Report to Department for Culture, Media and Sport

Incorporating Social Value into Spectrum Allocation Decisions

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Contents

The following appendices are available in a separate document:

Executive Summary

The authors of this document were appointed by DCMS in June 2014 to investigate ways of incorporating social value into spectrum allocation decisions. This is the group's final report.

The value of spectrum derives from that of the services that use it. Spectrum allocation aims to maximise the total value of those services. In this report, we categorise that value under three headings:

- *Private use value*: the private value of the service to its users less the cost of supply
- *Private external value*: the net private value of the service to individuals and that do not use it but are affected by positive or negative externalities
- *Broader social value*: the value of the service to citizens from its impact on social goods such as social capital, political freedoms, national culture, security and inequality (not reflected in private use or private external value)

The distinctions between these categories are not entirely clear-cut especially between private external and broader social value. We have interpreted our brief as covering all aspects of total value, with the particular focus being on exploring methods for incorporating broader social value into spectrum allocation decisions.

In practice, these decisions are usually about *re*-allocating spectrum between spectrum-using services. These services may be provided by either the public or the private sector, although for legacy reasons it would be very unusual to reallocate spectrum from the private sector to the public sector. In Section 2.2, we give some examples of specific allocation decisions over the next 10-15 years.

The key criterion for evaluating the impact of spectrum re-allocation decisions is their expected net impact on the total value of the relevant spectrum-using services. We ignore transition costs here, although they will in practice always need to be considered.

We distinguish between cases where the output of the affected services is likely to remain constant (so that the decision boils down to the expected net impact on their combined supply costs) and more complex cases where the decision will affect the quality, quantity or availability of one or both of the services as well as their supply costs. In the latter case, assessing the impact of a change in spectrum use is more difficult, particularly where there are significant changes in private external value or broader social value that are not reflected in market prices.

Section 2.4 discusses ways of creating incentives for the efficient use of spectrum by the public sector under both constant- and variable-output conditions.

The heart of the report is Section 3, which discusses techniques and procedures for assessing the total value of spectrum-using services as an input to allocation decisions. After reviewing the role of revealed preference (RP) – using market mechanisms to elicit and estimate the private use value of spectrum – we discuss three techniques for assessing total value: stated preference (SP), deliberative research (DR) and methods based on subjective wellbeing (SWB). We compare these three approaches, noting that their strengths and weaknesses are significantly complementary:

- SP data are easy to collect and provide statistically reliable results that can be expressed in monetary terms and therefore fed easily into the decision-making process. Their main disadvantage stems from these apparent strengths, in that some aspects of value, especially social value, are not commensurable with private use value and not reducible to money. More generally, there is a risk that in a poorly designed SP survey the questions asked may not relate closely to the way most members of the public think about the issues.

- In contrast, DR has the usual disadvantages of qualitative methods (lack of scalability and reliability, and concerns about some aspects of validity) but offers richer - and sometimes more valid overall - insights into how the members of the public think about the issues and trade-offs, given the relevant information and a chance to reflect and hear one another' views.

- SWB methods avoid the framing problems of SP (and, to a much lesser extent, DR) and – like SP but not DR - offer statistically reliable results based on large samples. Where suitable data are available, they can also be applied quickly and cheaply. Their disadvantages are a reliance on the availability of suitable data and, especially, concerns over whether they provide valid data on non-use (private external and broader social) value. Arguably, they may also be less reliable for evaluating marginal, as opposed to large, changes in spectrum-using services.

Our recommended procedure seeks to exploit the strengths of the three techniques by combining them. Like the HM Treasury Green Book, we recommend an initial triage stage to decide whether to investigate the impact of the options on external and broader social value and, if so, how elaborate and exhaustive that investigation should be. Where justified at the triage stage, we recommend a procedure including most or all of the following steps (outlined in more detail in Section 3.4):

1. Detailed problem specification

2. Translation of the options and trade-offs into everyday language

3. (Optional) develop an initial estimate of the likely impact on the private use value of the relevant spectrum-using services

4. Publication of a consultation document

5. Deliberative research (DR) study, where appropriate incorporating input from the consultation

6. Stated preference (SP) study using the results of the DR to develop valid questions

7. (If suitable data are available), social wellbeing (SWB) analysis to complement the SP results, possibly in combination with further DR to help interpret the relevance and validity of the results

8. Integrated summary of the results, without trying to reduce them to a single financial number

9. Recommendation or top-line summary of the options and trade-offs.

The aim is to not to generate a single monetary estimate of the impact of the options on total value, but to provide ministers with decision support through a combination of:

- A systematic framework, including a clear explanation of the options and trade-offs, especially the nature of the likely impacts on external and broader social value

- Some financial and non-financial numbers to show the scale of the decision and, where appropriate, the revenue likely to be foregone if the decision is to choose an option other than the revenue-maximising one

- Some illustrative verbatim quotes from the deliberative research and/or the consultation responses, showing how the public, once sufficiently briefed and given enough time, thinks about the issues and trade-offs

- A clear recommendation, or a short top-line summary of the trade-offs, showing how different judgments about the economic and social issues would lead to different spectrum allocations.

Finally, we recommend further work to test and develop our suggested procedure. This could usefully be accompanied by an exploration of the potential contribution to the issue of other academic disciplines, such as political science and economic psychology.

1. Introduction

1.1 Aims, Terms of Reference and Report Structure

Spectrum is a valuable natural resource that supports a large and growing range of commercial and public services, from mobile communications to defence, broadcasting to aeronautical and marine transport, private mobile radio to the emergency services. As its value to the economy and society has increased, its management has received more attention. This is reflected in legislation such as the Radio Communications Act 1996 and the Communications Act 2003, and in the previous Government's 2014 Spectrum Strategy.[1]

Spectrum management includes both spectrum *allocation* (deciding which generic types of service to deliver with each broad spectrum band) and spectrum *assignment* (deciding which specific organisation should have access to each frequency within a wider spectrum band). This report is mainly about spectrum allocation but the same principles apply to spectrum assignment.

The Spectrum Strategy (at paras. 2.11, 2.13 and 2.27) notes that:

- "Our aim is to elicit the best economic and social value for the UK from spectrum. That poses questions about how to assess 'best value' and how to deliver it….
- The analysis of the economic and social value of spectrum has largely been confined to computation of its economic or financial worth to private, individual decision-takers. However, spectrum also has a value to the state, communities and social and economic groups, which goes beyond, and is not captured by, its value to persons considered individually… .
- We intend to move towards a comprehensive system for valuing spectrum that keeps economic value as its bedrock, but extends this to take a range of social costs and benefits into proper account….

ACTION: We will develop a consistent methodology for assessing the full value of spectrum to the UK. To help us in this work we will invite a panel of experts to advise on options, and we will publish our conclusions by July 2015."

We are that panel, appointed by DCMS Ministers in June 2014 with the following brief:

[1] The UK Spectrum Strategy. Delivering the best value from spectrum for the UK. DCMS, 10 March 2014.

- To advise on options for evaluating the social value of spectrum which can be deployed alongside the evaluation of economic value[2]
- To consider how these options may or may not be consistent with the Government's valuation principles
- To consider how these options might be applied to future decisions on the change of use of spectrum
- To deliver a draft report outlining options and a proposed approach for evaluating the social value of spectrum, that can be finalised and delivered to Ministers by 15 May 2015.

We delivered an interim progress report in January 2015. The current document is our final report, submitted in July 2015.

In the rest of this section, we provide further background on the sources and types of value in spectrum-using services; spectrum allocation methods, instruments and issues; and the Government's current approach to social value.

Section 2 discusses different broad types of spectrum allocation decision, examples of future allocation decisions, the key criterion – the net impact of alternative allocations on the total value of spectrum-using services, and ways of creating incentives for efficient spectrum use by the public sector.

In Section 3, we turn to specific techniques and procedures for evaluating alternative spectrum allocations: revealed preference (RP), stated preference (SP), deliberative research (DR), and methods based on subjective wellbeing (SWB). We also briefly mention two other perspectives beyond the scope of this report: political science and economic psychology. We compare and contrast SP, DR and SWB, noting their somewhat complementary strengths and weaknesses, and propose an outline procedure for using them in combination. This section is the heart of the report and readers familiar with spectrum allocation may wish to skip much of the earlier material.

Finally, Section 4 summarises our recommended approach and briefly discusses areas for further work.

The report has six appendices:

- Appendix A covers some persistent problems in cost-benefit analysis (CBA).

[2] The UK Spectrum Strategy highlights use of wellbeing techniques, which we consider in addition to other methods such as stated preference.

- Appendix B illustrates how our decision criterion might be applied in practice using the 700 MHz example.

- Appendix C discusses some previous attempts to incorporate social value into spectrum allocation decisions.

- Appendix D, by Ben Shimson of BritainThinks, discusses the role of deliberative research (DR).

- Appendix E, by Daniel Fujiwara, Susana Mourato and Ricky Lawton of Simetrica, is an extended discussion of economic approaches to social value (SP and SWB).

- Appendix F, under the heading The Economic Psychology of Citizens, discusses political science and economic psychology as additional potential perspectives on the context and analysis of spectrum allocation decisions.

1.2 Sources and Types of Value in Spectrum-Using Services

In this section we discuss the different ways in which individuals may benefit from spectrum-using services, distinguishing between three different categories of value, and explaining why these are helpful. Following this, we explain some of the conceptual and practical difficulties involved in combining the different elements of value to reach an overall aggregate figure that could be used to inform spectrum allocation decisions.

Categorisation of sources of value from spectrum-using services

The value of spectrum to society reflects the value derived by consumers, citizens and suppliers from spectrum-using services. In this report we use the term **total value** to refer to the entire value to society of a good or service. Total value is therefore the aggregate value enjoyed by all individuals from spectrum-using services as consumers and citizens.[3]

It is helpful to distinguish between three different components of the total created by a spectrum-using service value (see Figure 1-1):

- Private user value: conventionally, private user value refers to the benefit enjoyed by individuals from their own use of the service, net of supply costs. This can arise from services provided by the commercial or the public sector, and can relate to an individual's consumption of a private

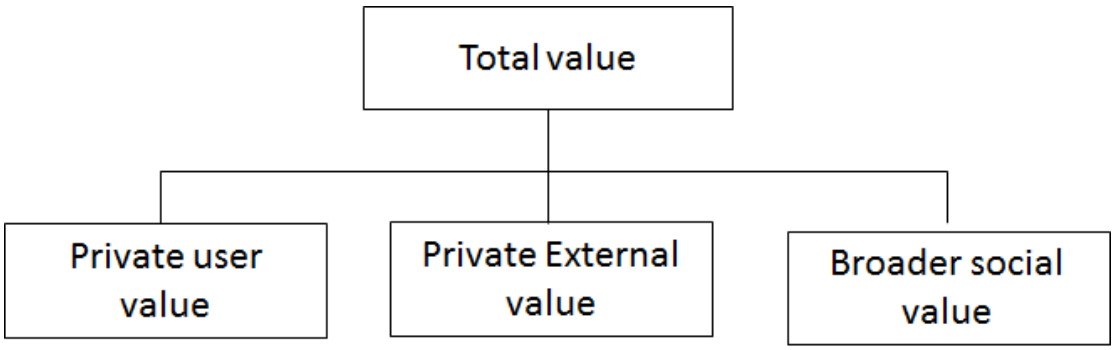
[3] Total value is also sometimes referred to as public interest, social welfare or utility, but not in this report. Appendix E uses the term 'social value', rather than 'total value', to refer to the aggregate value across individuals. We prefer the latter to avoid confusion with the component of broader social value.

good (such as mobile phone services) or from the benefit an individual gains from provision of a public good (such as defence) that is enjoyed collectively by all members of society.[4] More broadly, private user value may arise in other ways. For example, the users of a public good service may benefit indirectly from the impact that the service has on the conduct of *other* member of society. Alternatively, individuals may have an altruistic motive and care directly about the impact of the service on the wellbeing of their family and friends.

- Private external value: this is the benefit (or disbenefit) enjoyed by individuals who do not use the service ('non-users') which arise indirectly as a result of the use of the service by others. For example, interference from mobile services that affects the quality of TV reception would impose a negative externality on TV viewers, since this would reduce their private use value from watching TV. Importantly, private external value only arises in relation to external effects that are not reflected in market prices and hence are not taken into account by individuals in their decision making (these are referred to as 'non-pecuniary externalities').

- Broader social value: this is the benefit individuals derive as citizens from the contribution of the service to social goods that are enjoyed by most or all people in society, typically irrespective of income. Social goods that give rise to broader social value potentially include democratic freedoms, equality, tolerance of minorities, and other aspects of social capital and physical security.

Figure 1-1: Total Value of Spectrum-Using Services



[4] A public good in this context is defined by two characteristics: (a) suppliers cannot prevent individuals from using the service ((this is known as 'non-excludability); and (b) consumption by one individual does not preclude consumption by anyone else (this is referred to as 'non-rivalry'). Given these characteristics, suppliers cannot apply usage charges to consumers, so public goods may be undersupplied by the market. Usage of private goods, by contrast, is excludable, which allows suppliers to charge users if they wish.

The relative importance of the different components of value depends on the nature of the service. In addition, many aspects of social value are contested, and the relevance of broader social value, in particular, may be a matter of controversy. However, in order to reach good decisions, all components generating material values should be included.

In empirical valuation work, the three-way distinction we have made is normally replaced by a distinction between 'use value' and 'non-use value'. The former is the value associated with the direct use of a good or service. The latter is the value that an individual places on the use of the service by other individuals, or from the mere existence of the good or service (see appendix D 2.2.). In our classification, use value corresponds to the private user value derived by individuals from their own use of a service, and to the impact of this use on the private external value of non-users of this service. Non-use value corresponds to broader social value, as well as to components of private use value that arise from concern for others' (e.g. relating to altruism).

We recognise that the boundaries between the different categories of total value may not always be clearly defined in practice. This difficulty stems in part from the fact that private external value and broader social value are both types of external value, in the sense that they relate to value that is derived indirectly by individuals as a result of the others' decisions, rather than directly through their own personal consumption decisions. The sub-division of 'external value effects' into private external value and broader social value is therefore somewhat arbitrary. Nonetheless, it is common in spectrum policy for a distinction to be made between the two. This is reflected in our Terms of Reference, which distinguishes between the economic and social value of spectrum. We sometimes refer to the sum of private external value and broader social value as 'external value' (i.e. the value that is distinct from private use value).

We also consider that it is useful to seek to draw these conceptual distinctions, despite the inherent ambiguities, for two reasons. First, there are important differences in the extent to which the different elements of total value are likely to be reflected in market prices, and hence the risk of market failures that could affect spectrum allocation decisions. In particular, it is often the case that market prices will not fully reflect private external value or broader social value. If these costs and benefits are not taken into account in a spectrum allocation decision (whether in a market-based or administrative approach), there is a risk that a change of use may make the outcome worse rather than better.

The direct and usually best way to remedy this type of market failure is through an intervention that ensures that service providers take the relevant external costs and benefits into account (e.g. via taxes/subsidies applied to the relevant services). This

approach goes directly to the source of the problem, which is that the service is under- or over-consumed at the unadjusted price.

Remedying the problem by an intervention in the assignment of spectrum is an indirect and probably less certain approach. Because such an intervention operates by altering the price of spectrum, an input, it might encourage the firm to over-consume spectrum, so that correcting a market failure in services creates a further failure in spectrum allocation. The Spectrum Strategy implicitly recognises that direct subsidy of services may itself be problematic. It invites us in this report to assess ways of estimating the full (derived) value of spectrum, in order that this may be taken into account in the process of spectrum management.

The second reason for drawing a distinction between the different categories of total value is that this allows decision makers to consider the consequences of alternative spectrum allocations on the different components of total value, and to apply different evaluation criteria if appropriate. For example, in conventional cost benefit analysis estimates of willingness to pay for private and public goods are commonly summed and compared to costs. It is well known that this approach may be sensitive to the prevailing income distribution, and hence rests on a view that this is in some sense acceptable, or is addressed through suitable policy interventions. It is far from clear, however, that the standard cost benefit approach should be applied to the type of citizen-related social goods that potentially give rise to broader social value, and it may be more appropriate to apply an evaluation criterion that represents citizen interests in a way that is independent of income (such as majority voting with one vote per citizen).

Summing the components of total value

We recognise that there are both conceptual and practical problems with attempting to derive total value as the sum of the three components. A key conceptual issue is whether broader social value can be validly expressed in the same monetary terms as private use value and private external value. As discussed later, different measurement approaches, use incommensurate measures of value (e.g. qualitative or ordinal, especially for the broader social value).

Another important consideration alluded to above is that it may be inappropriate, as a matter of principle, to seek to measure individuals' willingness to pay for social goods related to broader social value and add this to their WTP for other elements of value. As discussed above, such a procedure would implicitly give greater weight to individuals with higher income, which may not be desirable from a policy point of view.[5]

[5] In principle, this could be addressed through the choice of a suitable set of distributional weights that adjust for income differences.

In addition to these points, a more practical issue is that the definitional boundaries between the three components of total value is far from clear, and there is a risk of double counting if the categories overlaps. It may, in principle, be possible to avoid this particular difficulty by estimating total value directly.

Finally, we note that it is generally easier to estimate the value associated with private use value for market goods through revealed preference methods that use market data. This is not usually possible in relation to external private value, broader social value, public and other non-market goods, and also elements of private use value that are related to non-use motives such as altruism. Thus an estimate of the private benefit of a service, say a television service, might be obtainable from its consumers, ideally using real market data, but to assess its wider social benefits (e.g. enhancing citizens' education level or quality of life) it may be necessary to interrogate a much wider group and interpret the responses appropriately. We discuss the available methods for estimating total value and its constituent parts in section 3.

1.3 Spectrum Allocation Methods, Instruments and Issues

Spectrum-using services (e.g. broadcasting) are allocated to specific frequency ranges. Allocation may be on a primary or a secondary basis[6]. The allocation process is carried out at an international level at World Radio Conferences (WRC) run by the ITU. This allows cross border effects to be taken into account and provides opportunities for harmonisation and the operation of services on a regional or wider basis. The decisions are recorded in the radio regulations. National administrations and regional bodies such as the European Union use the WRC allocations as the basis for national frequency allocations.

National spectrum authorities allocate spectrum to different types of service and then decide which organization(s) should be assigned use of each specific frequency, often using the instrument of a licence. This includes reissuing licences in bands whose use has not changed as a result of a national, regional or global decision; assigning new, previously unused, bands; and re-assigning bands whose use has been changed - a process known as 'refarming'.

The UK Spectrum Strategy Committee, which develops strategy at the national level, is chaired jointly by DCMS and the MoD and reports to the responsible Minister. Ofcom implements this strategy and compiles the UK frequency allocation table (FAT) that records the allocation and assignment of each frequency band. Ofcom

[6] Services with a primary allocation enjoy certain rights including protection from interference. Services with a secondary allocation must not interfere with primary services, but are themselves not protected from interference from primary services or other secondary services

also has direct responsibility for making some allocations and assignments for commercial spectrum use.

Changes of spectrum use often result from international decisions, e.g. at WRC or EU level. There may also be national changes of use where these do not adversely affect spectrum users in other countries. Ofcom is usually the agency tasked with implementing such changes of use in the UK. This may involve clearance of existing users from the affected spectrum and assignment of new users to it. If the existing allocation or change of use involves a public sector user (e.g. the MoD) other agencies may also be involved.

Traditionally, spectrum assignments were made by 'command and control' or administrative methods. Licences granting access to spectrum to private users and authorisations to public users were made directly on an administrative basis rather than by the operation of a market place. Commercial licences were subject to an administrative charge designed to recover the costs of spectrum management, rather than the full value or opportunity cost of the spectrum.

As demand for spectrum increased, attention turned to more 'economic' approaches to its management, the aim being to make the user pay an access charge that better reflected the scarcity value of the spectrum, encouraging more efficient spectrum use.

The options currently available to assign, or influence the assignment of, spectrum in the UK include the following:

- 'First come, first served': the spectrum authority has on occasion been prepared to assign spectrum not previously in demand to the first applicant for it satisfying appropriate conditions
- 'Beauty contests': competing applicants are judged on a variety of pre-specified criteria, the licences being granted to those scoring highest
- Auctions: the spectrum is allocated or assigned to the highest eligible bidder. In principle, the auction design may be modified to ensure that external benefits are adequately taken into account by bidders (for example by 'weighting' the bids of users that provide services with high external value.
- 'Administrative incentive prices' (AIP): the regulator seeks to proxy the market value of the spectrum via a calculation method; the user is charged the calculated amount.

Our task is to evaluate and make recommendations about methods to take into account externalities and broader social value when using these options to allocate or assign spectrum.

1.4 The Government's Current Approach to Social Value

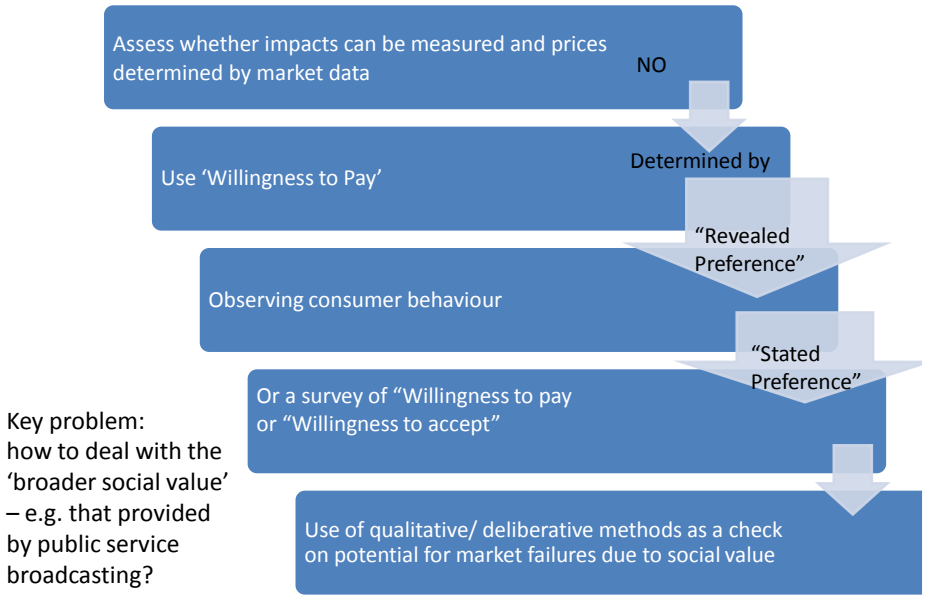
The Government's valuation principles are set out in the HM Treasury *Green Book on Appraisal and Evaluation in Central Government* (The 'Green Book').

This sets out currently accepted best practice for applying cost-benefit analysis (CBA) to government decision-making. The valuation of benefits is relevant to the measurement of value derived from spectrum. The Green Book does not propose that 'social value' constitutes a separate component of value, which should be measured separately to 'economic value'. Rather it recommends that appraisal and evaluation should take account of non-market impacts (in our terms, private external and broader social value) as well as direct market impacts, and leaves open the question of how decision-makers should combine them. This reflects the current state of development in CBA.

Non-market impacts (Green Book: p 57) constitute such benefits as time-savings, health benefits, prevented fatalities, design quality and the environment. The Green Book also indicates (p6) that various 'impact assessments', such as health, environment, and consumer impacts that include a mix of economic and social outcomes, can potentially be part of the overall approach to government decision-making, depending on the regulatory framework that applies to a given sector.

In the case of non-market approaches, where market indicators of value ('revealed preferences') are not available, a series of procedures are suggested involving 'stated preference' (what survey respondents say they would be willing to pay or accept) and a variety of proxies and indirect indicators such as how much transportation time or additional housing cost would be 'paid' for a given benefit.

Figure 1-2: The Green Book Approach



Adapted from UK Treasury (The Green Book July 2011) p23.

Other countries use slightly different approaches. The US equivalent to the Green Book is the US Government's Circular A4 from 2003.[7] These government documents mention a number of the difficult and persistent problems with CBA. These are discussed in detail in Appendix A. The implication is that each of these valuation methods, as well as the proposed combination of them outlined in this report are useful but fallible in the context of spectrum valuation. They should be used in the context of awareness of their limitations and in particular mindful that:[8]

(i) total value may not be the arithmetic sum of private use value, private external value and broader social value, because the categories may be incommensurate or may overlap;

(ii) value calculations may conflict with rights based approaches.

(iii) all stages of research including reporting should be transparent about assumptions and levels of uncertainty

[7] https://www.whitehouse.gov/omb/circulars_a004_a-4

[8] See appendix A.

(iv) transparency is particularly critical when qualitative research indicates the presence of broader social value that is difficult to quantify.

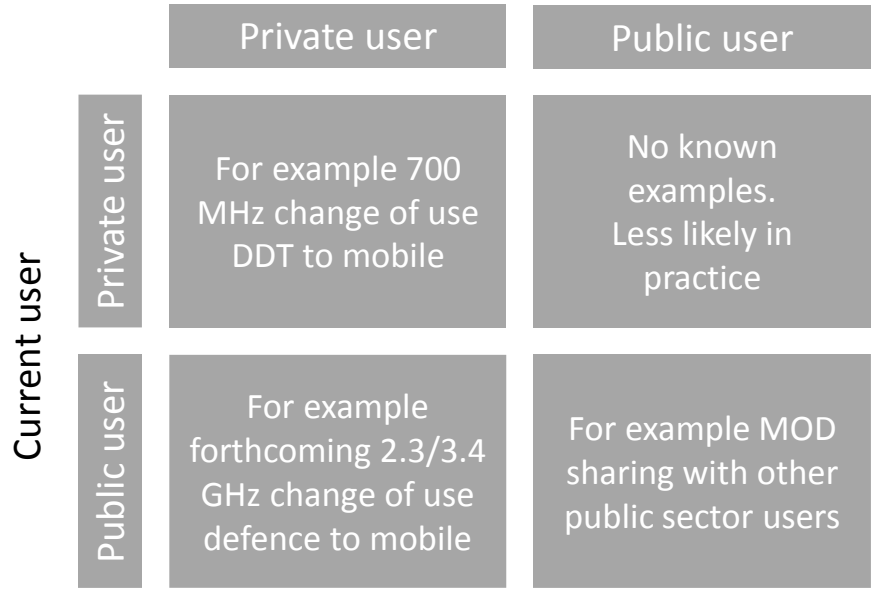
2 Spectrum Allocation Decisions

Section 2.1 first discusses the types of spectrum allocation decision that can arise, based on whether the current and new users are private or public. Section 2.2 highlights a number of future allocation decisions likely to arise over the next 10-15 years. Section 2.3 sets out a framework for assessing spectrum allocation decisions and discusses a simple criterion for determining whether a proposed change in allocation will increase the total value derived from spectrum services. Finally, Section 2.4 briefly considers how public sector users can be given incentives to make use spectrum efficiently.

2.1 Types of Spectrum Allocation Decisions

Ofcom manages spectrum used by commercial services. Spectrum used by public sector bodies (for non-commercial applications) is managed by other government departments such as the MoD. In practice, most allocation decisions involve reallocating spectrum that is already being used, in one of the four generic ways shown in Figure 2-1:

Figure 2-1: Types of Spectrum Reallocation Decision



Most major reallocation decisions fall into three of these categories:

- Private sector to private sector

- Public sector to private sector[9]
- Public sector to public sector.

In principle, spectrum could be reallocated from the private sector to the public sector, but this is currently unlikely since the expert consensus is that most public sector bodies, having historically been allocated spectrum at little or no cost, are still using an above optimal amount. We therefore do not consider this further.

Historically spectrum has often been allocated for the exclusive use of a particular type of service (e.g. mobile, broadcasting). Assignment of such spectrum is usually done on a licensed basis. A reallocation decision can also involve spectrum sharing between parties using technical coordination measures. In future, this may be done using Licensed Shared Access (LSA), a concept currently being developed to allow more efficient use of spectrum on a licensed basis that will provide a guaranteed quality of service for each spectrum user[10].

Finally, spectrum could also be allocated to licence exempt use. In this case any service that meets the technical criteria for use of the band may operate without a licence. Examples include Bluetooth and Wi-Fi.

The next section considers some important allocation decisions that may need to be considered over the next 10-15 years. We then discuss in more detail how the value of spectrum is derived from that of spectrum-using services. This provides a framework for making spectrum allocation decisions that are informed by the available evidence on the economic and social costs and benefits of alternative allocations.

2.2 Examples of Future Allocation Decisions

There are likely to be significant changes of use over the next 10-15 years, mainly driven by the voracious demand for spectrum for commercial mobile broadband (MBB) services[11]. However, these are not the only changes foreseen and services such as Public Protection and Disaster Relief (PPDR) will require more spectrum as they modernize and adopt broadband technologies. Further examples of commercial services that could require spectrum in future include machine to machine and

[9] For example spectrum being released by the MoD at 2.3 GHz and 3.4 GHz, which is expected to be auctioned by Ofcom in late 2015.

[10] Note that other forms of spectrum sharing are possible such as dynamic spectrum access. See Ofcom's Statement "The future role of spectrum sharing for mobile and wireless data services: Licensed sharing, Wi-Fi, and dynamic spectrum access". April 2014.

[11] Note that MBB spectrum is usually harmonised on an international basis to ensure that sufficient economies of scale exist for equipment manufacture and to facilitate device roaming between countries.

internet of things (IoT). For now Ofcom has not identified a specific requirement for new spectrum for IoT[12].There are many other examples too numerous to list here such as vehicle based systems and autonomous flight devices. Table 2.1 lists some major examples of change of use that are likely to occur[13].

Table 2-1: Potential Allocation Decisions for Mobile Broadband (MBB)

Service	Frequency band	Current use of band	Anticipated date of change	Notes
Mobile broadband	UHF 700 MHz	UHF TV broadcast	2020 – 2022	See Ofcom Statement[14] The proposed band plan for this spectrum includes an option for Supplemental Downlink (SDL) within the band[15]

[12] http://stakeholders.ofcom.org.uk/binaries/consultations/iot/summary/iot-cfi.pdf

[13] Note that there are other frequency bands likely to become available in the short term not listed here such as 1452-1492 MHz which is expected to be allocated to mobile at WRC15. In the UK this spectrum was recently traded by the current licensee.

[14] http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/statement/700-mhz-statement.pdf

[15] SDL is a downlink only channel which is aggregated with paired spectrum to increase delivery capability for multimedia applications.

Service	Frequency band	Current use of band	Anticipated date of change	Notes
Mobile broadband	UHF sub 700 MHz (470-694 MHz)	UHF TV broadcast[16]	Beyond 2022	Being considered by national governments, European Commission and RSPG and CEPT but a longer term decision given the commitment to provide terrestrial television services until at least 2030. See consultation responses to the Lamy High Level Group report commissioned by the European Commission[17]
Mobile broadband	4G and 5G services in sub 6 GHz (likely to be at 2.7 GHz and above)[18]	Multiple services including fixed links, satellite and aeronautical – public sector and private sector use	Beyond 2022	Ofcom has published indicative timescales for release of spectrum as follows[19] • 2.7-2.9 GHz (2028) • 3.6-3.8 GHz (2022) • 3.8-4.2 GHz (2028) It is highly likely that mobile services will share with incumbent services.

[16] Ofcom does not expect a full switch off of DTT prior to 2030. See http://stakeholders.ofcom.org.uk/consultations/700MHz/ftv/. Also, Ofcom will seek to ensure the protection of digital terrestrial television (DTT) operating in the 470 – 694 MHz band in the UK at WRC15. See http://stakeholders.ofcom.org.uk/binaries/consultations/wrc15/statement/UK_Positions_for_WRC-15.pdf

[17] Lamy proposed regulatory security and stability for terrestrial broadcasters in the remaining UHF spectrum below 700 MHz to be safeguarded until 2030 with a review by 2025 to assess technology and market developments. See http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=9736

[18] Other frequencies sub 6 GHz could become available such as 1427-1452 MHz but the timing of these is less certain and Ofcom indicate it is after 2022.

[19] http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/statement.pdf

Service	Frequency band	Current use of band	Anticipated date of change	Notes
Mobile broadband	5G services above 6 GHz	Multiple services including fixed links, satellite and aeronautical – public sector and private sector. Search for candidate bands is focusing on range 17-100 MHz[20]	Beyond 2022 and likely to be later	Work is being undertaken by a number of bodies worldwide to identify candidate bands for mobile services at above 6 GHz. This is likely to be an agenda item for WRC19. The requirements for spectrum are likely to be characterised by the need for wider channels (e.g. up to 100 MHz) and larger blocks of contiguous spectrum to support them. It is highly likely that mobile services will share with incumbent services in these bands. Ofcom has consulted on this matter[21]
PPDR	700 MHz band	UHF TV broadcast	Under discussion	The draft CEPT band plan for the 700 MHz band provides a national option for dedicated spectrum for PPDR services. Note that the UK currently intends to provide these services in commercially licensed mobile spectrum.
Programme Making and Special Events	Various bands including UHF	For audio and video services	Under discussion	Ofcom has proposed a move to spectrum at 2.3 GHz and 7 GHz[22]

[20] For example by the 5G Innovation Centre (5GIC) at the University of Surrey and METIS2020 a European Commission project under the 7th Framework Programme.

[21] http://stakeholders.ofcom.org.uk/binaries/consultations/above-6ghz/summary/spectrum_above_6_GHz_CFI.pdf

[22] http://stakeholders.ofcom.org.uk/binaries/consultations/pssr-2014/statement/Statement_on_camera_strategy.pdf

Service	Frequency band	Current use of band	Anticipated date of change	Notes
Licence exempt – RLAN (Wi-Fi) at 5 GHz	5350-5470 MHz	Various public services including Copernicus[23], and ITS (Intelligent Transport Systems)	After WRC19	The band is attractive for radio LANs as it is adjacent to licence exempt spectrum already used for this purpose. However there are coexistence issues with incumbent services and it is unlikely to be made available in the near future.

2.3 The Key Criterion for Efficient Allocation Decisions: Net Impact on the Total Value of Services

The key criterion for spectrum allocation decisions is the net impact on the aggregate total value of the services using the relevant spectrum. In other words, a proposed change in allocation represents an improvement if it results in an increase in the aggregate total value derived from the services that would be affected by the change. In addition, there are often significant transition costs, as with digital TV switchover. These are ignored in this report but may of course need to be factored into real-world spectrum allocation decisions.

As mentioned above, spectrum reallocation decisions usually involve an incremental increase/reduction in spectrum for different services which results in an incremental change in the total value derived by consumers and citizens from the services. To assess whether there is an increase in aggregate total value, we therefore need to compare the incremental benefit from the change in use, defined as the increase in the total value from the new use, against the opportunity cost, defined as the reduction in the total value from the existing use.[24]

It is important to be specific about the precise change in spectrum allocation that is being considered and the expected impact on the availability, cost, and quality of both the new and existing services. While a change in spectrum use typically involves a reduction in the spectrum available to existing services, these services will usually continue to be provided in some form using some combination of different

[23] The European Earth monitoring programme GMES (Global Monitoring for Environment and Security).

[24] In practice, the 'new' service will often already exist and this terminology is used for convenience.

spectrum, additional network investment, and/or increased use of other inputs and methods of supply. The impact of the proposed spectrum reallocation on the output of the new and existing services should take account of the next best alternative for the suppliers to the relevant spectrum

There is an important conceptual and practical distinction between changes of use that have no effect on the output of either the existing or the new service ('constant output') and changes of use that do affect the output of one or both services ('variable output'). The discussion below considers the implications of the net total value criterion for each of these cases in the context of licensed spectrum that is allocated for the exclusive use of a particular type of service. Appendix A provides a stylized example to illustrate how the net total value criterion for an efficient change of use is applied. Spectrum may also be made available in the form of licensed shared access or licence exempt spectrum (see section 2.1), and we briefly comment on these two cases.

Constant output case

In the constant output case, the provider of the existing service is able to fully mitigate the impact of the change in spectrum use through the means described above, albeit at an increased cost of supply. Similarly, the new service uses the additional spectrum to provide the same output at lower cost.

If the output of both the new and existing services are unaffected by the proposed change in spectrum, this implies that there is no change in any of the components of total value for either service, except for their supply costs. The opportunity cost of the change is thus equal to the increase in the supply cost of the existing service, and the incremental benefit is equal to the reduction in the supply cost of the new service.

The implication of this is that there is no need to estimate the impact of the proposed change in allocation on the benefits to consumers and citizens from either service, and hence there is no need to consider changes in private external value or broader social value for either service. Instead, it is sufficient to estimate the net impact on supply costs, which should be considerably less challenging.

Variable output case

In contrast, in the variable output case the change in use affects the output as well as cost of one or both services: for example, the existing service may be unable to maintain its output, even after taking mitigation steps, and/or the new service may be

able to increase or improve its output.[25] The empirical assessment of the variable output case is typically much more complex than the constant output case, and will require an assessment of the incremental impact of the change of allocation on the private user value, external value, and broader social value for both services.

In theory, it may be possible to simplify matters if the output of the existing service is unaffected by the proposed reallocation (we refer to this as the *semi-variable output case*). In this case the opportunity cost of the proposed change is equal to the increase in the supply cost of the existing service (since there is no impact on the output of the existing service by assumption). While the incremental benefit to the new service will generally depend on the change in all three components of total value, it may be useful to first consider whether the reduction in the cost of supply for the new service (evaluated at the original output level) outweighs the increase in the cost of supply of the existing service.

If this is the case, this implies that the proposed reallocation would increase aggregate total value unless the increase in output of the new service would give rise to a significant incremental loss of private external value or broader social value from the new service (noting that a reduction in broader social value is a priori unlikely, since the output of the new service will be greater). This reasoning suggests that it may only be necessary to carry out a relatively high level assessment of the impact of the reallocation on the benefits derived from an increase in the output of the new service aimed at assessing whether there is a risk of a material reduction in private external value.

Licensed shared access

With licensed shared access, a given band is used by two or more applications. Each service effectively has a sub-band for its exclusive use on a temporal or geographic basis. The advantage of this approach is that it offers the potential to increase efficiency and the value derived from spectrum by allowing several services to access the band.

The assessment of a proposed change of use involving licensed shared access again involves a comparison of the opportunity cost and the incremental benefit for the affected services. The key difference compared to the licensed access case is that the analysis must be based on the net impact on the value of all the services in the band. While this does not raise any new valuation issues in terms of the underlying principles, practical implementation will be more complex due to the greater number of services to be considered.

[25] It is possible, though unusual, that the reduction in spectrum means that the existing service can no longer be provided at all. In this case, the opportunity cost of spectrum for this service is equal to the total value of the service foregone.

Licence exempt access

With licence exempt access, any service that meets the technical criteria for use of the band may operate without a licence. While users benefit from access to "free" spectrum, they face the risk of access problems caused by congestion/interference from other users. Licence exempt access is therefore generally unsuitable for services that require high sunk equipment costs and are vulnerable to interference.

Whether to offer a band on a licensed or unlicensed basis depends on the nature of the designated service(s). Licensed access is generally preferable where demand for the band in the same geographical space is sufficiently great that there is a risk of harmful interference that would significantly compromise the total value of spectrum-using services.

2.4 Incentives for Efficient Spectrum Use by the Public Sector

This section briefly discusses how public sector spectrum users can be incentivised to make efficient decisions on spectrum use though an appropriate market mechanism (such as auctions, trading, and AIP).[26] For the purpose of this section we assume that as a matter of practice the spectrum assigned to a public sector service (e.g. defence) will be reduced only if this does not lead to a loss of service output/capability, for example because spectrum is 'surplus to requirements' or the service can be delivered using different inputs.

The main advantage of market-based mechanisms for spectrum allocation over alternative administrative approaches is that they devolve decisions to the people best able to judge the relevant trade-offs. The efficacy of market mechanisms depends on: (a) whether a change in spectrum usage has a financial impact on spectrum users; and (b) the extent to which this financial impact fully reflects the impact of alternative spectrum usage on the total value of the service (including private external value and broader social value where relevant). If these two conditions are met, the experts who best understand the trade-offs involved will face the correct prices of the inputs they may use to provide services, and they will have both the incentive and the information to make efficient choices.

We discuss each of these conditions below.

Financial impact of spectrum allocation on public sector bodies

In general, changes in spectrum allocation may have an impact on both the costs and the revenues of service provider. For a commercial private sector service

[26] For a fuller discussion, see Cave, Martin, *Review of Radio Spectrum Management*, DTI and HM Treasury, March 2002.

provider, changes in supply costs and/or revenues achievable from an incremental change in spectrum will affect profits and hence influence spectrum usage decisions.

In contrast, the impact on public sector bodies will depend on whether budgetary processes allow them to retain any cost savings (and/or revenue increases if applicable) arising from a change in spectrum usage. For this to be the case, there needs to be an arrangement by which the public sector body can retain cost savings or proceeds from releasing spectrum (at least for a reasonable period of time). Without such as arrangement (e.g. because cost savings have to be passed back to the funding body), the public sector body will have no incentive to economise on its spectrum usage, and the change of use decision will need to be made on an administrative assessment of costs and benefits rather than through a market mechanism

Alignment of financial impact with incremental change in total value of service

Assuming that budgetary arrangements ensure that public sector spectrum users can retain cost savings (or revenue increases) from changes in spectrum use, there is then a question of whether the financial incentives faced by public sector spectrum users are likely to reflect the incremental impact on the total value from the service they supply. As noted above, we assume that a spectrum reallocation occurs only if the public service that is currently using the spectrum (the existing user) is able to maintain its output.

We first consider the situation where the proposed change in spectrum has no impact on the output of the service that gains the use of the spectrum – this is the constant output scenario described earlier. Following this we consider the (semi-) variable output scenario where the output of the service gaining use of the spectrum increases.

Constant output case

We established earlier that it is efficient to reallocate spectrum in the constant output case provided the reduction in the cost of supply for the new service exceeds the increase in the cost of supply for the existing service. It follows that provided the existing public sector user is able to retain any cost savings (e.g. due to a reduction in AIP) and/or the proceeds from trading spectrum, then it will have a financial incentive that is fully aligned with the impact on the total value of the service is supplies.

The new service that benefits from the change in spectrum use may be provided commercially or by another public sector body. These possibilities correspond to a public sector to commercial sector change of use, and an intra-public sector change of use, respectively. Any reduction in supply costs will lead to an increase in the profit of a commercial service, and hence its incentives will be properly aligned with

efficiency. This will also be the case for a public sector service, provided that it can retain the reduction in cost, net of any payment for the spectrum.

Variable output scenario

In this scenario we still assume that the spectrum reallocation does not result in a loss of service output/capability for the existing (public sector) user but does allow the new user to increase output. The efficiency of the change of use therefore depends on the incremental change in the private user value, external value, and broader social value associated with the increase in output of the new service, as well as on the net impact on the combined supply cost of the services.

In this case, market mechanisms may not lead to an efficient outcome since the financial incentive of the service that benefits from the change of spectrum use may not fully reflect the change in the total value of the service it provides. This is true whether the new service is provided commercially or by a public sector body, and even if there are arrangements that allow public sector spectrum users to retain any cost savings and revenue changes from a change in spectrum use.

Specifically, whilst a commercial provider of the service that gains the spectrum will benefit from any increase in profits, this may not be closely aligned with the incremental change in the total value of the service from the change of use if the increase in output results in a significant incremental change in private external value or broader social value that are not fully monetised by the commercial service provider. In principle, this could be remedied through subsidies for the commercial service that ensure these non-financial impacts are taken into account by the commercial service provider.

A similar difficulty can arise if the service that gains the spectrum is provided by a public sector body in that the new user's willingness to pay may not capture all of the incremental value generated by the activities for which the spectrum is to be used. In practice, however, this may be a more acute problem for an intra-public sector change of use, compared to the public to commercial sector case, since the new public sector service provider may be less able to monetise the incremental value of the increase in service output. This may arise for two reasons: services provided by the public sector often have zero or low service revenues; and external value may be particularly significant. These same issues may also arise in the cases of some commercially provided services (e.g. public goods provided under contract).

Implications

Market mechanisms can play a useful role in the evaluation of intra public sector change of use, especially if the decision is a technocratic one of evaluating cost savings from using additional spectrum and identifying efficient combinations of inputs. In this situation, provided the spectrum-releasing department is enabled to

keep the resulting proceeds or cost savings and the department obtaining the spectrum pays the opportunity cost, a market mechanism can lead to an efficient outcome.

Where the decision depends on the scale of externalities and broader social value, market mechanisms are less useful and other approaches may be needed. Ultimately, decisions of this nature require ministerial judgment, in the same way as decisions on taxation and public spending priorities are matters for ministers. The techniques discussed in the following section (stated preference, deliberative research and subjective well-being) aim to provide decision support to ministers making those judgments.

3 Techniques and Procedures for Establishing Value

This section considers the main empirical methods that could be applied to estimate the total value of spectrum services to consumers and citizens. We outline the main features of each method, assess the applicability to spectrum valuation, and propose a procedure for combining them into an integrated decision support procedure that could help ministers make efficient spectrum allocation decisions.

The primary focus of this section is on valuation techniques that can be applied to goods and services generating broader social value. These include both marketed services, such a mobile communications, and non-marketed services such as defence. In the former case, customers' willingness to pay for private use the service (or, more precisely, potential suppliers' conjectures of that magnitude) can in certain conditions be inferred from the auction proceeds, permitting use of that method to allocate or assign the spectrum on a 'private use value' basis. Thus if an auction process is adopted, the problem we are addressing may default to estimating private external and broader social value. Whereas, in the case of a non-marketed output, it may be necessary to estimate all components of value.

Section 3.1 considers the revealed preference (RP) valuation method. This is the standard approach for estimating the private use value of goods and services using market prices. Sections 3.2 and 3.3 consider and contrast three alternative techniques for assessing the impact of a change in spectrum use on the incremental total value of spectrum using services, none of which relies on market prices: stated preference (SP), deliberative research (DR) and methods based on subjective wellbeing (SWB). Section 3.4 considers the link between the above methods with auctions, while section 3.5 sets out a possible procedure for combining the various methods.

3.1 Revealed Preference valuation methods

Revealed preference (RP) valuation methods provide a means of estimating the private value individuals derive as users of goods and services based on their observable purchase decisions made in the market place. RP methods can be applied straightforwardly to market goods and service to provide estimates of WTP on the basis of market prices, and estimates of consumer surplus based on the observed relationship between demand and price.

RP valuation can also be applied to non-market goods for which there is no market price. This involves identifying a complementary market good whose price captures the impact of the non-market good (this is often referred to as a 'hedonic price'). For example, a comparison of the price of comparable properties in areas with different levels of mobile coverage may provide a way of assessing the value of mobile coverage.

The applicability of RP methods to non-market goods is limited by a number of fairly restrictive conditions: (a) the existence of a suitable complementary market good; (b) consumer WTP for the market good being significantly influenced by the non-market good; and (c) sufficient data to allow for the impact of the non-market good on the price of the market goods to be identified statistically after controlling for other relevant factors

In addition to these practical limitations of RP methods, the choices agents reveal in their spending decisions will reflect the private value that they gain from their own use of a service. For this reason, RP methods do not capture economic externalities or broader social value even where applicable.

A further issue with RP methods may restrict their applicability to spectrum allocation decisions is that they provide valuations based on past choices. The usefulness of RP estimates of value to a future spectrum decision will therefore depend on the extent to which it is possible to find an RP estimate that relates to a comparable situation.

3.2 Three Non-Market Valuation Methods

For the reasons set out in the previous section, we consider that RP valuation methods are likely to be of limited assistance in the estimation of the impact of changes in spectrum allocation on total value, particularly where there are significant changes in private external value or broader social value, or other aspects that are not reflected in market prices either directly or indirectly. We therefore need to look beyond RP at other techniques. We are not starting completely from scratch, but previous efforts are of rather limited help:

- As already discussed in Section 1.4, the Green Book already attempts to incorporate social value into government decision-making in general using stated preference (SP) techniques and cost-benefit analysis (CBA). However, SP techniques have some clear limitations, discussed shortly, and there are also some persistent, related problems with trying to use CBA to measure social or total value, the fundamental one being the incommensurability of economic and social value (see Appendix B).

- Appendix C briefly discusses two previous attempts specifically to incorporate social value into spectrum allocation decisions: Ofcom's digital dividend review (DDR) in 2005-07[27] and the 2012 report of the BEREC/RSPG working

[27] http://stakeholders.ofcom.org.uk/consultations/ddr/statement/. Damian Tambini, a member of the current panel, acted as a consultant to Ofcom for the DDR.

group.[28] The DDR concluded that the differences in the estimated social value of the various services competing for the spectrum to be released by analogue TV switch off were insufficient to alter their rankings, but that this might reflect weaknesses of the methods used to assess them. The BEREC/RSPG report recognised the importance of incorporating social value but did not reach a consensus view of how to either define it or assess it.

We have explored three non-market techniques for assessing the total value of spectrum as alternatives to revealed preference:

- Stated Preference (SP)
- Subjective Wellbeing (SWB)
- Deliberative Research (DR)

Note that we describe these as techniques for evaluating the *total* value of spectrum, since they can, in combination, be used to estimate or explore the elements of consumer and citizen value from spectrum services that are unlikely to be reflected in market prices (most notably private external value, broader social value, and potentially elements on non-use value such as altruism).

Figure 3.1 summarises the three non-market valuation methods, and we describe the key features of each below. Further details on the DR method can be found in Appendix D, and on SP and SWB in Appendix E.[29]

Figure 3-1: **Non-market valuation methods**

Technique	Description
Stated preference	Stated preference relies on asking hypothetical questions via a survey ('contingent valuation') or choice experiment ('conjoint measurement'), to see how people respond to a range of choices and establish the extent of a collective willingness to pay for a particular benefit. It is used in Government by, for example, the Department for Transport

[28] Joint BEREC/RSPG Report on exploring the economic and social value of radio spectrum for certain electronic communications services with respect to the frequency assignment procedures, BoR (12) 15, 2012.

[29] Appendix D was prepared by Ben Shimson of BritainThinks. Appendix E was prepared by Daniel Fujiwara, Susana Mourato and Ricky Lawton of Simetrica.

Deliberative Research	Deliberative research aims to involve the public in decision-making. It enables a limited number of participants to find out more about a topic, consider relevant evidence, discuss this evidence and present their views. Deliberative research has, for example, been used in the NHS and in assessing the public's preference for different combinations of BBC services
Subjective Wellbeing	Subjective wellbeing valuation uses subjective wellbeing data to attach monetary values to non-market goods. It relies on the availability of time series data that allows analysts to identify the impact of a potential change in spectrum services on wellbeing. It does not rely on revealed or stated preferences.

3.2.1 Stated preference valuation

The most obvious way to measure the total value the public would place on specific combinations of spectrum-using services is to ask them – in other words, to use an SP approach. Decision-makers would rarely need very precise estimates. All they would need is to see if asking respondents about total value (including the value placed on externalities and wider social benefits) changed the ranking of the options.

SP is a well-established approach to empirical valuation for both market and non-market goods and services. There are two main types of SP: contingent valuation (CV) and choice experiments. Whilst both are potentially relevant, the former is likely to be more relevant in the context of spectrum-related policy changes which may be complex for individuals to assess. We therefore focus on the CV approach here, but further details on the CE approach can be found at appendix D4.2. We use the term SP to refer specifically to the CV approach in the main body of the report.

As indicated above, SP valuation is a survey-based method in which the monetary value of non-market goods and services is elicited by directly asking people what value they attach to specified changes in those goods and services. In an SP study of spectrum allocation, respondents could be asked to value a change in final outcomes relating to spectrum services that results from a change in spectrum allocation. This would be used to derive a monetary estimate of the WTP for a specified outcome

SP valuation is based on a preference satisfaction account of welfare and is therefore based on the assumption that individuals' choices are rational and stable over time. The ability of the method to provide an accurate estimate of actual WTP clearly relies on the extent to which individuals' responses to a hypothetical survey are similar to the actual choices they would make in an equivalent 'real' situation.

Advantages

SP has a number of advantages, including:

- SP data are cheap to collect and have the added benefit of being relatively easy to feed into the decision-making process because the results are either expressed in financial terms (covering any combination of the components of total value in Figure 1.1) or in the form of a total value ranking of the options.

- Results are fairly reliable, being based on large samples, can be sensitive to small changes in question wording.

- SP valuation is highly adaptable and can (in principle) be used to value a wide range of goods and services provided these can be accurately captured in the survey in a way that elicits meaningful responses. In particular, SP methods are capable of dealing with situations in which there are planned future changes in spectrum allocation, and the possibility of new services.

- SP surveys can incorporate qualitative follow-up questions to provide diagnostic insights, i.e. not only respondents' WTP but also the underlying reasons for their responses.

- SP methods can capture both use and non-use values in a single WTP estimate.

Disadvantages

The main weakness of SP methods is that the validity of results can be low because the question wording is usually the same for all respondents, based on hypothetical questions that reflect what the policy-maker wants to know rather than the way each respondent thinks about the issue. SP methods typically seek to produce policy-relevant results expressed in financial terms, regardless of their validity or appropriateness.

However, if an SP survey is developed in a way that matches how respondents think about the issue and avoids trying to force everything into a monetary scale, its results can be much more valid.

In addition to these, other disadvantages of SP are:

- SP suffers from a number of well-known weaknesses relating to hypothetical bias, insensitivity to scope, framing effects, and focusing effects. These derive from its reliance on responses to a hypothetical choice scenario.

- There may also be practical limitations on the ability to adequately describe the implications of changes in spectrum allocation in terms that allow respondents to form a meaningful view.

- As noted above, results may be sensitive to small changes in survey design.

These issues can be mitigated to some extent through careful study design (see Appendix D4 for details).

3.2.2 Subjective wellbeing valuation

SWB valuation is a more recent method that offers an alternative approach to traditional SP valuation techniques. SWB valuation, like SP valuation is a survey-based approach. However, the purpose of a SWB survey is simply to gather time series data on respondents' self-reported (subjective) wellbeing and relate the results to (mainly objective) features of their lives such as post codes and marital and employment status rather than to elicit WTP estimates as in a SP survey. SWB surveys will typically ask respondents to evaluate their overall life satisfaction or happiness on a sliding scale (e.g. 1 to 10).

A key distinction between SWB and SP valuation is that SWB is based on a mental state account of welfare, rather than a preference satisfaction account. This means that SWB looks at what things make people feel more satisfied with their life, rather than with what people want, which may not necessarily be the same, depending on the context.

The survey data on SWB is correlated with data on a range of relevant market or non-market outcomes to identify any significant relationships (with appropriate controls included for other relevant factors that influence SWB). A monetary equivalent of a change in a non-market or market outcome can be obtained by including a measure of income in the statistical analysis.

Assuming suitable data are available, the main question about the validity of SWB as a way of assessing the total value is whether (and, if so, how much) a respondent's subjective wellbeing is likely to be affected by changes in spectrum services that occur as a result of a change in spectrum allocation, particularly where this leads to a change in the provision of social goods related to broader social value. The answer seems to be contested and unclear.

Advantages

SWB has a number of advantages, including:

- SWB methods avoid some of the weaknesses of SP, the main one being that they do not rely on direct questioning of respondents' stated preferences on

the basis of a hypothetical choice scenario. As a result, SWB valuation does not suffer from hypothetical bias, insensitivity to scope, framing effects, or focusing effects. SWB does not rely on the assumption of rationality and can therefore potentially deal with a wider range of situations than preference-based methods such as RP and SP.

- SWB methods are more cost effective than SP methods as they can be carried out using existing national survey data, eliminating the need to collect primary data.

- Finally, SWB results can be fairly reliable if large-sample data are available.

Disadvantages

SWB has some limitations that are of particular relevance to its applicability to assessing spectrum allocation decisions:

- SWB valuation can only be used to assess future policy changes that have a similar impact on outcomes to changes that respondents experienced in the past. If this is not the case, and is not captured in the historic data on policy outcomes, then SWB cannot be applied.

- A further related limitation is that SWB cannot be used to estimate non-use values associated with considerations such as altruism or existence values. The reason for this, again, is that respondents are generally unlikely to have experienced significant changes in outcomes that affect non-use values, and hence their effect cannot be identified.

- A further question arises over the way these methods convert changes in SWB into their money equivalent using data on the response to windfall financial gains and losses. This raises two potential problems. First, the response to a windfall gain or loss (they are not symmetrical) is likely to be psychologically different from that to other increases or decreases in the respondent's financial situation (e.g. earning more money by working longer hours versus gaining a promotion versus taking on a better-paid job one hates). Secondly, wealth and income inequalities mean that using a single 'average' conversion rate between SWB and money is unlikely to be appropriate, especially for cases where the direct and indirect impacts of a spectrum reallocation vary significantly between different income groups.

Having raised these concerns, we note that SWB methods are relatively new and still in development. It is possible that the lack of data on comparable policy outcomes may become less of a constraint on the applicability of SWB valuation to spectrum allocation decisions as the amount of cumulative SWB data increases. The view that SWB cannot be used to measure non-use values (the main focus of this report) is a

more fundamental problem, but even this limitation may not be entirely black-and-white: for instance, one researcher has used SWB in both industrialised and emerging economies to value the Millennium Development Goals and income inequality, both of which relate to non-use values.[30] Another study has found attitudes to public services to include a significant element of altruism.[31]

While SWB valuation may evolve as experience is gained, at present there is no established best practice, and there may be problems which are not yet identified. We therefore consider that this is a promising approach to explore, but would caution against placing a high degree of reliance on SWB analysis on its own at this stage.

3.2.3 Deliberative research method

Deliberative research (DR) refers to a range of techniques for which the main aim is to understand how participants' views and preferences change as they are exposed to, and have time to reflect on, new information and other people's views on an issue. Appendix D discusses these methods in more detail.

The main DR techniques are *'citizens' juries'*, typically one-off multiday events (often reconvened) with 10-30 participants, and *'deliberative workshops'* involving multiple workshops of 10-20 participants, each lasting from half a day to two days. All DR techniques share the following characteristics:

- **Time:** participants are given enough time to learn, think and debate in real depth. By the end of the event, the picture that emerges should show what they think once they have a good understanding of the issues and trade-offs and have had a chance to hear, and think about, others' views.

- **Information:** DR methods use a structured approach to build up participants' understanding step by step during the event using a combination of fact sheets, live presentations, Q&A sessions, etc. As far as possible, the information provided is based on undisputed facts. If some information reflects a particular view, it is matched with other information reflecting the opposite view in order to present a fair and balanced picture overall.

- **Transparency of purpose:** unlike most public opinion research, DR methods let the participants know about the policy background and the aims of the

[30] Edsel L Beja, Jr, *Subjective Well-Being Approach to the Valuation of International Development: Evidence for the Millennium Development Goals* (January 2011) and *Subjective Well-Being Approach to the Valuation of Income Inequality* (October 2011), Munich Personal RePEc Archive, Munich University.

[31] J Hudson and PR Jones, 'The importance of the "ethical voter": An estimate of "altruism"', *European Journal of Political Economy*, 10 (1994), 499-509.

exercise, from the start. This engages participants and prevents them from being distracted by speculation about the purpose of the research.

Advantages

The great advantage of DR methods is that they show what members of the public think about a policy issue once they have real - although still somewhat simplified - understanding of the options, trade-offs and what other people think. They are therefore especially relevant under the following conditions:

- There are several policy options.
- The likely consequences of each option are largely agreed by the relevant experts.
- There are trade-offs between the options and no expert consensus about which is best, because the choice involves value judgments. (In most cases, there will also be some disagreement about the likely consequences of each option, especially if they involve commercial or political vested interests).
- The issue is important but complex and not something the general public normally thinks about.
- Citizens' priorities are likely to change with better understanding of the options and trade-offs.

Some spectrum allocation decisions are relatively minor and/or can be made validly using market mechanisms or technocratic judgment. But if the decision is large and involves significant private external value or broader social value - the focus of this report - value judgments about the trade-offs will be needed. In these cases, most or all of the above conditions will apply and DR methods may have an important role. Even in these cases, however, we recommend that they should be used in combination with one or more of the methods already discussed - RP, SP and SWB - because of the disadvantages of DR methods, as we now discuss.

Disadvantages

The key difference between DR and the other techniques is that it is largely qualitative. A large-scale DR study might be based on as many as, say, 12 groups of 15 participants. Although the resulting sample size of 180 is comparable to that of a smallish survey, the resulting data are not only much more expensive but also not strictly comparable: part of the strength and weakness of qualitative methods is that the participants are not responding to an identical stimulus and their responses are only semi-structured.

Each discussion in a DR study will be somewhat different, despite being guided by an identically briefed facilitator following the same structure, introducing the same information in the same sequence, and using the same discussion guide. These differences stem from the attitudes and personalities of the participants in each group, especially the more talkative ones; the style and approach of the facilitator (perhaps unconsciously reflecting his or her own opinions on the topic); and how all these individuals interact on the day.

Further, the discussions need to be summarised and interpreted twice before they become results: first by the facilitator of each discussion and then by the researcher or research team for the whole study. Both stages involve some subjectivity. The degree of subjectivity can be reduced in a number of ways but is inherent in these methods. For this reason as well as the main one – their relatively small sample sizes and limited scalability - we rate DR methods relatively low on reliability, although this can be somewhat mitigated if the study involves multiple workshops and the researchers challenge each others' conclusions, testing them where necessary against the detailed record of the discussion.

Despite these limitations, the results may be more valid than for the other methods because DR can generate rich insights and come closer than the other methods to eliciting citizens' views on the issues once they have been briefed and had a chance to reflect, hear others' views, and so on. The extent to which DR methods achieve these benefits in practice naturally depends on the skill and objectivity of the facilitators and researchers.

As already noted, DR methods' strengths and weaknesses are complementary to those of the other, quantitative, methods. Our recommendation, discussed more fully later, is therefore to use them in combination. In particular, we recommend conducting DR before an SP or SWB study to ensure that the SP/SWB questions, and their specific wording, are close enough to the way survey participants think about the issue (or, at least, would think about it given enough time and information) to produce valid responses.

One option suggested by Ben Shimson in Appendix D is to create a small comparison group within an SP study comprising people who have participated in a DR study. Comparing these respondents' answers to the SP survey with those of the main sample would give an indication of the validity of the SP results.

DR methods can also be used after an SP or SWB study to help the researchers interpret the quantitative results.

3.2.4 Other potential approaches

The problem we are addressing is essentially a multi-disciplinary one. It may be possible to mobilize other academic disciplines than those on which we have largely relied in order to solve it. Two such disciplines are political science and economic psychology[32], and there may be others.

3.2.5 Summary and conclusions

Table 3.1 provides a high level summary of the methods we have considered and the key considerations discussed above. The table includes RP as well as the three non-market valuation methods (SP, SWB and DR), although as we have seen, RP is not well suited to assessing the total value of a spectrum-using services that create significant private external and broader social value, since this will not be reflected in market prices.

Based on our review of the currently available valuation methods, it is clear that each of these has advantages and disadvantages, and that there is no single 'best' approach. In particular:

- RP methods provide a market-based method of valuing non-market goods and services which relies on actual observed choices. The applicability of this approach to spectrum allocation decisions is limited, however, by the lack of suitable market data. In addition, RP-based estimates of WTP will only reflect private user value and will not capture private external value of broader social value that is not reflected in market prices.

- SP methods are more flexible than RP and SWB methods which in theory can be applied to any non-market good or service. However, they rely on survey responses to hypothetical choices and are vulnerable to a number of well-known methodological problems that can undermine reliability.

- SWB is a developing approach that offers an alternative way of eliciting valuations to RP and SP methods. The key advantage of SWB over SP is that it avoids the biases associated with hypothetical surveys. However, SWB is much less flexible than SP and its application to spectrum allocation decisions is likely to be limited by data constraints and the difficulty of identifying significant relationships between SWB and outcomes of interest. In addition, its applicability to assessing private non-use value and broader social value is, at best, limited and unclear.

- DR methods offer a different type of approach to RP, SP and SWB in that their primary purpose is to develop an in-depth understanding of citizens' views on different policy choices, rather than to provide a quantitative

[32] See appendix F

valuation estimate. DR methods are therefore not a substitute for the other method, but could be usefully used as a complement.

The relationship between SP and DR is pretty much the familiar one between qualitative and quantitative research techniques. In market research, qualitative methods are often used before conducting a large-scale survey, to ensure that the questions 'work' and uncover the issues of interest, and sometimes afterwards, to help interpret the survey results and their possible implications. In the context of spectrum allocation decisions, we see a particular role for DR *before* conducting an SP study, to maximize the validity of the SP data.

SWB methods complement both SP and DR in a positive way by avoiding asking any questions that frame the issue or 'lead the witness'. However, they have the weaknesses discussed above: the dependence on the availability of relevant data, the questions about the financial measure of value, and especially the question about their ability to measure non-use value and social value.

In light of these findings, we suggest that it is likely to be appropriate to use the different available valuation methods in combination with one another. The next section outlines a procedure for combining the approaches.

Table 3-1: Relative Merits of Approaches to Assessing Total Value

	RP	**SP**	**SWB**	**Deliberative**
Theory of value	Preference satisfaction	Preference satisfaction	Mental state	Flexible (Including rights based and rules based)
Measurement approach	Choice in actual market. e.g. demand estimation ,hedonic pricing	Choice in hypothetical market. e.g. CV survey method	Regression of Self-report wellbeing survey data with outcomes.	Deliberative research elicit informed views e.g. deliberative workshops

	RP	SP	SWB	Deliberative
Most useful for measuring	Captures private value to users of service. Does not capture private external value or BSV	In principle can measure all aspects of total value	In principle can measure all aspects of total value, but application to non-use values usually limited by data	Insight into citizens' views on policy choices esp. initial Identification of potential sources of BSV
Key advantages	Market-based approach rather than survey	Well-established method that is highly flexible .Applicable to future changes	No reliance on hypothetical survey and does not assume rationality	Allows respondents to provide considered and well-informed view on complex issues
Key problems	Limited applicability, esp., to future changes due to lack of existing markets Does not capture non-use or social value	Hypothetical, framing, focusing bias Preference instability	Limited applicability to future changes Inability to identify impact of policy on SWB Questionable measure of money equivalent of a change in SWB	Limited scalability. Subjectivity, 'leading the witness'

3.3 Using the Approaches under Different Spectrum Assignment Regimes.

In recent years, spectrum in the UK has been almost entirely assigned either by administrative methods (i.e. by choice exercised by the spectrum regulator) or by auction. In the former case, the regulator must seek to estimate and compare the full value of the spectrum in alternative uses, including the private value, conventional externalities and broader social values.

In the case of an auction, however, the assignment method is intended to capture the private value of the spectrum using service, in the sense that a firm's willingness

to pay for a licence is derived from its expectation of the excess of revenues over costs (before spectrum costs) it will gain from its utilisation of the licence.

There is some debate about how effective auctions are in practice in ensuring that the spectrum is allocated and priced to maximise private benefits, by ensuring that the licence goes to the firm which can use it most efficiently. A poorly designed auction can fall down in a number of ways:

- Where there is great uncertainty about long-term costs and revenues – as is often the case in fast-changing technology and telecoms markets - the spectrum may go to the most over-optimistic bidder rather than the one best placed to use it (the 'winner's curse'). Such over-optimism may be reinforced in an auction with repeated rounds, as bidders' subjective beliefs about the value of the spectrum are influenced by other bidders' bids.
- There may be an agency problem, if managers believe that their job prospects or future remuneration depend on the company having access to the spectrum, especially if there is a good chance that they will no longer be at the company when the negative consequences of overbidding come home to roost.
- The way in which the available spectrum is packaged for sale (choice of lot size) may determine the nature of the winning bidder.
- If the auction designer sets too high a reserve price, some spectrum may be wrongly taken out of use for an extended period.
- Where bidders are proposing to use different business models (for example, some relying on advertising revenue, others on direct service charges) the linkage between bidders' willingness to pay and end users' welfare may be complex or fragile.
- Finally, bidders may collude to keep prices low.

Despite these challenges, the past decades have seen a great deal of experience of auctions, so that design errors are increasingly avoided. With these improvements, auctions are the best way of ensuring that, in cases where most of the value generated by the spectrum at auction is private use value, it is allocated to those best able to exploit it, while also capturing for the state scarcity rents from it that in other circumstances might go unnecessarily to firms. Thus most governments and regulators have themselves revealed a fairly consistent preference for using auctions to assign high-value spectrum.

When an auction is employed, it can be assumed that the ranking of the bids of various contenders reflects, to an approximation, the relative private benefits each contender expects to generate. Consequently, the valuation task in this case is confined to estimating the conventional externalities and the broader social value.

Can estimates of these magnitudes be fitted into an auction process?[33] One possible tool is the use of so called bidders' credits. Under this process, a bidder seeking to provide a service offering private external value and/or broader social value worth in total £50 million would be assumed for the purpose of finding the auction winner to have bid £50 million more than it did. On this footing, a firm of this kind bidding £200 million would beat another firm offering zero additional value which bid £240 million, but it would have to pay only £200 million.

The estimate of additional value can either be derived from one of the methods derived above, in units of value commensurate with the monetary units in which bids are made, or can be estimated more subjectively and informally.

[33] Note that a more efficient way of taking account of broader social effects may be to subsidise the service directly, rather than indirectly by altering the price of an input into its production.

4. A Recommended Procedure for Incorporating Broader Social Values in Spectrum Valuation

Given the individual strengths and weaknesses of the three techniques discussed above, the procedure we recommend is to use them in combination rather than looking for a 'horses for courses' approach that tries to find the single technique best fitted to the particular decision.

In our view, none of the current valuation techniques or procedures is capable of providing a single valid and reliable quantitative measure of total value in any case with significant externalities and wider social value. We also consider that it is doubtful that it will be possible to devise such a technique, given the inherent difficulties in estimating the different aspects of total value, and problems arising from lack of commensurability of the measures.

Our recommended procedure is therefore to use multiple perspectives to provide several complementary measures and insights as support to those making the decision. The aim is to be 'roughly right' – including by showing the wide range of uncertainty – rather than 'precisely wrong' (by providing a single, spuriously accurate, figure).

Section 3.4 discussed the alternative spectrum assignment regimes (an administrative process or an auction) in which the valuation process is embedded. As noted, each of these methods imposes a requirement for the estimation of different components of total value. However, it seems likely that the process described below is capable in outline of meeting the needs of both processes, and of making the relevant judgments more systematic, balanced and better informed.

We have identified two generic routes for estimating the net impact on the total value of alternative spectrum allocations (ignoring transition costs):

- **Route 1: deliberative research (DR) followed by a stated preference (SP) study.** This can almost always be used. It is extremely flexible and can be tailored to the specific issues. It offers precise numerical answers in a policy-relevant form and, potentially, diagnostic data (from the DR) on why respondents express particular preferences. However, the results may be unreliable because SP involves (a) the respondents sufficiently understanding the options and their implications to give meaningful answers (hence the DR) and (b) asking them to put financial values on social/citizenship issues. It may be possible to reduce both problems using trade-off/conjoint research, i.e. asking respondents to choose between bundled options (potentially including prices, costs or tax payments).

- **Route 2: research based on subjective wellbeing (SWB), perhaps in combination with some DR.** This has the advantage of minimising the extent to which respondents are prompted, including to put financial values on social/citizenship issues. However, it depends on the availability of data that are either directly relevant to the options or close enough to allow their incremental impact on SWB to be deduced. It is also likely to produce less precise and detailed answers than Route 1, and measure slightly different outcomes (wellbeing rather than considered reflections on value to the public or social implications of options). And its ability to address non-use and social value is still unclear. Again, this aspect could be explored using DR.

Triage stage

The UK Treasury Green Book describes a generic 'Triage Stage' at which decisions may be made whether to commission a study, taking into account issues as the tractability of the valuation problem, the range of results, the importance of accuracy and the scale of the impact (Green Book, p58, 11). We recommend that spectrum decisions should follow this practice. The triage stage should aim to:

- Identify whether this is a constant or variable output scenario. In the constant output case, the focus switches to analysing the net impact on supply costs and there is no need to research private external value or broader social value. This may also be the case in the intermediate 'semi-variable' output case discussed above. (The rest of the procedure discussed below assumes a variable output case).
- Be clear about what components of valuation are required, given the expected assignment method.
- Identify qualitatively the potential sources of private external value and broader social value
- Roughly evaluate (a) their likely importance relative to the private use value estimated either by an auction process, or by RP (and/or SP/SWB if market data are not available) and (b) the likely cost and effort of the research and analysis that would be needed to assess them meaningfully
- On the basis of the above, especially the balance between (a) and (b), decide whether to continue to some or all of the procedure outlined below.

Full procedure

We here outline a full procedure aimed at providing maximum information to support a spectrum allocation decision. The full procedure uses both Route 1 and Route 2, described above.

1. Specify the allocation options and estimate in some detail the expected technical, financial and service quality outcome for each option (changes in the cost, quality and availability of the affected services).
2. Translate the outcome for each option into everyday language suitable for discussing with the public (e.g. prices, familiar measures of service quality). This may involve small-scale qualitative research to check the language.
3. (Optional) Develop an initial estimate of the impact of the options on the economic use value using a willingness-to-pay/willingness-to-accept (WTP/WTA) survey and/or by extrapolating from revealed preference (RP) data, e.g. the estimated private value of FTA television based on [hours viewed] x [cost/viewer-hour of pay TV], ideally allowing for any differences in average audience appreciation.
4. Publish a consultation document outlining the options and qualitative statements of potential impacts on non-use value (externalities) social value.
5. Route 1: Deliberative research to develop an understanding of how the public thinks about the impact of the options on social value.
6. Use the results of the deliberative research to design an SP study to give a numerical estimate/range for the incremental social value of the options.
7. (If suitable subjective wellbeing - SWB - data are available) Route 2: Use existing and/or new data to estimate the impact of the options on SWB. Use previous estimates of the financial equivalent of changes in SWB (for each main segment of the public, where appropriate) to compute a numerical value/range.
8. Summarise the results, without attempting to reduce them all to a single financial number. The report to ministers should describe the trade-offs in qualitative, non-technical terms supplemented by financial and other numbers and illustrated with verbatim quotes from the DR and/or the consultation responses showing how the public, once sufficiently informed, sees the issues.
9. Provide either a recommendation to ministers or a top-line summary of the trade-offs underlying the decision. The key judgment is whether the differences between the different options' net impact on the non-use and social value generated by the spectrum-using services are sufficient to alter the ranking based on their private use value.

Our recommendations are pragmatic. For some spectrum allocation decisions, the expected net impact on the combined private external value and/or broader social value of the relevant spectrum-using services is insufficient to merit investing significant resource in order to incorporate them. At the other extreme, these impacts – or, strictly speaking, the differences between the impacts of the different options –

may be so important that they may determine the option chosen by ministers. As in the Green Book, we therefore recommend an initial triage stage to decide how much, if any, effort and resource to invest to explore these values.

One issue to be clarified as part of the triage stage is whether the decision is about a constant or variable output case. With constant (or near-constant) output, the quality, quantity and availability of the affected services will be unchanged. In this case, there will be no impact on the services' private external value or broader social value and the analysis boils down to looking at the net impact on their combined expected supply costs (and, in practice, the transition costs). The challenges we address relate to the more complex variable output cases, where the net impact on non-use and social value may be a big issue.

What is the objective?

Even where these indirect impacts are important enough to justify a major analysis, however, our recommendation is that the analysts should not, in the present state of knowledge and technique, attempt to reduce the results to a single financial number. Instead, we recommend a 'middle path' whereby the aim is to provide decision support to ministers through a combination of:

- A systematic framework, including a clear explanation of the options and trade-offs, especially the nature of the likely impacts on private external and broader social value

- Some financial and non-financial numbers to show the scale of the decision (and, where appropriate, the revenue likely to be foregone if the decision is to choose an option other than the revenue-maximising one)

- Some illustrative verbatim quotes from the deliberative research and/or the consultation responses showing how the public, once sufficiently briefed, thinks about the issues and trade-offs

- Either a clear recommendation or a short, top-line summary of the trade-offs showing how different judgments about the economic and social issues would lead to different spectrum allocations.

Recommended procedure

To reach this objective, we recommend using some or all of the procedure outlined in Section 3.4. In summary, these are:

1. Detailed problem specification

2. Translation of the options and trade-offs into everyday language

3. (Optional) develop an initial estimate of likely impact on the economic use value of the relevant spectrum-using services

4. Publication of a consultation document

5. Deliberative research (DR) study

6. Stated preference (SP) study using the results of the DR to develop valid questions

7. (If suitable data are available), subjective wellbeing (SWB) analysis to complement the SP results, possibly in combination with further DR to help interpret the relevance and validity of the results

8. Integrated summary of the results, without trying to reduce them to a single financial number

9. Recommendation or top-line summary of the options and trade-offs.

Our key conclusions and recommendations here are both negative and positive:

- The negative ones relate to the significant conceptual and measurement challenges of incorporating private external value and broader social value into spectrum allocation decisions; the limitations of the different methods; and the temptation to try and reduce the results (especially using SP and cost-benefit analysis) to a single set of financial numbers.

- The positive ones are about the benefits of using a systematic procedure, as outlined above; and within that, clarifying the options and their detailed expected implications for the spectrum-using services; investing in extensive DR before proceeding with SP work; and, more generally, exploiting the complementarities of the techniques discussed in Section 3 so that the whole analysis is more likely to be valid and reliable than the sum of its parts.

Overall, we see these conclusions and recommendations as offering a message of hope: there is no single silver bullet but there is real scope for more systematic, evidence-based spectrum allocation decisions that take account of their expected impact on non-use value and wider social value.

Possible areas for further work

Finally, we see this report and our recommendations as work in progress. The main areas for further work relate to piloting the recommended procedure and further investigating the strengths and weaknesses of the stated preference, deliberative research and subjective wellbeing approaches, used separately and in combination.

We also see merit in exploring the potential to draw on insights from other disciplines including political science and economic psychology, as discussed briefly in Section 3.2 and more fully in Appendix F.

It is also important that progress is made in estimating the external effects of spectrum-using services other than those associated with the broader social values which are considered here.