought to pick "technological winners" and impose equipment and other restrictions accordingly. This is motivated by the potential to boost technology diffusion and achieve economies of scale in production.

3.3.1 Costs and benefits

Efficiency gains / market failure

Liberalising spectrum allocation is anticipated to have substantial efficiency gains through removing artificial restrictions on the use of spectrum. Under a command and control system, where the amount of spectrum that can be used for a particular service is decided centrally, regulators must attempt to match supply and demand for each service. Given the difficulties in assessing this, and adjusting over time, often excess supply or excess demand can result, leading to "a wasteful use of the spectrum based on an artificial scarcity" (European Parliament, 2007).

For example, areas of spectrum may be left idle, even where there are other valuable services willing to use the spectrum – a clear inefficiency. Alternatively, if demand for a service exceeds the capacity of the spectrum allocated to it, higher consumer prices may occur. Further, restricting the

[29] Standardisation here refers to a range of policies, including specifying the detailed characteristics of radio equipment (for instance to ensure interoperability) and the allocation of services to frequency bands – including international frequency harmonisation.

provision of certain services in some areas of the spectrum may mean that low value services operate to the exclusion of higher value services.

Providing users with greater flexibility over how to use spectrum can lead to efficient outcomes over time, as firms are able to adjust more quickly to changes in both supply and demand than regulators. This is particularly true where liberalisation of spectrum trading is combined with secondary trading, allowing firms easy access to the areas of spectrum that they value.

However, the introduction of flexibility into spectrum usage leads (by definition) to a loss of control for the regulator. This increases the risk of harmful interference - in a liberalised system, new combinations of interfering technologies are harder to foresee than under a standardised system. Creating a strategy to address this is an important part of any move towards technology/service neutrality. The clear assignment of property rights for spectrum and ground rules for limiting interference in radio-regulatory provisions will be important parts of this strategy. The development of modern digital signalling systems to reduce interference will also contribute to limiting the impact of this issue.

It has also been argued that allowing the market to decide which technologies and services should be used may not enable some economies of scale to be achieved. The idea is that standardisation creates larger product markets and requires less sophisticated equipment (with no need to operate across the spectrum), and so can lead to substantially reduced production costs. It is also suggested that standardisation, by ensuring interoperability between different products, can contribute to achieving beneficial network effects. These arguments are also made where bandwidth harmonisation occurs across international borders. Developments in technology mean that economies of scale arguments are becoming less important as equipment is able to access more than one spectrum band without significant cost penalties. Tri-band and quad-band mobile phone handsets, for example, have been available for some time and many expect software defined radio technologies to increase in importance over time.

In principle, at least, where the benefits of standardisation are high, a market system could lead to the establishment of a standard without intervention from the regulator, either through explicit agreement, or through competition. However, it is likely that this may take some time to occur, following a period of competition.[30] This delays the potential benefits from the standard which, in the case of large markets (such as mobile telephony)

[30] For instance, in the US (where there is no mandatory standard), CDMA technology (the basis of 3G communications) was generated following a period of competition (Valletti, 2001).

can impose significant costs. The need to agree standards in a harmonised system is also likely to take some time.

Technology/Innovation

The benefit of standardisation in promoting innovation and the uptake of new technology is widely debated. Advocates claim that standardisation is crucial to the uptake of new technology, by forcing firms to recognise the standard, and so leading to faster diffusion. This allows the quick attainment of "network benefits", whereby the value to all users in the system is determined by the number of users within the system. While there is recognition that a market-based system may arrive at the same point, it is argued that this is likely to take longer, and so impose significant opportunity costs. The imposition of technological standards is also claimed to lead to greater innovation in end use markets, through creating a larger platform for service innovation.

Advocates of technology neutrality, on the other hand, argue that market-based approaches create greater incentives for firms to develop new technologies, through the opportunity for faster uptake onto the market. Under the current system, new technologies are often restricted to higher frequencies, and hence suffer higher deployment costs to cover large geographical areas. Greater flexibility in the market allows faster adjustment to consumer trends and product developments. Standardisation can lead to "lock-in" to inferior products, as it takes time to remove old standards and develop new ones. Similarly, the inability of firms to easily gain access to spectrum to trial and launch new products deters innovation. Further, the variety of products offered in a liberalised market is likely to have value to consumers in itself.

Competition

Liberalising spectrum usage is expected to benefit competition, through removing barriers to entry (particularly artificial bandwidth restrictions), and increasing the overall capacity of spectrum for any particular application. Firms will have the incentive to compete to develop the winning technology standard, leading to competition on price and quality of service, as well as increased innovation.

However, although competition may be intense in the short-term, as different standards struggle to gain consumer recognition, there is the potential for the extent of these benefits to be constrained if market power develops in the market. The existence of network effects can lead to a "tipping point": once a product becomes sufficiently popular, consumers are likely to prefer it over other services (even though they may be superior in other ways). This can lead to the establishment of a dominant firm with significant market power[31]. However, this is a general finding for markets characterised by network effects and may also apply under standardisation.

It has also been suggested that equipment standardisation can promote competition in product markets for equipment as providers operate under a single common standard (rather than multiple proprietary designs); and between service suppliers and network operators, due to the interoperability of terminals and other equipment.

3.3.2 Existing evidence

Estimating the likely impact of removing restrictions is difficult, as the precise context of various markets, technologies and the current situation plays a crucial part in determining the overall effect. As such, any conclusions drawn must be conditioned to particular areas of spectrum, and the relevant technologies.

Standardisation versus liberalisation

The importance of context in developing the appropriate spectrum assignment system has been illustrated in a study by Indepen and Aegis (2004). In a series of case studies (historical and future), they examine the role and benefits of standardisation in the UK across a range of technologies. As displayed in Table 3, in a total of 12 studies, they found a negative effect of standardisation in 7 and a positive impact in 3, with the remaining 2 neutral. It should be noted however that two of the case studies where positive effects from standardisation were found (GSM and PMR) related to the past effects of standardisation and negative effects from standardisation were found in both of these spectrum bands looking forward.

[31] Microsoft's dominance of operating systems, and the consequent competition investigations, is often cited as an example of this effect.

Table 3: Costs and benefits of European standardisation in the UK

	Effect of harmonisation / standardisation	Impact
1a. GSM 900 &1800 - historic	▪ Faster service roll-out: £876-5,774m	Positive
1b. GSM 900 & 1800 – future	▪ Higher network/opex costs for operators (less cost of replacement handsets) ▪ More efficient use of spectrum (factor of three ▪ Possible competition stimulus	Possibly negative
2. TETRA	▪ Forgone value from idle spectrum: around £5m/annum.	Negative
3. Broadband Fixed Wireless Access at 2 GHz	▪ Forgone use by BFWA: £900-4,400m	Negative
4. 32 GHz fixed services band	▪ Little effect	Neutral
5a. PMR at 450-470 MHz – historic	▪ More efficient use of spectrum ▪ Avoid interference ▪ Cost of replacing equipment ▪ NPV of benefits £70m - £100m	Positive
5b. PMR at 450-470 MHz – future	▪ Consumer cannot access wideband services ▪ No interference issues	Negative
6. UHF TV frequencies	▪ Potential considerable costs from withholding spectrum from 3G services ▪ Few benefits to harmonisation	Neutral – unlikely to be positive
7a. Radio car keys	▪ Avoid need to move incumbent military users ▪ Avoid cost of reissuing key fobs: £4-40m ▪ Avoidance of interference costs: £4-34m	Positive
7b. Telemetry and telecommand systems	▪ Release of spectrum: NPV of £5m ▪ Cost of denying users access to spectrum: NPV of £4,200m	Negative
8a. Program Making and Special Events (PSME) – historic	▪ Costs of moving existing users to harmonised allocation: considerable ▪ Benefits of international mobility ▪ Avoid interference: £2m	Negative
8b. PMSE – future	▪ Spectrum remains idle ▪ Potential gains in spectrum efficiency	Negative

Note: The study addresses international frequency harmonisation and radio standardisation separately. For each case study, the effects of a change of policy were examined – either towards standardisation, or a move away from standardisation. We do not distinguish between the two in the table.
Source: Indepen and Aegis (2004)

The effect of standardisation varied from extremely positive (up to £5.7 billion in the case of GSM historically) to very costly (£4.4 billion in the case of reserving the 2GHz band to 3G services). Despite the variety of effects, many of which are particular to the specific technologies and policies in question, a few general lessons can be drawn.

First, the size of the market is important in determining the potential effects of seeking to standardise equipment and services. In larger markets, the faster diffusion of a new technology can have substantial benefits - as witnessed in the case of GSM. Further, larger markets can offer substantial benefits from economies of scale. However, the Indepen and Aegis (2004) study comments that economies of scale do not always predominate – particularly in fixed link services.

More generally it is clear that the costs of inefficient allocation of spectrum are much greater in mass consumer markets. Restricting the use of potentially high value technologies through insufficient spectrum allocation can have substantial costs. For instance, Hazlett (2005) estimates that preventing commercial mobile radio services from using the 402MHz allocated to television costs trillions of dollars in the US. Similarly, as discussed further below, restricting the spectrum allocated to mobile telephony appears to prevent substantial consumer benefits being achieved.

Second the nature of the international market may determine many of the benefits of standardisation. In internationally mobile technologies (such as car fobs), standardisation is likely to have greater benefits, particularly through the avoidance of interference, as applications travel into other areas. The nature of the market in different countries is also of concern – where national patterns of demand vary widely (e.g. programme making) imposing international frequency harmonisation may cause significant costs in moving users to other parts of the spectrum.

A third area determining the success of standardisation measures is to the nature of demand and supply for services within that sector of the spectrum. Where spectrum is congested, standardisation can alleviate harmful interference. However, where there is demand for alternative technologies that could use the spectrum (for instance Broadband Fixed Wireless Access at 2GHz as discussed in Indepen and Aegis (2004)) then the costs of standardisation can be substantial.

Liberalisation of the mobile telephony spectrum

A number of studies have focused on the benefits of liberalisation within the mobile telephony spectrum.[32] Historically, the use of the 900MHz and 1800MHz spectrum bands has been limited to the deployment of 2G or GSM networks, but with the advent of 3G technology, there are growing demands for this restriction to be removed.[33]

A study addressing the liberalisation of the mobile telephony spectrum has been undertaken by Booz Allen Hamilton (2006), commissioned by the UMTS forum. This simulates the European wide area mobile communications market over 15 years, comparing the effects of standardised and liberalised spectrum management approaches.

The report finds that a liberalised management approach would lead to substantially worse outcomes, including lower usage per subscriber (by 3%), higher average revenue per subscriber (by 7%), lower penetration (by 5%) and higher industry costs (by 17%) over fifteen years. Further, the liberalised scenario indicates a cumulative reduction in consumer surplus of EUR244 billion over the fifteen year period.

This analysis suggests that more value may be offered in wide area mobile communications through a standardised approach. However, as in any modelling exercise, it is important to consider the assumptions the simulation is based on. The study assumes that liberalisation leads to increased costs through both reduced scale in production, and greater interference management costs. Crucially however, there is no assumption that liberalisation could promote either efficiency or innovation through allowing greater capacity for any given service. Instead the assumption appears to be that innovation occurs regardless of the spectrum management approach – and that harmonisation and standardisation will lead to faster implementation and penetration of new technology. Further, the study does not take into account other technological developments (e.g. convergence between wireless technologies) and the potential impacts of license-exempt spectrum on existing technologies are not discussed.

[32] Hazlett and Munoz (2006b) comment that mobile telephony markets are frequently analysed for four reasons. First, it is the dominant spectrum-based service (in terms of revenues). Second, unlike the next most important application (broadcasting) it is not intensely political. Third the sector is critical to economic development and fourth, the importance of the sector to investors means that data is available.

[33] In July 2007, the European Commission proposed the repeal of the GSM directive, which restricts the technologies that can be used within Europe.

The findings of the Booz Allen Hamilton report contrasts with a number of other studies, which suggest that allowing more flexibility in the use of the mobile telephony spectrum and, in particular, refarming the 2G spectrum to 3G could produce substantial benefits. As discussed above, for instance, Indepen and Aegis (2004) found that the current GSM standards may be imposing costs by delaying the introduction of 3G technology. Pratt and Bellis (2006) have estimated that re-allocating the EU 2G mobile spectrum towards 3G would result in gains in consumer surplus of EUR 2.9 billion per annum, or EUR 6 per annum per capita.

Ofcom (2007b) recently released a consultation paper examining the proposed implementation options for the release of the 2G spectrum to 3G within the UK. This estimates that the cost savings from rolling out 3G in the 900MHz band would range from around £1.35 billion to £4.25 billion (net present value), depending on the level of service adoption. These figures have, however been criticised on several points by Vodafone, in their response to the consultation, suggesting that the correct figures are 0.0 – 0.3 billion (Vodafone, 2007).

The Ofcom (2007b) paper highlights the potential competition difficulties resulting from liberalising the mobile telephony spectrum alone, due to the fact that only two operators hold licenses at 900MHz, and suggests that having five operators with access to the band would be optimal.[34] It is estimated that a move from five to four operators in the market could lead to a total welfare loss of £1.1 billion (comprised of £4.9 billion loss in consumer surplus and a £3.8 billion increase in producer surplus).[35] In addition, the report suggests that a further loss in dynamic efficiency (due to a delay in introducing 4G technology) of around £570 million could result from the loss of an operator.[36]

More generally, a number of studies have estimated the impact of extending the amount of spectrum available to mobile telephony. International evidence has shown that spectrum allocation has a significant effect on retail markets with econometric analysis of 29 wireless telephone markets indicating that a greater allocation of spectrum is associated with lower retail prices (Hazlett and Munoz, 2006a).

[34] Based on a comparison of the incremental costs of existing operators releasing spectrum and the benefits of greater competition for different numbers of operators.

[35] Based on a Cournot oligopoly model with the exit of one operator in 2010/11.

[36] Case with 25% uplift in economic value, and 5 year catch-up period.

Simulations based on this model across a number of countries suggest that the potential benefits – as would occur under a more liberalised spectrum management system - could be substantial. In the US for instance, allocating an additional 200MHz to wireless telephony could lead to a 50% fall in consumer prices, and an additional $77 billion of consumer surplus per annum (Hazlett et al., 2004). Within the UK, a simulation of releasing 140MHz of spectrum (such as occurred during the 3G license auctions), is estimated to have achieved around $64 billion in consumer surplus gains (Hazlett and Munoz, 2006a).

Clearly, the scarcity of spectrum constrains the ability to reallocate to different uses in practice. Within the EU, however, simulations indicate that the existing spectrum allocation is inefficient, and that allowing a change of use could reap economic benefits. Reallocating TV band spectrum to mobile telephony, for instance, could reap benefits of between $700 and $1,700 additional consumer surplus per person (net present value) (see Hazlett et al., 2006b Table VI). Similarly, Farge et al. (2007) estimate that releasing the 'digital dividend'[37] to the mobile spectrum could result in 0.6% additional GDP growth per year by 2020 compared to release to broadcast TV.

These results suggest that spectrum liberalisation, by reducing barriers to entry and making reallocation of spectrum to high value purposes easier, may benefit consumers through reducing prices and hence increased consumer surplus, although it should be noted that these estimates do not account for any interference or other costs following liberalisation.

Analysis of spectrum management regimes in South America supports these results. Hazlett and Munoz (2006b) note that the average amount of spectrum allocated to cellular services in Latin American is significantly lower than the EU average (102MHz compared to 266MHz). They suggest that this could be caused either by inherent market differences (lower demand for mobile services) or inefficient allocation of spectrum due to regulatory intervention. Hazlett, Ibarguen and Leighton (2006) test whether extending property rights to spectrum (i.e. liberalisation) led to lower prices and higher output in Latin America. Data for sixteen countries was collected, with Guatemala and El Salvador taken as "liberal" regimes (using a dummy variable). The analysis indicated that liberal regimes had higher bandwidth, and lower market concentration (based on HHI). Further, both of these were found to be associated with lower prices and higher market output (minutes of mobile phone use). Based on these effects, a first approximation of the welfare estimates indicated that liberalisation led to an increase in consumer surplus of around 29% of initial industry revenues.

---

[37] The digital dividend refers to the release of spectrum that will occur following the proposed switch off of analogue broadcasting between 2010 and 2012.

Similar results have been found by Hazlett (2004), in a study analysing the effects of spectrum property rights on the value of licenses (in spectrum auctions) across 24 countries. Liberal regimes tend to lead to reduced bids for licenses, suggesting that operators expect lower retail prices.

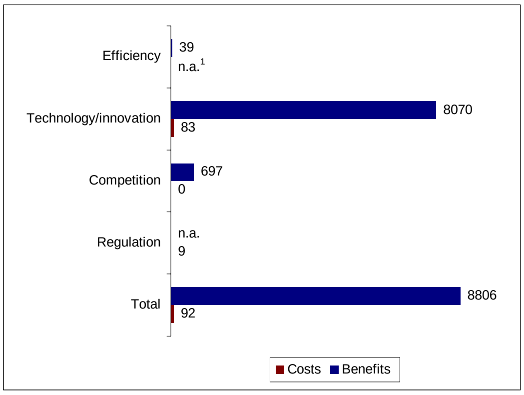
Ex ante quantitative assessments

A further strand of evidence consists of large scale high-level estimates of the effects of liberalisation on efficiency, innovation and competition, as carried out by Analysys et al. (2004) for the European Commission.[38] The estimated costs and benefits of either imposing trading and liberalisation or restricting liberalisation (relative to the status quo) are reported below.

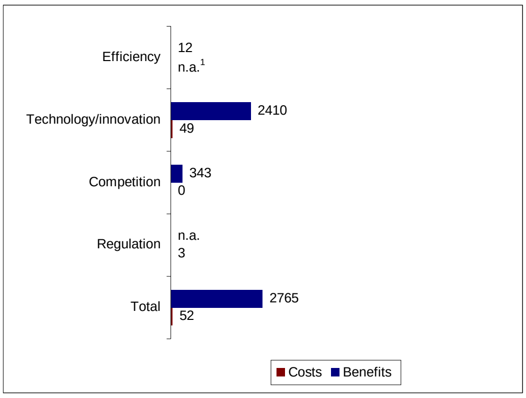
Liberalisation is not defined precisely in terms of the restrictions to be removed, as it is in the case studies discussed above. Instead, the direction and scale of the effects of liberalisation are based on assumptions such as higher number of trades, lower prices and more frequent innovation.

Table 4: Costs and benefits of spectrum liberalisation in the EEA (EUR million per annum)

Trading and liberalisation



Existing liberalisation[2]



[1] These include "other national policy goals", which are unquantifiable due to their largely political nature. For instance, a desire to assign spectrum free-of-charge, or support a particular industry.
[2] Analysed as restricting any existing liberalisation in Member States at the time of the study.
Source: Analysys et al. (2004)

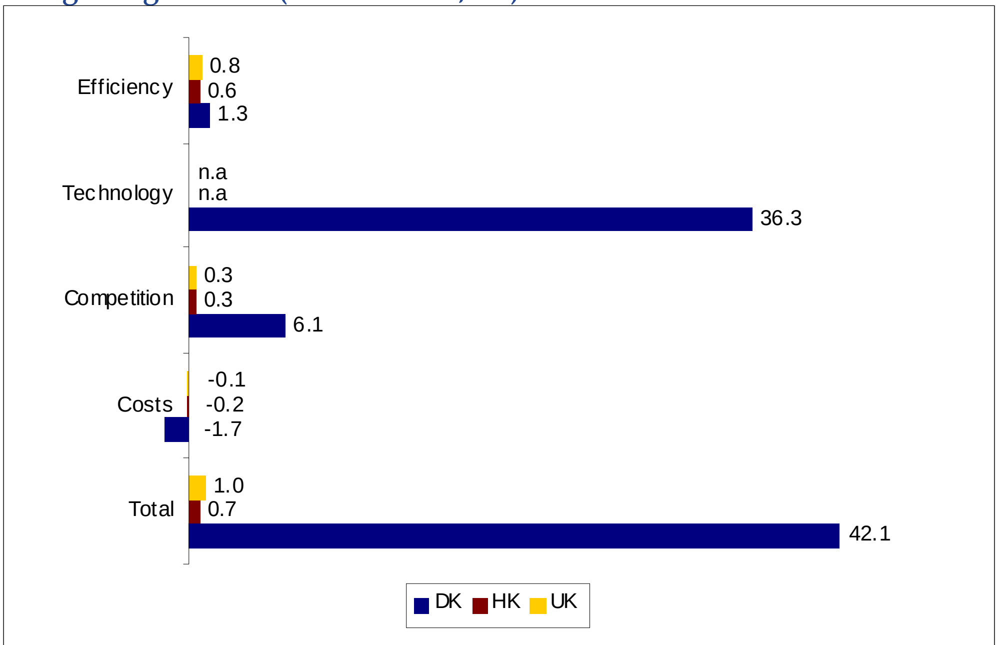
[38] See section 3.1 for more discussion of the methodology of this and the following studies.

Table 4 indicates the potential benefits of liberalising spectrum, as well as allowing secondary trading. The total benefits for trading and liberalisation are substantially higher than those for the "trading only" case (discussed in section 3.1 above). This is largely due to higher innovation (EUR 8,070 million compared to EUR 860 million) and competition (EUR 697 million compared to EUR 18 million) benefits.

While the numbers here are larger than those found in the Indepen and Aegis (2004) study, this is not surprising, as this report analysed a much larger proportion of the spectrum.

As in the trading case similar estimates have been produced for the Danish, Hong Kong and UK markets. These are reported in Figure 7.

Figure 7: Net benefits of spectrum trading and liberalisation in Denmark, Hong Kong and UK (% GDP * 100,000)



Note: Excludes initial set-up costs. Case for Denmark acting unilaterally. If coordinated with other European countries, total net benefits are estimated to increase to EUR 17 million per annum. Costs include administration and interference management costs.
Source: DotEcon et al. (2006), Ofcom (2004d), Ovum et al. (2006)

The results from these studies and the Analysys et al. (2004) study directly oppose those of the Booz Allen Hamilton (2006) (henceforth BAH) report, which found that imposing liberalisation in the wide area mobile sector would produce considerable downsides to the consumer. It is useful to consider the factors that drive these different results.

The first key difference is that, while Analysys et al. assume a significant level of trading even in their "status quo" assumptions, BAH take no account of the trading system in analysing the spectrum management approaches.

This difference feeds into the assumptions made in each report. BAH take an essentially static view of the effects of liberalisation, assuming a loss of economies of scale and increased interference management costs, and hence significantly higher industry costs. Through their simulation model, this translates into higher prices, lower usage and hence lower consumer surplus.

Analysys et al. on the other hand, do not take account of any loss of economies of scale as a result of liberalisation. Instead, as liberalisation is allied with trading, it is assumed to lead to lower prices, increased innovation and faster diffusion of new technologies.

The BAH study focuses on the particular debate of whether standardised equipment is beneficial within the mobile sector, regardless of the wider debate on spectrum management. As such it does not account for some important factors that are included in the Analysys et al. report:

- **Competition:** By considering the whole spectrum (and including trading), the Analysys study allows new competitors to enter the market, leading to lower prices.

- **Efficiency:** Again, allowing for the whole spectrum, Analysys includes the potential benefits from change of use under liberalisation.

- **Innovation:** Analysys et al. assume that countries with liberalisation innovate faster, and diffuse technology more quickly. BAH, on the other hand, in a sensitivity scenario, take the view that standardisation speeds up take-up of a new technology, and hence is preferable to liberalisation.

Overall, this suggests that the Analysys et al. (2004) report is more useful in assessing the benefits from changing the spectrum management approach in general. The BAH study does not account for the potential benefits of opening up more spectrum to users, or allowing more scope and hence incentive for innovation to occur. In particular, this ignores the difficulty of constricting users to certain bands as technologies converge.

However, while the different results are largely due to the different focuses of the reports, the assumptions over innovation are more fundamental. BAH assume that the technology chosen by a regulator is the same as would be chosen by the market, but with faster implementation. As radiocommunications becomes increasingly complex, this seems difficult to support.

While the Analysys et al. study appears to provide more useful guidance to the formulation of spectrum management policy, it is important to recognise that many of the costs suggested in the BAH report may apply in the short term following liberalisation. In particular, as new technologies are implemented, there may be losses in interoperability and economies of scale. This is particularly likely if different markets move at different speeds, leading to a loss of geographical economies of scale. Further, as discussed earlier, these considerations are likely to be greatest in large international markets, where roaming is a possibility.

Introducing technology and service neutrality in practice

The evidence above suggests that there are potential welfare gains from reallocation of the spectrum enabling greater access for higher value technologies. Further Analysys et al. (2004) and related studies have indicated that these benefits could be substantial if achieved across the spectrum. However, the question remains as to whether these gains could be achieved in practice.

There has been little evaluation of the performance of existing spectrum management regimes. However, the evidence that is available suggests that liberalisation has had positive effects, particularly in increasing the supply of spectrum available to operators (Hazlett, 2006). Guatemala and El Salvador, for instance, have the highest bandwidth allotments available to mobile carriers within Latin America (Hazlett and Ibaraguen, 2002).

It is difficult to separate the effects of liberalisation from those of introducing secondary trading. However, in general, most trades have not involved change of use requests (Analysys et al., 2004). In the US, trades through the disaggregation or partitioning mechanisms are low relative to total license sales (DotEcon et al., 2006). On the other hand, some of the significant cases discussed above, such as the Nextel transactions (whereby a mobile telephony network was created from the aggregation of local area SMR licenses) have involved change of use.

While there is little empirical evidence directly addressing the effects of liberalisation on interference, and interference costs, there have been few examples of changes of use causing harmful interference – although this must be placed in the context of the low number of trades involving a change of use (Analysys et al., 2004).

The most noteworthy example where a change of use has caused interference difficulties is the Nextel SMR purchases. The flexibility allowed led to substantial interference problems with public safety systems and commercial mobile networks. The FCC has been required to order a comprehensive band restructuring with the equipment retuning and replacement costs estimated to be up to EUR 2 billion (Booz Allen Hamilton, 2006).

While this illustrates the potential problems resulting from spectrum liberalisation, experience suggests that properly defining property rights can avoid any difficulties. Within the US, the definition of harmful interference is ambiguous, with an emphasis on mutual arrangements to resolve interference issues (Marcus et al., 2005). Other countries (such as New Zealand and Australia), by contrast, have clearly defined property rights, by imposing conditions on licensees. In Australia levels are fixed according to geographic boundaries, while in New Zealand area and frequency parameters are defined on a case-by-case basis. These countries do not appear to have had significant interference problems following liberalisation. In New Zealand for instance, licensees have always resolved any disputes without relying on court intervention (DotEcon et al., 2006).

3.4 License-exempt spectrum

3.4.1 Costs and benefits

Efficiency gains / market failure

The most important characteristic of a license-exempt spectrum is the extremely low barriers to entry which allow a large number of firms to enter the market with associated costs and benefits. The capacity of the market is likely to expand, placing downward pressure on prices and hence benefiting consumers. License-exempt spectrum would also avoid inefficiencies caused by artificial restrictions of a certain amount of spectrum to one user.[39] On the other hand, it is possible that the collective use model of spectrum may be less efficient at allocating a given capacity between competing uses, due to the lack of coordination within the market (Benkler, 2002).

The major limitation of license-exempt use is the potential for harmful interference, as excessive entry (based on no licenses or charges to use the spectrum) leads to above optimal entry into the market. Interference is most likely where spectrum is scarce and technology is such that the presence of several emitters at the same frequency damages other emitters' signals (Faulhaber and Farber, 2003). The extent of this problem will vary dependent upon the power of the signal transmitted, the size of the area being transmitted to, and the population density in that area.

Power limits are likely to be crucial to the degree of interference (Hazlett, 2005). In the case of short range applications, for instance, property owners (homes or enterprises) are able to exercise effective control on the use of the spectrum, due to their exclusive rights over the premises where the application is used. No such control can be developed at reasonable cost in case of long-range applications (e.g. wide area services), particularly in densely populated (metropolitan) areas.

Technology / Innovation

The low barriers to entry under a license-exempt spectrum model are likely to encourage innovation, with firms able to trial and launch new products relatively easily. Product development is also promoted by firms having security of access and tenure on the spectrum.

[39] For instance where areas of spectrum undergoing high levels of demand are seen next to areas of spectrum not in use.

Competition

Competition is promoted by the lack of entry barriers into license-exempt markets, with entrants not required to purchase spectrum as under a spectrum trading system. In addition, collective use of spectrum can relieve congestion in other (licensed) spectrum bands which enhances competition within those markets. For example, the use of WiFi and voice over IP technology inside mobile telephones provides additional capacity in traffic hotspots. This limits pressure on licensed spectrum, and so allows more firms to enter the mobile telephony market.

Regulation

Collective spectrum solutions have potential implications for regulators in the need for centralised coordination of interference management. This is not the case where spectrum is used on a small local level (e.g. wireless internet connections), where power limitations reduce the potential for interference, but may be the case in wide-area services.

Separately, collective use of spectrum may reduce regulatory costs, through reducing illegal usage of spectrum within licensed frequency bands.

3.4.2 Existing evidence

The case for extending license-exempt use of spectrum rests upon the potential growth of competition and particularly innovation that have been witnessed in the existing license-exempt bands. A number of studies have indicated that a range of new technologies have provided considerable benefits, and predicted that growth will continue.[40]

Mason and DotEcon (2001) estimate the benefits to the UK of allowing public access radio local area network provision (RLAN). This indicates potential benefits of between £487 and £642 million per year in terms of consumer surplus. While this would drop substantially in the case of interference or congestion, they note that this is unlikely.

Other existing studies have focused instead on the historic and projected growth of the market in applications utilising license-exempt spectrum. Benkler (2002) comments on the startling growth of wireless communications devices. Mott MacDonald (2006) estimate that the market in license-exempt applications will be EUR26.5 billion in 2009. Further, Indepen et al. (2006)

[40] In estimating the potential benefits from license-exempt spectrum, studies have assumed that the allocation of the spectrum is not highly restricted. If this were the case, it is likely that the predicted benefits would be much lower, as innovation would not be possible.

suggest that the future value per MHz of license-exempt applications is likely to exceed that of current licensed applications. For instance, they estimate a value per MHz of £69 million for WiFi public access in 2020, compared to £50 million for mobile telephony. However, it is clear that the projections for license-exempt technologies are very uncertain, and so must be treated with caution.

These studies seek to address the *additional* value added by license-exempt spectrum, through estimating the increase in consumer surplus from the applications (using license-exempt spectrum) in comparison to the "next best" application (if one exists). Indepen et al. (2006) assess whether a) there are any substitutes for the license-exempt application, and b) if there are, the cost savings related to the application. Mott MacDonald use a cruder estimate of the percentage of the economic value of the total sector value that is dependent on access to license-exempt spectrum.[41]

These studies reinforce the qualitative argument that license-exempt areas of spectrum support innovation and the development of new services, indicating that the new applications have significant economic value. These services have largely been developed in areas of the spectrum that have been historically license-exempt and, crucially, are not congested. This may be of limited use in assessing the *further* implementation of license-exempt spectrum into areas which have traditionally been governed by property rights regimes.

While it appears that license-exempt spectrum does lead to the development and introduction of new products and services, the arguments for and against the extension of license-exempt spectrum depend on the ability to control the harmful interference resulting from excessive entry into the market.

In the case of short-range applications, power limits restrict the use of the spectrum to limited distances, controlling the damage from excessive interference. However, for wider area transmissions, this will not be possible, and is likely to necessitate substantial regulation to avoid low quality services.

[41] For instance, 100% of the value of the wireless LANs sector is assumed dependent on access to license-exempt spectrum, compared to only 10-20% of the medical devices sector.

This appears to limit the extension of license-exempt usage to the entire spectrum at present. However, a range of new technology is changing the way in which signals are handled, and may lead to changes in spectrum allocation systems in the future (European Parliament, 2007). In particular, the development technologies, such as cognitive radio (which can identify areas of spectrum not in use) and spread spectrum (which uses many frequencies limiting the power at any one frequency), which can theoretically use any spectrum band, may allow a much wider range of applications to operate in unlicensed spectrum bands.[42]

A recent study (SCF Associates, 2006) has estimated the potential impacts from the predicted effects of imposing license-exempt spectrum. Comparing a scenario with Europe-wide spectrum trading alongside a license-exempt band with a scenario of just spectrum trading (and liberalisation) and a scenario whereby Member States follow separate spectrum policies, the modelling indicated that incorporating unlicensed spectrum use led to higher GDP per capita and foreign direct investment across the EU.

While this result was clearly dependent on the input assumptions – particularly that innovation would remain low in the spectrum trading scenario as existing operators 'corner' the market spectrum – it indicates that, if technically feasible, license-exempt spectrum could produce significant benefits.

3.5 International spectrum management

In the sections above we have assessed the available evidence examining various policies for introducing greater flexibility into spectrum management. However, in assessing the most appropriate spectrum management within the EU, it is also necessary to consider the international aspects of spectrum management.

International coordination of spectrum management is well established. However, currently international obligations as set down by the EU and ITU are largely limited to avoiding harmful interference across national borders and harmonisation of certain bands (for instance GSM and UMTS services). While these obligations limit the ability for an individual country to implement service and technology neutrality, they still leave substantial scope for the development of individual trading systems. As discussed in section 2 those countries that have implemented spectrum liberalisation have done so in a wide variety of ways.

[42] See European Parliament (2007) for a fuller discussion of new technologies.

Under current EU proposals however, the spectrum management systems would become much more coordinated. Analysys et al. (2004) have presented the main arguments supporting the need and justification for coordination of spectrum liberalisation. They advocate that several of the benefits from spectrum trading have a Community dimension – that is that they will not be achieved without all Member States undergoing liberalisation.

In particular, it is argued that coordination of spectrum liberalisation will provide firms with economies of scale, as they can enter several markets simultaneously. This in turn, will boost the potential for innovation, as firms will be attracted to a large European market, as well as competition (particularly in small Member States). In a Europe with a multitude of regulatory and/or trading systems, firms are required to understand a wide range of processes, necessitating a significant outlay of resources. Further, differing technical and service restrictions hinder the rollout of Europe-wide products. Further savings will be made in spectrum regulation, through economies of scale and scope.

It is estimated that these benefits could be significant, accounting for up to 20% of the competition benefits, and 30-40% of those from increased innovation. In the case of Denmark, the total benefits from coordinated trading and liberalisation are estimated to be EUR 163 million per annum, as opposed to EUR 116 million with unilateral action (DotEcon et al., 2006).

However, several concerns must be set against these potential benefits. First, it should be noted that imposing Europe-wide policies over spectrum may not lead to the creation of a common European spectrum market, as other national legislation (such as environmental) may prevent this. For instance, if one Member State sets out particularly strict limitations on non-ionising radiation, this is likely to diminish the attractiveness of spectrum usage rights in that country, relative to others.[43]

Second, the imposition of a Europe-wide policy will, by definition, restrict Member States' ability to design a system according to their particular national characteristics and needs. Four particular areas of concern can be identified (European Parliament, 2007):

- Legacy issues: based on differences in the way historic usage rights have been assigned.
- Lack of flexibility in existing licenses e.g. due to long duration.

---

[43] BAKOM response to public consultation on the review of EU regulatory framework for electronic communications network and services.

- Protection of public policy objectives.
- Current bands used by non-commercial sectors. This may be exacerbated by the fact that several countries have not currently begun to implement spectrum trading, and so will be unable to properly input their particular needs into the development of any Europe-wide policy. Further, there may be a loss of regulatory innovation as a result (Analysys et al., 2004).

4 Conclusions

The existing evidence is supportive of further liberalisation of the European spectrum. There is a strong theoretical case, which is supported by the existing quantitative evidence. Countries which have implemented more flexible spectrum management systems have seen some notable changes of use and within South America have benefited from lower consumer prices and greater competitiveness. Equally importantly these countries have avoided the potential adverse impact on interference where property rights have been correctly assigned.

However while in general spectrum liberalisation is likely to be beneficial it is clear that caution should be applied in extending the use of more flexible mechanisms, as these may not be appropriate in certain areas of the spectrum, or for certain applications. Developing the appropriate regulatory framework will be crucial to realising the benefits from increased flexibility in spectrum management.

Given the importance of spectrum to a wide range of industries as well as national interests, there is remarkably little quantitative evidence evaluating existing forms of spectrum management. Studies are instead generally based around either simulations of different policy frameworks, or case studies of previous experiences. Whilst we believe the available evidence supports greater spectrum flexibility, further research into these areas could be planned to capture the experiences arising from future liberalisation. This would strengthen the evidence base, as well as providing a useful source of best practice for the future development of liberalised spectrum management systems.

Below we summarise the available evidence in relation to each of the areas of reform suggested by the European Commission.

Secondary trading

The Commission has proposed that trading of spectrum usage rights should be implemented except in specified spectrum bands.

The case for implementing secondary trading in European Member States is strong in theory. Providing greater flexibility over who can use spectrum and how that spectrum can be used should lead to higher efficiency and benefit competition. Further, by liberalising access to spectrum, firms will be given incentives to innovate, and hence support competitiveness and productivity. However, the public good elements of spectrum – in, for instance, public broadcasting, must be taken into account for in any trading scheme.

Despite the strong theoretical case, the existing evidence analysing the effects of spectrum trading is somewhat limited. Countries that have implemented trading appear to have seen only modest numbers of trades although with some identifiable benefits. However, no robust ex post evaluations (either quantitative or qualitative) of trading regimes have occurred. Evidence from South America is supportive, but should be applied in the European context with caution. Given these caveats, developing secondary markets in Europe must give proper consideration to the structure of the trading system.

In addition, it is clear that although secondary trading may bring benefits in many areas of the spectrum, it should not be unrestricted. Several uses of spectrum may have national value that would not be reflected in a market, and these areas must be protected in any system.

Technology and service neutrality

The Commission has suggested that technology and service neutrality should be default principles in spectrum management.

The evidence suggests that trading and liberalisation systems can have extremely beneficial effects. Markets that have allowed spectrum users more flexibility, particularly in South America, have developed more competitive end product markets. There is evidence of some significant changes of use taking place. Further, with the clear designation of property rights harmful interference has not, to date, caused significant difficulties. The predictions of extremely large monetary benefits from liberalisation are necessarily speculative, based largely upon assumptions over the future value of innovations. However, in general technology and service neutrality appears likely to be the "least harmful" option, and as such appears the most appropriate form of spectrum management in the absence of clear evidence otherwise. Interference, as mentioned above, appears controllable even under a liberal system.

In some cases mandated standards have been associated with substantial economies of scale and other benefits. However, there are several examples where standards have had a negative impact. Further, correctly picking the standards to support is becoming increasingly difficult, as the range of standards and applications grows in number and complexity. Regulatory intervention as a result runs the risk of "lock-in" to an inferior standard and dampening innovative activity.

Despite the potential for benefits from liberalisation it may not be appropriate in all spectrum bands. In some areas of the spectrum, where even a small amount of interference is potentially extremely harmful (such as healthcare services), the regulatory framework may need to be more restrictive than in other areas.

License-exempt usage

The European Union has proposed that individual spectrum rights should only be offered where clearly justified – making license-exempt use of spectrum the default case.

The existing license-exempt spectrum has led to the rapid growth of a wide range of products with significant economic value. There is likely to be a role for the wider application of license-exempt spectrum in some areas of the spectrum particularly with the development of new technologies (such as cognitive radio). However, at present, caution will be required in extending license-exempt usage into more congested areas of the spectrum, particularly for wide-area applications, due to the potential for harmful interference.

European coordination

Under the European Commission's proposals, management of the European spectrum will become increasingly coordinated. Decisions such as the bands appropriate for spectrum trading and exceptions to technology and service neutrality will be taken at a European, rather than a national, level.

The potential benefits from coordination are substantial – through greater economies of scale and the creation of a European market. Under the current system, whereby each Member State can implement trading and liberalisation separately, firms are faced with a mass of different regulations and systems, imposing a significant cost. Greater coordination would avoid this and so promote European growth and competitiveness

In order to realise these potential benefits, care needs to be taken in the reform of spectrum management systems throughout Europe, to take account of national factors and legacy issues. Experiences of secondary trading systems have not been straightforward, and the task is more complex for trading across national borders.

Care must be taken in ensuring that the attempt to coordinate European policy does not slow down liberalisation in those countries that have begun to implement it. For these reasons minimum standards (such as the common minimum set of bands for trading[44]) may be most appropriate, providing the opportunity for Member States to liberalise further if they wish.

[44] As suggested in the UK response to the "Commission communication on the review of the regulatory framework for electronic communications networks and services".

Glossary

administrative incentive pricing (AIP)	A measure of pricing whereby prices for spectrum usage rights are set to reflect the opportunity cost of the rights
allocation of spectrum	Determining what spectrum can be used for, including restrictions on technologies, power and other aspects
assignment of spectrum	Determining who can use spectrum – which users are granted access.
command and control	The traditional method of managing access to spectrum, whereby a central regulator determines both allocation and assignment of spectrum
disaggregation	The dividing of spectrum into multiple smaller spectrum rights, in terms of frequency blocks, geographical area or time period.
dynamic efficiency	Gains in efficiency through response to consumer trends and technological change
GSM	Global system for mobile communications – a second generation digital mobile telecommunications system
harmonisation	The common designation of frequency bands for particular services across national borders
hoarding	Purchasing and holding spectrum for anti-competitive reasons
license	Also a usage right. A license gives users the right to use spectrum (within a certain band, and with certain restrictions)
license-exempt	Bands of spectrum for which no license is required
PMR	Private mobile radio – privately operated communications system (e.g. taxi cabs)
secondary trading	The trading of spectrum usage rights in a secondary market (i.e. once they have been initially assigned to users)
service neutral	A spectrum usage right is service neutral if the rights holder can produce any service they wish within their frequency band
standardisation	The specification of various services, including restrictions on equipment and power
static efficiency	An increase occurs when the output per unit of spectrum is increased.
technology neutral	A spectrum usage right is technology neutral if the rights holder can use any technology they wish to provide services
TETRA	Terrestrial trunked radio – a standard for mobile radio systems
third generation (3G)	The next generation of mobile communications systems
usage right	See license

References

Aegis, Indepen and Transfinite (2006) "Technology-neutral spectrum usage rights", Final report for Ofcom. Available at www.ofcom.org.

Analysys, DotEcon, Hogan and Hartson (2004) "Study on conditions and options in introducing secondary trading of radio spectrum in the European Community", May.

Analysys and Mason (2005) "Spectrum demand for non-government services 2005-2025", Final report for the Independent Audit of Spectrum Holdings, September.

Australian Productivity Commission (2002) "Report of the Public Inquiry into Radiocommunications Acts and of the Market Based Reforms and Activities", Undertaken by the Australian Communications Authority, Australian Productivity Commission, Melbourne, December, available at: www.pc.gov.au/inquiry/radiocomms/finalreport/radiocomms/pdf.

Benkler, Y. (2002) "Some economics of wireless communications", Harvard Journal of Law & Technology, Vol. 6 No.1.

Booz Allen Hamilton (2006) "Thriving in Harmony Frequency harmonisation: the better choice for Europe", A Study from the UMTS Forum.

Cave, M. (2002) "Review of Radio Spectrum Management: An Independent Review for the UK Department of Trade and Industry and HM Treasury", Ofcom, London.

Cave M. and Crowther P. (2006) "Driving forward spectrum liberalisation", printed as part of "Reforming Spectrum Policy", Vodafone Policy Paper Series, 5, October.

Chestnut L.G. and Mills D.M. (2005) "A Fresh Look at the Benefits and Cost of the US Acid Rain Program", Journal of Environmental Management, Vol. 77, Issue 3 , 252-266, November.

DotEcon and Analysys (2006) "Introduction of new instruments in spectrum management in Denmark", Report prepared for the National IT and Telecom Agency.

Ellerman, A.D., Schmalensee, R., Joskow, P.L., Montero J.P. and Bailey, E.M. (1997) "Emissions Trading under the U.S. Acid Rain Program: Evaluation of Compliance Costs and Allowance Market Performance", Center for Energy and Environmental Policy Research, MIT.

Ellig J. (2005) "The Economic Costs of Spectrum Misallocation: Evidence from the United States", Prepared for conference on Spectrum Policy in Guatemala and Latin America, Universidad Francisco Marroquin, Guatemala City, Guatemala, June 9-10, 2005.

Europe Economics (2006) "Economic impact of the use of radio spectrum in the UK", Report for Ofcom, November.

European Parliament (2007) "A Common European Spectrum Policy: Barriers and Prospects", Study requested by the European Parliament's committee on Industry, Research and Energy, December.

Farge S., Blackman C., Bohlin E. (2007) "The Mobile Provide: Economic Impacts of Alternative Uses of the Digital Dividend", Summary Report, September 2007.

Faulhaber, G., and Farber, D. (2002) "Spectrum management: property rights, markets and the commons", paper presented at the 14th Biennial Conference of the International Telecommunications Society, Seoul, 18-21 August.

Faulhaber G. (2006) "The governing regime of spectrum", printed as part of "Reforming Spectrum Policy", Vodafone Policy Paper Series, 5, October.

FCC (2002) "Report of the Spectrum Efficiency Working Group, Federal Communications Commission" Washington, DC, 15 November.

FCC (2002) "Report of the Spectrum Policy Task Force, Federal Communications Commission" Washington, DC, 15 November.

FCC (2003) "Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets", Report and Order and Further Notice of Proposed Rulemaking, October.

FCC (2004) "Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets", Second Report and Order and Further Notice of Proposed Rulemaking, September.

Frontier Economics (2005) "Liberty and Harmony? The Pros and Cons of Common Standards for Usage of Radio Spectrum", Bulletin, June.

Harrison (Jr), D. (2003) "Ex-Post Evaluation of the RECLAIM Emissions Trading Program for the Los Angeles Air Basin, presented at a Workshop on Ex-Post Evaluation of Tradable Permits: Methodological and Policy Issues", January 21-22.

Hazlett T. (2004) "Property Rights and Wireless License Values", AEI-Brookings Joint Center for Regulatory Studies, Working Paper 04-08.

Hazlett, T. (2005) "Spectrum tragedies", Yale Journal on Regulation, Vol. 22 No.2.

Hazlett T. (2006) "Spectrum allocation and economic efficiency: An international perspective", printed as part of "Reforming Spectrum Policy", Vodafone Policy Paper Series, 5, October.

Hazlett T.W. and Ibarguen G. (2002) "An Experiment in Airwave Ownership: Spectrum Liberalization in Guatemala", Paper delivered to the Association for Private Enterprise Education Annual Meetings ,April 9 2002.

Hazlett, T.W., Bazelon, C., Rutledge, J., Hewitt, D. (2004) "Sending the Right Signals: Promoting Competition through Telecommunications Reform", a report to the US Chamber of Commerce, US Chamber of Commerce, Washington, DC, 22 September.

Hazlett T., Ibarguen G., and Leighton W. (2006a) "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization", George Mason Law and Economics Research Paper No. 06-07.

Hazlett T., Müller J. and Muñoz R. (2006b) "The Social Value of TV Band Spectrum in European Countries", 8 INFO, No.2, 62-73.

Hazlett T. and Muñoz R. (2006a) "A Welfare Analysis of Spectrum Allocation Policies", George Mason Law and Economics Research Paper No. 06-28.

Hazlett T. and Muñoz R. (2006b) "Spectrum Allocation in Latin America: An Economic Analysis", George Mason Law and Economics Research Paper No. 06-44.

Hazlett T., and Spitzer M. (2006) "Advanced Wireless Technologies and Public Policy", 79 Southern California Law Review 3, 595-665.

Indepen and Aegis (2004) "Costs and benefits of relaxing international frequency harmonisation and radio standards", final report to Ofcom, March.

Indepen, Aegis and Ovum (2006) "The economic value of license-exempt spectrum", final report to Ofcom, December.

ITU (2004) "Workshop on Radio Spectrum Management for a Converging World", Background paper, International Telecommunication Union, Geneva, February.

Kraemer, R.A., E. Kampa, and E. Interwies (2003) "The role of tradable permits in water pollution control", Ecologic, Institute for International and European Environmental Policy.

Kwerel, E., Williams, J. (2002) "A proposal for a rapid transition to market allocation of spectrum", Federal Communications Commission, Washington, DC, OPP Working Paper No. 38.

Lichtenberger, E. (2003) "Spectrum Trading in Germany, Austria and the UK: The influence of regulatory regimes and evaluation of criteria on competition in the European Mobile Telecommunications Sector", August 2003. Available at www.ictregulationtoolkit.org.

Marcus, J., Nett L., Scanlan M., Stumpf U., Cave M., and Pogerel G. (2005) "Towards More Flexible Spectrum Regulation", WIK-Consult, Germany, December.

Mason and DotEcon (2001) "Spectrum management strategies for license-exempt spectrum", Final report to Radiocommunications agency, November.

Mott MacDonald Ltd., Aegis Systems Ltd., IDATE, Indepen Ltd. and WIK Consult (2006), "Final Report: Study on Legal, Economic and Technical Aspects of 'Collective Use' of Spectrum in the European Community", Report for the Radio Spectrum Policy Unit (RSPU) of the Information Society Directorate-General of the European Commission.

NERA (1989) "Radio Spectrum Management – Time for a Market-Based Approach", NERA Topics #1.

OECD (2005) "Secondary Markets For Spectrum: Policy Issues", Directorate for Science, Technology and Industry, Committee for Information, Computer and Communications Policy, Working party on Telecommunication and Information Services Policies, 20 April.

Ofcom and UK Radiocommunications Authority (2003) "Spectrum Trading Consultation", UK Office of Communications, London, November. Available at: www.ofcom.org.uk.

Ofcom (2004a) "A Statement on Spectrum Trading", UK Office of Communications, Statement, London, 6 August. Available at: www.ofcom.org.uk.

Ofcom (2004b) "Consultation on Spectrum Market Liberalisation", UK Office of Communications, London, 17 September. Available at: www.ofcom.org.uk.

Ofcom (2004c) "Spectrum Framework Review", UK Office of Communications, Consultation document, London, 23 November. Available at: www.ofcom.org.uk.

Ofcom (2004d) "Spectrum Trading and Wireless Telegraphy Register Regulations", UK Office of Communications, London, 2 December. Available at: www.ofcom.org.uk.

Ofcom (2005a) "Spectrum Framework Review: Implementation Plan", UK Office of Communications, London, Consultation Document, 13 January. Available at: www.ofcom.org.uk.

Ofcom (2005b) "A Statement on Spectrum Liberalisation", UK Office of Communications, London, 26 January. Available at www.ofcom.org.uk.

Ofcom (2005c) "Spectrum Framework Review", UK Office of Communications, London, 28 June. Available at www.ofcom.org.uk.

Ofcom (2006) "Spectrum Usage Rights: Technology and usage neutral access to the spectrum", Office of Communications, London, Consultation document, 12 April. Available at: www.ofcom.org.uk.

Ofcom (2007a) "Communications Market Report", UK Office of Communications, London, Research Document, 23 August. Available at: www.ofcom.org.uk.

Ofcom (2007b) "Application of spectrum liberalisation and trading to the mobile sector", Consultation document, 20 September.

Ovum, Indepen and Aegis (2006) "Hong Kong Spectrum Policy Review", Report for the Commerce, Industry and Technology Bureau.

Pratt N. and Bellis J. (2006) "Spectrum liberalisation: the benefits of refarming spectrum", printed as part of "Reforming Spectrum Policy", Vodafone Policy Paper Series, 5, October.

Sandbach J. (2006) "Driving forward spectrum liberalisation", printed as part of "Reforming Spectrum Policy", Vodafone Policy Paper Series, 5, October.

SCF Associates (2006) "Benchmarking Impacts of EU Policy: Options for Economically Efficient Management of Radio Spectrum", Final report for DG Information Society and Media, 06 December.

Sutherland E. (2007) "European Spectrum Management: Successes, Failures & Lessons", ITU workshop on market mechanisms for spectrum management, Geneva, January22-23.

UK Radiocommunications Agency (2002) "Implementing Spectrum Trading", UK Radiocommunications Agency, London, available at www.radio.gov.uk.

Valletti, T.M. (2001) “Spectrum trading”, *Telecommunications Policy*, Vol. 25 655-70.

Vodafone (2007) “Application of spectrum trading and liberalisation to the mobile sector”, Response to Ofcom consultation.

Xavier, P., Ypsilanti, D. (2006) “Policy issues in spectrum trading”, 8 INFO, No.2, 34-61.

Annex 1 Case Studies

New Zealand

New Zealand was the first country to move towards a more liberalised spectrum management system, with the main points of reform set out in the 1989 Radiocommunications (RA) Act. Spectrum licenses can be categorised as follows:

Management Rights Regime (MRR)

The MRR is a two-tier system, managing spectrum access through tradable property rights:

- Spectrum *management rights* (the upper tier) provides unrestricted uses over a nationwide block of spectrum. This includes the sole authority to assign spectrum licenses to others within that block.

- *Spectrum licenses* (lower tier) are fully tradable, but may specify conditions of use.

Radio License Regime (RLR)

The RLR is an administrative system providing for the licensing of sites and transmitters, and covers the majority of radiocommunications services (both mobile and fixed). Licenses usually specify the equipment and methods to be used, and must be renewed yearly. RLR license are not tradable.

General User Licenses (GULs)

GULs cover license-exempt use of spectrum.

Other licenses

For completeness, it must also be noted that not all licenses fall under one of the above three categories. In particular:

- non-commercial broadcasting radio licenses are awarded separately and are supervised by the Ministry of Culture and Heritage and the Te Puni Kokiri; and

- the State has retained ownership of certain rights to spectrum bands and products used to meet defence obligations.

Secondary trading

Spectrum trading in New Zealand is allowed within the MRR regime. Currently, about 30% of the spectrum used for telecommunications or broadcasting has been converted to MRs. This is not expected to increase significantly in the future.

Despite this, there has been very little activity in the secondary market in New Zealand. Trading has largely been limited to FM and AM radio broadcasting, where there has been significant consolidation.

The low level of trading activity can be explained by a number of factors (Marcus et al., 2005). First, it may be that the initial spectrum allocation was efficient and market and technology changes have not been such as to alter it. Second, management rights were allocated nationally (rather than regionally as in Australia) reducing the number of potential buyers. Third, licenses have been tailored to specific users on a case-by-case basis, making change of use difficult.

The initial assignment of management rights has been questioned. Because many of these have been allocated to the State, the pool of tradable rights has been reduced. In addition, because the State has tended to issue licenses on a use-by-use basis, change of use through trading has been difficult. Also, many MRs have been taken up by firms wanting to transmit on the frequencies themselves.

The design of license periods may also affect the level of trading. Allocated spectrum differs in terms of license period termination dates and the technical parameters relating to interference, making it impractical to combine rights and licenses. Further, similarly to Australia, finite license periods reduce trading opportunities as it makes it harder for users to recover their investments.

In addition, in many cases there has been unused spectrum available from the Radio Spectrum Management Group (the body which administers the radio spectrum).

To improve on this situation, the Cabinet agreed in 2003 to reallocate commercial MRs to existing users based on an estimation of market value; subject to a case-by-case review to ensure consistency with New Zealand's international radio obligations and with the general objective of maximizing the value of the spectrum to society as a whole.

Technology and service neutrality

Spectrum that is allocated to private management rights (i.e. those not held by the State) is not assigned to any particular use. The management rights holder has the right to decide the use of spectrum, within interference limits.

Much of the useable spectrum however is either unallocated, or is in the form of State management rights[45]. In this case, the State authority grants spectrum licenses which are use specific, and typically contain service requirements (Marcus et al., 2005). Spectrum allocated under radio licenses is also use specific.

There has been little liberalisation in the broadcasting spectrum, with the exception of the growth of license-exempt spectrum. The main changes are in the conversion of radio licenses to spectrum licenses, although as described above, this is unlikely to increase in the near future.

Interference is controlled through the case-by-case area and frequency parameters for initial license assignments.

[45] The majority of the State held management rights are for broadcasting. There are also telecommunications management rights held by the State.

Australia

Overview

Spectrum liberalisation and trading in Australia began with the Radio Communications Act coming into effect in July 1993. Previously spectrum had been managed through a command and control system.

Spectrum management is undertaken by the Australian Communications and Media Authority (ACMA) formed from the merger of the Australian Broadcasting Authority (ABA) and Australian Communications Authority (ACA) in 2005.

There are four main types of licenses in Australia:

Apparatus licenses

Apparatus licenses represent the traditional command and control system in Australia, and authorise the holder to use a specific type of radio transmitter or receiver at a certain location and to provide a certain category of service. They have a maximum license period of 5 years (after which renewal is likely), and are tradable. The majority (approaching 70%) of spectrum is covered by apparatus licenses (Marcus et al., 2005).

Spectrum licenses

Spectrum licenses define the rights and obligations for accessing and using a given "parcel" of spectrum. As far as possible they are service neutral and technology neutral. Spectrum licenses can be traded, leased, combined or broken up and have a maximum license period of 15 years (after which there is no presumption of renewal). Increasingly, apparatus licenses are being converted into spectrum licenses.

Class licenses

Class licenses authorise users of designated segments of spectrum to operate on a shared basis, where common frequencies are employed or equipment is operated under conditions.

Broadcasting and defence licenses

Broadcasting and defence applications are treated differently from other type of licenses in terms of license fees/taxes, obligations and conditions of license renewal.

Secondary trading

Both apparatus and spectrum licenses are available to be traded, although the former requires approval by ACMA.

The Australian Productivity Commission (APC) reported on the experience of spectrum trading in Australia in 2002. The estimates for spectrum licenses (updated to 2004) are reported below.

Table 5: Spectrum license trading in Australia 1998-2004

Year	Number of licenses traded	Percentage turnover rate
1998-1999	50	13.8
1999-2000	33	5.4
2000-2001	47	7.7
2001-2002	51	8.4
2002-2003	54	8.8
2003-2004	22	3.6
Total trades	**246**	**na**

Note: Turnover rate = number of licenses traded each year/total number of spectrum licenses in issue.
Source: Marcus et al. (2005)

As the APC reports, it is hard to accurately assess whether this rate of trading is high or low, due to difficulty in determining an appropriate reference point. However, it is probable that these figures overstate the actual number of trades, as a large number are likely to have occurred between different entities under the same financial control, or that occurred as a result of a sale, merger, or takeover of the company which holds the spectrum license. Also, the number of spectrum license sales seems to have been larger than the number of apparatus license trades (which represented an estimated 2% of licenses in 2000-01 (APC, 2002).

Two possible explanations for this depressed level of trading have been presented. First, as there is no presumption of renewal of spectrum licenses, potential buyers are discouraged from investing in future use, which in turn results in a dramatic decrease in the value of a license with its expiration date approaching. Second, ad valorem taxes payable on secondary trades significantly increase the transaction costs of trading (Marcus et al., 2005).

Technology and service neutrality

Spectrum licenses in Australia are largely technology and service neutral. Licensees are provided with a wide flexibility in the type of uses that they can provide. However, all spectrum (between 9 kHz and 300 GHz) is allocated to various uses, providing some limitations on users' flexibility.

The United States

Overview

Spectrum associated with equipment and services that are operated and used by the US Government is managed by the National Telecommunications and Information Administration (NTIA), whereas spectrum associated with all other equipment and services is managed by the Federal Communications Commission (FCC).

Until one and a half decades ago, spectrum was managed by standard command and control mechanisms in the US. In particular, spectrum was assigned through administrative procedures and spectrum licenses were linked to the requirement that each holder also control the transmission equipment. The latter regulation[46] also impeded the ability of holders to sell or lease licenses.

The first breakthrough occurred in 1993 when the FCC started to use auctions to award new spectrum licenses. Due to regulatory inertia, auctions took off slowly, with only 10 percent of the most valuable spectrum having been assigned through auctions by 2001.

The FCC established a Task Force in 2002 in order to improve spectrum policy and, in particular, assist in identifying and evaluating changes in spectrum policy that would increase the public benefits derived from the use of radio spectrum. In fact, the creation of the Task Force initiated the first ever comprehensive and systematic review of spectrum policy at the FCC.[47]

The Task Force issued a report in November 2002, formulating guidelines for the reforming of spectrum policy. The main recommendations of the Task Force can be summarised as follows:

1. Spectrum policy must evolve towards more flexible and market-oriented regulatory models that must be based on clear definitions of the rights and responsibilities of both licensed and unlicensed spectrum users, particularly with respect to interference and interference protection.
2. No single regulatory model should be applied to all spectrum: the FCC should pursue a balanced spectrum policy that includes both the granting of exclusive spectrum usage rights through market-based mechanisms

[46] Intermountain Microwave Decision by FCC from 1963.

[47] Note that liberalised spectrum management primarily relates to the non-government spectrum.

and creating open access to spectrum "commons", with command-and-control regulation used in limited circumstances. In particular,

- The ownership model should be applied primarily but not exclusively in bands where scarcity is relatively high and transaction costs related to market-based negotiation of access rights are relatively low.
- The commons model should be applied primarily but not exclusively in bands where scarcity is relatively low and transaction costs are relatively high. This model also has potential applicability in the creation of "underlay" rights in spectrum for low-power, low-impact applications, e.g., for operations below an established interference temperature threshold.

3. The FCC should seek to implement these policies in both newly allocated bands and in spectrum that is already occupied, but in the latter case, appropriate transitional mechanisms should be employed to avoid degradation of existing services and uses.

These guidelines, mainly focus on spectrum assignment, i.e. on how to assign a given spectrum to users, and do not address the issue of spectrum allocation, i.e. how to determine specific uses on a certain band.

Regarding the latter, the US has moved progressively towards of flexible use of the spectrum. In particular, the FCC can opt for flexible use, whenever such use:

- is consistent with international agreements;
- would be in the public interest;
- would not deter investment in communications services and systems, or technology development;
- would not result in harmful interference among users.[48]

[48] Based on the 1934 *Communications Act.*

Secondary trading

License transfers have been possible in the US for several years, although with some significant exceptions (Marcus et al., 2005). A 2003 FCC report[49], simplified transfers and leases for a wide range of wireless services. In particular, the report committed to settling applications within 21 days (unless they required more intensive review).

Transfer activity is estimated to involve around 1,000 leases a year. However, transfers through partitioning and disaggregation mechanisms are extremely low (Analysys et al., 2004).

Technology and service neutrality

Practices within the US are generally liberalised, and the FCC normally limits only power radiated (in three categories) for new services (Marcus et al., 2005). Otherwise users are free to provide any service using whichever technology they wish (unless prevented by international agreement).

[49] FCC (2003) *Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets: Report and Order and Further Notice of Proposed Rulemaking.*

The United Kingdom

Overview

The UK is one of the first countries in Europe to commit to a progressive spectrum policy. Spectrum management is undertaken by the Office of Communications (Ofcom), having been conducted by the Radiocommunications Agency until 2003. In recent years, there have been significant movements towards greater flexibility in the use of spectrum, with the launch of the *Spectrum Framework Review* in 2005, and several consultations on spectrum liberalisation.

The review committed Ofcom to the development of a more market-based system, with a vision that:

1. Spectrum should be free of technology and usage constraints as far as possible – policy constraints should only be used where they can be justified.
2. It should be simple and transparent for license holders to change the ownership and use of spectrum.
3. Rights of spectrum users should be clearly defined and users should feel comfortable that they will not be changed without good cause.

The transition to a more liberalised spectrum policy started in the new millennium. The first major step was the auction of 3G telecom licenses between 6 March and 27 April 2000. Following that, the government undertook a review of the radio spectrum management leading to the publication of the *Spectrum Framework Review* in 2005[50].

The Spectrum Framework Review contains the main guidelines for the implementation of a more flexible spectrum policy in the UK, the main focus being on trade and liberalisation.[51]

The review sets out Ofcom's vision for 71.5% of spectrum to be governed by market mechanisms (i.e. trading and liberalisation) by 2010, with a further 6.9% license-exempt. This compares with the share in 2000, whereby 95.7% of spectrum was governed by control and command mechanisms with the remaining 4.3% license-exempt (i.e. none governed by market mechanisms).

[50] The review of radio spectrum management was based on the 2002 study by Professor Martin Cave.

[51] Auctions had been introduced by the time of the review.

Secondary trading

Following the publication of the *Spectrum Framework Review* in 2005, trading was introduced for certain applications (such as data networks and national paging) in December 2004 and is expected to be extended to almost all suitable licenses by the end of 2007.

The rights extended under tradable licenses are not complete property rights, and Ofcom has the right to revoke them without compensation (Aegis et al., 2006).

To date trading has been limited. There were 5 trades in assignments[52] independent of other commercial activity (i.e. mergers and acquisitions) in 2005 and 11 in 2006 (Ofcom, 2007).

Technology and service neutrality

Liberalisation is a more complex issue than trading and is being introduced by Ofcom in three ways (Aegis et al., 2006).

- Licenses auctioned from 2006 onward will not specify the service or technology to be used. Constraints will be in general technical parameters (such as maximum power, or the need for guard zones).
- Licensees may apply to Ofcom to request a variation to their license characteristics. Applications will be considered in terms of impacts on competition and/or spectrum management (particularly potential interference).
- Changes to geographic or frequency boundaries that do not involve a significant risk of interference will be allowed through spectrum trading (as a partial transfer).

Regarding new technologies that might co-exist with licensed use, like UWB and cognitive radio, Ofcom encourages their progress, however, due to mixed experiences; cognitive radio may not be offered license-exemption.

[52] An assignment is the authorisation given by Ofcom for a station to operate using a specific radio frequency channel in a defined location under specific conditions, and a license may be comprised of a large number of assignments.

London Economics
11-15 Betterton Street
London WC2H 9BP
Tel: +44 20 7866 8185
Fax: +44 20 7866 8186
Email: info@londecon.co.uk

London | Cardiff | Brussels | Dublin | Paris | Budapest | Valletta.