Report to Department for Culture, Media and Sport

Appendices

Incorporating Social Value into Spectrum Allocation Decisions

Patrick Barwise, London Business School

Martin Cave, Imperial College

Peter Culham, Ofcom

Tony Lavender, Plum Consulting

Neil Pratt, Ofcom

Damian Tambini, London School of Economics

Final Report

November 2015

Contents

Appendix A. Some persistent problems with measuring value in CBA

Use of Cost Benefit Analysis (CBA) in government is widely acknowledged as an important tool for decision-making that introduces systematic rigour and evidence, and reduces risk that decisions over resource allocations could be made on the basis of private interest capture - or the whims and biases of decision-makers - that could potentially reduce welfare. These are all disciplines that would be welcome in spectrum allocation decisions. However cost-benefit analysis is by no means non-controversial, either in terms of which valuation methods are used, or in terms of the discipline as a whole. (See in particular Sen, 2000; Sunstein, 2013, 2014a 2014b; Sandel 2012). In an area of such high economic values and social implications as spectrum allocation it is essential that decision makers are aware of these challenges which is why we here note some interrelated and overlapping theoretical challenges for valuation.

Equity and Distributional impacts. (Sunstein 2014 and Sen 2000: 946). Costs and benefits are not distributed across society as a whole and those expected to bear the cost of a decision or project are not always the same people who benefit from it. Cost benefit analysis does offer means to incorporate the distributional impact of a decision by adjusting for example values according income and differential distribution of costs and incomes. (Green Book p24-25). In the case of spectrum decisions benefits may for example be subject to complex and uneven distribution across different demographic groups, early versus late adopters, and according to geographical distribution of services. For example the value of mobile/ internet services may accrue more to younger affluent users, and broadcasting benefits to older/ less affluent demographics.

Rights/ freedoms. Sen (2000) points out that cost-benefit theory is fundamentally based on consequentialist, utilitarian theory, in contrast with deontological (rules-based) approaches to value. In the context of spectrum allocation problems may for example arise in relation to coverage obligations if these are expressed in terms of information rights deriving for example from Article 10 of the ECHR. If a hypothetical value measurement indicated that over the population as a whole net benefits from mobile/ internet use of UHF frequencies so far outweighed broadcasting benefits that DTTV switch-off should be radically accelerated, this may undermine the availability of broadcasting for some consumers. Article 10 ECHR includes rights both to impart and to receive ideas and has been seen to entail a right to receive public service broadcasting. On the other hand spectrum may be essential to

providing access to the internet which may in turn be necessary to access public services that are paid for by taxation[1]. In both cases the value of universality of access or rights of access would need to be taken into account by decision makers. Valuations that are based on sum of individual utilities tend to miss out on this kind of issue, and approaches to Broader Social Value (including deliberative approaches) have difficulty in accommodating such issues.

Quantifiability. The difficulty of quantifying outcomes can be due to a range of phenomena, including: objections that outcomes *should not* be quantified for moral reasons (often overlapping with rights based arguments), problems of ignorance and lack of data, problems of uncertainty and risk and problems of monetization and commensurability. (See in particular Sunstein 2013, 2014). In relation to all of these problems, which are discussed below, there are methodological debates about best practice, questions of scientific integrity and procurement independence, and important questions of transparency (not covering up problems but acknowledging them) that should be taken into account in designing research.

Monetisation. Some goods can be quantified, but are difficult to monetise. Surveys of willingness to pay for some outcome are the usual way of coming up with a cash value for a given good, including non-use values and social value. The US government guidance makes the following suggestion for reporting: “To the extent feasible, you should quantify all potential incremental benefits and costs. You should report benefit and cost estimates within the following three categories: monetized, quantified but not monetized; and qualitative but not quantified or monetized”[2].

Probability (Uncertain Outcomes). Any assessment of future utility is a prediction and involves an assessment of probability that predicted outcomes will in fact come to pass. According to the relevant US Treasury guidance (2003; section g);” Where there is significant uncertainty and the resulting inferences and/or assumptions have a critical effect on the benefit and cost estimates, you should describe the benefits and costs under plausible alternative assumptions”[3]. (See Sunstein 2013). Given the timescales

---

[1] See for example: Plum Consulting: Study of methods for assessing the public value of Satcom in a spectrum trading environment. (2012, February 27). Retrieved from https://artes.esa.int/projects/study-methods-assessing-public-value-satcom-spectrum-trading-environment

[2] US Office of Management and Budget. (2003). Circular A4 section G.

[3] US Office of Management and Budget. (2003). Circular A4 section G. https://www.whitehouse.gov/omb/circulars_a004_a-4

involved in spectrum licensing cycles (which can be in the decades) transparency of assumptions is required. In the UK and the US, a number of standard procedures are recommended to deal with risk uncertainties, and mitigate the risk of optimism bias for example. (Green Book, P31). In the case of Spectrum decision-making, sensitivity analysis (how much would the range of potential known unknown values skew the calculation of costs and benefits?) is particularly important.

All the standard Green Book (section 5.74) proposals would apply to Spectrum decisions, and the US principles of full disclosure and transparency would be particularly important. However any approach in the area of spectrum should perhaps develop a less risk-averse approach to innovation. The notion of the spectrum as an innovation commons, and the positive value of untried new technologies should be part of the approach to risk. It would be counterproductive if current projections of value and social value undermined future innovation in services delivering social value by favouring incumbents.

Discount rate. Future outcomes are not valued at the same rate as current values, and costs and the various benefits may not occur in the same period. In the UK, a standard discount rate of 3.5% annually is applied to CBA. (Green Book, p26-27). In the US by contrast, the discount rate is either 3 or 7% depending on the methodology applied. In the case of spectrum decisions the standard UK rate of discounting should apply.

Double Counting. When there is a lack of theoretical consistency in the overall framework for value, categories can overlap, there is the danger of double counting: expressing social values as individual values, and so forth.

Changing preferences. (Sen, 2000: 945; Sunstein, 1990: 781). The traditional rationale for public service broadcasting is that it should 'make the good popular and the popular good.' As discussed in Appendix E, this creates problems for economists if their methodologies for assessing value are based on constant preferences, , given that the standard methods for assessing non market valuations are based on a preference satisfying model.

Incommensurability. The aim of finding a common monetary value for the utility or welfare associated with a decision is to enable the final balancing of costs versus benefits. In the case of spectrum allocation and assignment decisions the goal is to choose between different potential uses. According to Sunstein: "Incommensurability occurs when the relevant goods cannot be aligned along a single metric without doing violence to our considered judgments about how these goods are best characterized" (Sunstein 1990). In

the making of large-scale decisions about allocation of resources (impacting for example the institutions and conditions for media and communication in society) such questions of incommensurability arise. The value measured either by contingent valuation studies or by wellbeing methods reflect individual utility. In social value type survey questions in contrast, we may be asking respondent to make a judgement about what makes a good society (for example the role of subsidised free to air broadcasting in a good society). Research may find that consumers don't enjoy some spectrum using services, and do not use them, but at the same time they have strong views on the importance to society of providing such services.

Whilst the Green Book summarises currently accepted orthodoxy, there has been widespread experimentation and innovation in valuation techniques within government, and outside it, and there is currently a wide variety of techniques that are used to evaluate the loose bundle of phenomena referred to as 'social impacts' or 'social value'. This report cannot review them at length, but they include:

Social Impact Appraisal "social impacts cover the human experience of the transport system and its impact on social factors, not considered as part of economic or environmental impacts."[4]

Social Return on Investment[5] uses a stakeholder led process to identify financial indicators of social benefits of third sector projects. This could be adapted to take into account stakeholder and established public policy objectives regarding spectrum using services, and adopt research tools that will assess the importance of spectrum access in achieving these social benefits.

Multiple Criteria Decision Analysis[6]. This technique enables complex criteria and objectives to be applied to various decisions and weightings to reflect social as well as economic objectives.

Wellbeing Valuation. This is explored in more detail in Section 3.2.2. This approach is based on correlating large datasets to examine the welfare associated with various factors. This could include spectrum using services.

---

[4] Department of Transport TAG Unit A4.1. Social Impact Appraisal. January 2014. Department of Transport Transport Analysis Guidance (TAG).

[5] Wood, Claudia and Leighton, Daniel. Measuring Social Value. Demos 2010.

[6] See: Multi-Criteria Decision Analysis: A Manual. UK Government (2009). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7612/1132618.pdf

References

Department for Culture, Media & Sport. (2014). *The UK Spectrum Strategy: Delivering the best value from spectrum for the UK*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/287994/UK_Spectrum_Strategy_FINAL.pdf

Hazlett, T. W., Müller, J., & Muñoz, R. (2006). The social value of TV band spectrum in European countries. *Info*, *8*(2), 62–73. http://doi.org/10.1108/14636690610653590

Joint BEREC/RSPG Working Group on Competition Issues. (2012). *Report on exploring the economic and social value of radio spectrum for certain electronic communications services with respect to frequency assignment procedures* (No. BoR (12) 15). Retrieved from http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/61-joint-berecrspg-report-on-exploring-the-economic-and-social-value-of-radio-spectrum-for-certain-electronic-communications-services-with-respect-to-the-frequency-assignment-procedures

Kenny, R., Foster, R., & Suter, T. (2014). *The value of Digital Terrestrial Television in an era of increasing demand for spectrum*. Communications Chambers. Retrieved from http://www.digitaluk.co.uk/__data/assets/pdf_file/0015/87000/The_Value_of_DTT_in_an_era_of_increasing_demand_for_spectrum_20-1-14.pdf

Levin, H. J. (1971). *The invisible resource: Use and regulation of the radio spectrum*. Baltimore: Johns Hopkins Press. Retrieved from http://books.google.de/books?id=uSOMAQAAQBAJ&lpg=PP1&ots=Zvab6RwhsR&dq=The%20invisible%20resource%3A%20Use%20and%20regulation%20of%20the%20radio%20spectrum&lr&hl=de&pg=PP1#v=onepage&q=The%20invisible%20resource:%20Use%20and%20regulation%20of%20the%20radio%20spectrum&f=false

Lewin, D., Marks, P., & Nicoletti, S. (2013). *Valuing the use of spectrum in the EU: An independent assessment for GSMA*. Plum Consulting. Retrieved from http://www.plumconsulting.co.uk/pdfs/Plum_June2013_Economic_Value_of_spectrum_use_in_Europe.pdf

Sandel, Michael. (2012). What Money Cannot Buy. Penguin.

Sen, Amartya Kumar. (2000). The discipline of cost-benefit analysis. Journal of Legal Studies 29(S2): 931-952.

Study of methods for assessing the public value of satcom in a spectrum trading environment. (2012, February 27). Retrieved from

https://artes.esa.int/projects/study-methods-assessing-public-value-satcom-spectrum-trading-environment

Sunstein, Cass. R. (1990). Incommensurability and Valuation in Law. Michigan Law Review. Vol 92 p779.

Sunstein, Cass. R. (2000). Television and the Public Interest. California Law Review 2000, 503

Sunstein, Cass. R. (2013). Nonquantifiable. {http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2259279

Sunstein, Cass. R. (2014). The Limits of Quantification {http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2424878

The Congress of the United States. Congressional Budget Office. (1997). *Where do we go from here? The FCC auctions and the future of radio spectrum management*. Retrieved from https://www.cbo.gov/sites/default/files/fccauct.pdf

Wood, Claudia and Leighton, Daniel. (2010). Measuring Social Value. Demos, London.

Appendix B. An Illustrative Example

This appendix sets out a simple stylized example to illustrate the application of the net impact on total value criterion set out in section 2.3. For expositional purposes we ignore the conceptual and practical difficulties involved in summing the three components of total value that are highlighted in the main body of the report.

The example is constructed to be as simple and transparent as possible to facilitate understanding. It considers a decision whether to allocate a band of spectrum (denoted band A) that is currently used by service E (the existing service) to service N (the new service).[7] The spectrum band is assumed to be allocated to one or other of these two possible uses on an exclusive licensed basis.

The example uses illustrative figures for the different components of total value to illustrate how the allocation decision may affect the aggregate total value from the two services. Two hypothetical scenarios are constructed that relate to the constant output and variable output cases discussed in section 2.3. After discussing these two scenarios, we briefly comment on the potential causes of inefficient allocation decisions.

Scenario 1: Constant output case

In this scenario, we suppose that in the current allocation service E is provided using band A, and service N is provided using a different spectrum band, referred to as band B. This allocation is compared against the alternative allocation in which service N is provided using band A, and service E continues to be provided using band B (and/or other non-spectrum inputs).

The key assumption that underpins this constant output scenario is that the output of both services is the same in the current and alternative allocations. Two other assumptions made for simplicity are: first, that band B would otherwise be unused; and second, that both services are financially viable without subsidy in either allocation.

Figures 2.5 and 2.6 show the assumed cost, economic use value and external value for each service in the current and proposed alternative allocations, respectively. External value here includes both economic non-use value

[7] As noted in the main report, the term ‘new service’ is used to refer to the service to which the spectrum band in question is allocated following the change in use. In practice this service may already be provided using al, and this usage is not intended to imply otherwise. This would be the case, for example, if additional spectrum is allocated to existing mobile or DTT services

relating to conventional externalities, and broader social value, as explained in section 2.3.

Since the output of both services is constant, the economic use value and external value for both services is the same in both allocations. The key difference between the two allocations therefore relates to the change in the cost of supply of the services. In this example, the cost of supply for service E is increased by 100 in moving from the current allocation to the proposed alternative allocation. The cost of supply for service N, however, is reduced by 40.

It follows that the net impact of the proposed change in allocation is an increase in the cost of supply of the two services of 60 (i.e. 100 – 40). Since there is no impact on the user benefits or the external value of the service, this is directly reflected in a corresponding reduction in the total value of 60 (i.e. the total value in the current allocation of 1080 less that in the proposed alternative allocation of 1020). Hence, the value derived from spectrum is higher in the current allocation than in the proposed alternative.

As explained in section 2.3, the net total value criterion can be simply expressed in the form of a comparison between the opportunity cost of the proposed change in use to the existing service, and incremental benefit to the new service. In the constant output case, this reduces to a simple comparison between the increase in the supply cost for service E and the reduction in the supply cost for service N. This is apparent in this example, since the opportunity cost of 100 to service E is exactly equal to the increase in supply costs from the proposed change in use, and the incremental benefit of 60 to service N is exactly equal to the reduction in supply costs. Since the former exceeds the latter, we arrive at the same result that the value derived from spectrum is higher in the current allocation than in the proposed alternative.

Figure 2.5: Total Value in current allocation

	Service E	Service N	Total
	Band A	Band B	
A. Cost	100	120	220
B. User benefit (gross)	400	200	600
C. External benefit	200	500	700
Value to society (-A+B+C)	500	580	1080

Figure 2.6: Total Value in proposed allocation

	Service E	Service N	Total
	Band B	Band A	
A. Cost	200	80	280
B. User benefit (gross)	400	200	600
C. External benefit	200	500	700
Value to society (-A+B+C)	400	620	1020

Scenario 2: Variable output case

In this scenario, we depart from the assumption that the output of both services is the same in both allocations. In particular, we assume that band B is not suitable for service N, and hence this service has no output unless it

can use band A. The output of service E is assumed to be the same in both allocations. Apart from this specific change, the example is otherwise unaltered.

The assumption that service N cannot be provided without the use of band A is clearly something of an extreme case which would not usually apply in practice. However, it has the virtue of simplicity which helps to bring out the logic very simply.

Figure 2.7 shows the assumed cost, economic use value, and external value for each service in the current allocation. The key change compared to Figure 2.5 is that service N generates no value to society in the current allocation, since it is assumed to produce no output. The relevant cost and value figures in the alternative proposed allocation are unchanged from those shown in Figure 2.6. For ease of comparison, these are shown in Figure 2.8, which is identical to Figure 2.6.

Comparing Figures 2.6 and 2.7, it is clear the only impact of the proposed change in allocation on service E is an increase in the cost of supply of 100 (as in the constant output scenario). By contrast, the proposed change in allocation in service E results in an increase in supply costs of 80, combined with an increase in user benefit of 200, and an increase in external benefit of 500. Adding these components, we see that the proposed change in allocation results in an increase in the total value from service N of 620 (i.e. 200 + 500 – 80).

As explained in section 2.3 the net total value criterion can be expressed in the form of a comparison between the opportunity cost of the proposed change in use to the existing service, and the incremental benefit to the new service. In this example, the opportunity cost is again 100, which is exactly equal to the increase in the supply cost for service E in moving from the current to the alternative allocation. The incremental benefit is 620 (i.e. the increase in user benefit from service N of 200, plus the increase in external benefit of 500, less the increase in cost of 80).

In contrast to the constant output scenario, the incremental benefit is not exactly equal to the reduction in the supply cost for service E, because of the change in the output of service E in moving from the current to the alternative allocation. Since the incremental benefit exceeds the opportunity cost, we again arrive at the result that the value derived from spectrum is higher in the proposed alternative allocation than in the current allocation.

As noted above, this example is based on the extreme assumption that service N cannot be provided in the current allocation. However, the logic carries over to the more general (and realistic case) in which both services can be provided to a greater or lesser extent in both allocations. The only change in the more general case is that the computation of the opportunity cost and incremental benefits must be adapted appropriately.

Figure 2.7: Total Value in current Allocation

	Service E Band A	Service N	Total
A. Cost	100	0	100
B. User benefit (gross)	400	0	400
C. External benefit	200	0	200
Value to society (-A+B+C)	500	0	500

Figure 2.8: Total Value in proposed allocation

	Service E Band B	Service N Band A	Total
A. Cost	200	80	280
B. User benefit (gross)	400	200	600
C. External benefit	200	500	700
Value to society (-A+B+C)	400	620	1020

Potential causes of inefficient allocation decisions

The examples in scenarios 1 and 2 illustrate the application of the net total value criterion. This criterion will result in efficient allocation decisions, provided that the opportunity cost and incremental benefit both take fully into account the impact of the proposed reallocation on the total value from the services. Where this is not the case, however, there is a risk that allocation decisions may not increase the total value from the spectrum-using services. The possibility of such an outcome applies to allocation decisions that are made administratively, and to allocation decisions that are driven by market mechanisms such as spectrum pricing or auctions.

In the case of administrative allocation decisions, the decision-maker relies on estimates of the opportunity cost and incremental benefit. If these estimates depart significantly from the 'true' values, however, for example because of the difficulty in measuring economic non-use value and broader social value, there is a risk that this procedure may lead to an incorrect allocation decision. This is not inevitable, however, and what matters is whether the 'measurement error' reverses the order of the alternative allocations, such that a change in allocation is indicated where this is not efficient (or vice versa).

In the case of allocation decisions made by market mechanisms, the potential for inefficiency arises if the spectrum-users are not able to fully appropriate the total value from the service they provide. This might be because of the difficulty of monetising external benefits, for example, or in some cases because of financial constraints that arise from the inability to even monetise economic user benefits (for example because the service is provided for free at the point of use). Again, these considerations do not inevitably result in a market failure, and what matters is whether they have the effect of altering the willingness to pay of the spectrum-users in a way that reverses the order of the alternative allocations, such that a change in allocation is indicated where this is not efficient (or vice versa).

Appendix C. Previous Attempts to Incorporate Social Value

Digital Dividend Review

Decisions regarding how best to allocate the 'Digital Dividend' (spectrum released by ending analogue TV transmissions) have triggered debates about how to incorporate measures of social value into spectrum allocation decisions. This is because decisions may involve displacing public broadcasting uses (which have argued that they deliver social benefits that justify their receiving non-market spectrum as a form of indirect subsidy) with telecommunications services that have been delivered by private markets.

Given that allocation may involve markets (such as auctions) or pseudo-markets (incentive pricing) it was argued that optimum welfare (or optimal total value) may not be achieved by such a decision if some aspects of that value were not reflected in private value. The objective of research was to ascertain if there is significant 'social value' not reflected in consumer demand or conventional measures of value.

In the context of the Digital Dividend Review (DDR), Ofcom commissioned a programme of work by consultants that employed a range of stated preference and deliberative methods to ascertain whether the social value was significant enough to impact decisions regarding the allocation of UHF spectrum previously licensed for analogue TV broadcasting.

The Ofcom research was concerned with identifying potential sources of market failure caused by the presence of externalities. This led to their concept of 'Broader Social Value' being conceptualised as the 'BSV externality'.

The DDR work found that social value, while significant, was not significant enough to alter the ranking of potential uses, because social value was proportionately less significant than private value and did not vary greatly across potential uses such as more DTT, HDTV, and extending broadband.

Whilst the general approach worked in the case of the DDR, it is clear that the framework would requires further theoretical development. The reason that markets or market proxies would underestimate total value are: on one hand, social value may be underestimated because it is an externality not reflected in WTP. On the other hand, it may be neglected because the methods used to measure value (such as WTP, CV, Hedonic Pricing) tend to neglect impacts that are hard to measure or express in a monetary value because they relate to the 'soft stuff' of democratic, cultural or societal benefits and costs, or what

we have been referring to as value based on key rules, institutions or principles such as equality.

BEREC/RSPG working group

Reflecting the wider interest across Europe in this problem, the Joint BEREC/RSPG Working Group on Competition Issues (2012) reviewed approaches to the social value of spectrum by surveying regulators across Europe. They argue that "for the purposes of this report, social value is treated separately, as a notion, from economic value (…) (Social value could hereby be defined as that value which is not captured by the price paid resulting from spectrum assignment)." (2012, p. 10). Such a definition has the virtue of clarity but the fact that it is negative (all value other than private value) is not particularly helpful in developing methods of measurement.

The BEREC/RSPG report in fact differentiates between two notions of social value that loosely.

The first: "Social value resulting from spectrum usage by electronic communication services" reflects the notion that spectrum plans and pricing generally already reflect policy priorities: "When assigning radio frequencies to a particular commercial activity, the social value of usage of radio frequencies is carefully assessed at a national level based on policy decisions such as pluralism, commercial activities, consumer welfare and externalities such as productivity and better competitiveness" (2012, p. 11). In practice, the following aspects would be considered and then translated into requirements for the mobile operator:

- Facilitating access to resources for citizens and the economic sectors
- Continuity of services
- Quality of the service
- Coverage of territory & the digital divide
- Facilitating economic competition and growth (p. 12)

The second: "Social value as externality resulting from spectrum usage"

"Where the social value is examined as an externality in the case of electronic communications services, the analysis will be aimed at identifying the benefits derived from the usage of spectrum. The social value of the usage of radio spectrum would not be created by the availability of radio frequencies per se, but by those activities, economic, cultural, collective and social which are made possible by using radio frequencies." (p. 12f.)

"When measuring externalities or relevant benefits the resulting social value could be assessed according to the following non-exhaustive factors" (p. 13):

- Benefits to citizens/firms from coverage obligations or innovative services
- Service provider/operator can generate its own profits, i.e. enhance the economic value from various uses of spectrum

- Consumers benefit not only from services offered by service providers/operators but also by non-economic activities (i.e. safety, culture, social services, etc.) which are enables by current and future usages of spectrum
- The citizen benefits from additional revenues for the State generate by awards, direct and indirect jobs created by commercial activities, fiscal revenues etc.
- Level of competition might bring benefits to consumers or to the network operator
- Impact on social integration and on the fight against different types of exclusion
- Impact on the environment and the contribution to sustainable development
- Level of harmonisation of frequency bands and standards
- Development of public health and security services
- Benefits from cultural exchange
- Impact on employment rate and diversification of the industry (effect on GDP)
- Externalities or merit goods (democracy, educational standards etc.)

"The social value of rights to radio frequencies differs from the economic value a firm attaches to the relevant authorization (or firm's valuation). The social vale is ultimately the results of the usage of radio frequencies and services generated. **In assessing the amount of social value related to specific radio frequency assignment, it is recognized that there are several other effects, such as broader social values arising from different services (for example a better-informed democracy, higher educational standards or a more inclusive society) and other externalities** (e.g. investment spillovers, non-internalised network effects, and potential health effects." (p. 14, emphasis added).

We are quite clear that it is not appropriate, theoretically or methodologically, to arrive at estimates of total value can be derived from the sum of private value (consumer surplus + producer surplus) and externalities (economic and social). This is because the problems of measurement and incommensurability are too great.

In the work done by NRAs to date, no consensus has been reached regarding how best to approach this problem. In most cases, the Digital Dividend allocation decisions did not involve allocation or assignment decisions that engaged uses such as national security, scientific and domestic security, and therefore the research did not develop methods for measuring these complex and difficult to monetise public good values.

As Professor Sunstein has argued, 'in view of the character and consequences of television programming, any system for the regulation of

television should be evaluated in democratic as well as economic terms. The economic idea of “consumer sovereignty” is ill-suited to the communications market’ [8]

[8] Cass Sunstein. Television and the Public Interest. California Law Review 2000, 503.

Appendix D. The potential role of deliberative research

By Ben Shimshon, Co-Founder and Director, BritainThinks

Overview

This short essay offers a brief overview of deliberative methods, their broad uses and applications. It then goes on to consider the potential for deliberative research in relation to the task of valuing the public impacts of spectrum allocation decisions, offering two potential applications for deliberative techniques.

Deliberative research techniques differ from traditional public opinion research approaches by virtue of their concern with understanding how participants' views change following exposure to new information and points of view on a topic or issue. They are particularly valuable in relation to complex, low-engagement, topics where expert opinion is divided, and there are clear trade offs between different policy options.

The use and allocation of electromagnetic spectrum is a very low-engagement topic for members of the general public. As such, standard valuation or preference ranking techniques may only access a 'top of mind' understanding of the relative value of different uses of spectrum. In this context, there is a *prima facie* case for considering deliberative approaches as part of the approach to establishing the public value impacts of spectrum allocation decisions. However, the qualitative nature of deliberative work means that these techniques are likely to provide only one part of the solution, perhaps as a compliment to traditional stated preference survey work.

This essay proposes two potential roles that deliberative techniques could play:

1. Exploratory deliberative research to inform the broad approach to assessing non-monetary valuation
2. Case-by-case deliberation to examine particular allocation decisions

What is deliberative research?

Deliberative research approaches offer an opportunity to understand how the views and opinions of members of the public change and develop when they are given the time, space and information to consider an issue or policy debate in real depth.

Traditional quantitative surveys and standard qualitative research methods (such as focus groups and depth interviews) are concerned with understanding people's 'top-of-mind' views given how much (or little) they already know about a subject. In contrast, deliberative approaches seek to understand how members of the public respond to new information and points of view on a subject or topic about which they may know very little to begin with. They are particularly useful for issues involving complex trade-offs, where citizens' preferences may change in the light of a deeper understanding of the implications of their choice – for themselves, other groups or generations, or for society more broadly.

Deliberative approaches can take a range of forms, from Citizens' Juries and workshops, often involving between ten and thirty participants, through to Citizens' Summits which may involve thousands simultaneously. They can take the form of one-off events, or a series of activities, sometimes running over months or years (see Exhibit D1 at the end of this appendix for a description of some common forms of deliberative research). Regardless, there are some defining qualities that characterize deliberative research, and set it apart from other approaches:

- **Time:** Deliberative research gives participants time to talk, think and debate in real depth, issues that they might otherwise give little attention to. Whether a small scale workshop or a Citizens' Summit, deliberation rarely takes less than a day, and Citizens' Juries often convene for two or three days (and reconvene further down the line to look again at an issue, or consider new developments).
- **Information:** Whist they typically involve an initial exercise to understand participants' pre-existing views and knowledge levels about the issue at hand, deliberative methodologies are characterized by structured approaches to building participants' knowledge and understanding of the topic. Information provision can take a number of forms including live presentations, Q&A evidence sessions, filmed content, and fact sheets.
    - As far as possible, this baseline information should reflect the 'undisputed facts' of an issue. Whilst some experts or campaigners may place more emphasis on some of the facts to support their particular prescription, the information provided to participants should be recognized as a fair and balanced account by the widest possible spectrum of experts and interest groups engaged with the topic being deliberated.
    -

    - Information is usually prepared specifically for the deliberative process, with great care, attention, expertise and oversight applied to ensure that it is accessible and understandable to everyone who will be taking part in the research, regardless of their existing knowledge levels and intellectual capacity.

- **Balance:** The most worthwhile deliberative processes are concerned with topics that involve trade offs. Deliberative approaches involve exposing participants to the fullest range of perspectives on what should be done. This involves presenting the case that advocates from across the spectrum of expert views make for particular policy prescriptions, setting out the values and principles that they feel should be taken into account and why they support a particular course of action.
    - Whilst it is often valuable to have 'live' evidence sessions for these purposes, it is important to ensure that evidence from different sources is structured similarly, and that the presenters are of similar standing and experience, in order to avoid presentational effects from unduly swaying participants' views. Where a process involves multiple workshops, this may take the form of written or filmed inputs to ensure consistency.
- **Transparency of purpose:** Unlike much traditional public opinion research, where the purpose of the exercise may not be known to participants, deliberative approaches are characterized by a clear task or purpose that the participants are aware of from the start. Whether their role is to influence a decision, choose between options, or simply to inform a communications plan or campaign, participants in a deliberative process are 'insiders' – aware of what they are part of, how their views will be used, and what can and cannot be changed as a result of their deliberation.
- **Representativeness:** Participants in a deliberative event generally reflect the contours of the population more broadly in terms of age, gender, social class and geography. Alongside this, there may be valid reasons to consider over-representing some groups whose voices might be of particular relevance or interest to the topic. This may be because a particular group disproportionately uses a service under consideration, or because they are a seldom-heard voice whose interest in an issue is often overlooked in mainstream debate.

When is deliberative research useful?

Deliberative approaches can be helpful in relation to a wide range of complex subjects. However, there are a number of characteristics that tend to be shared across issues and topics that where deliberative approaches are most successful:

- Topics where there is a genuine choice to be made, with clear consequences and trade offs. Deliberation is most valuable where the likely implications of different policy options are known and can be clearly set out to participants. Where the trade-offs are less clear- cut, or there is disagreement amongst experts about what may or may not occur as a result of a particular course of action, deliberation can be less effective.
- **Decisions where citizens' values matter for choosing between options** – If the decision or issue is a purely technocratic matter of identifying the best way to do something, then involving citizens may not be the right way to proceed. In contrast, if the decision involves trade-offs and prioritisations on the basis of the relative importance of different outcomes to citizens, then deliberative approaches can be helpful in uncovering citizens' *informed* priorities.
- **Issues where citizens' priorities are likely to change with additional information**. Deliberation is most useful where there is good reason to believe that 'top of mind' public opinion may not be taking due consideration of all of the implications of a decision. In particular, deliberation is useful where it is important to understand how views are likely to change through exposure to alternative viewpoints, a more thoroughgoing understanding of the consequences of a decision, or simply exposure to trade offs that are not well recognized in the public discourse.
    - In this sense, deliberative research is often discussed in terms of participants' journey from considering an issue in a purely private 'consumer' mindset, towards a more full consideration of the implications of a course of action from a 'citizen' perspective.

The table below offers a summary of when deliberative research is an appropriate methodology, and when it may be less useful.

Useful applications of deliberative	Less useful applications of deliberative
• Issues where there are a range of different expert prescriptions, but an agreed body of facts	• Issues where there is consensus on the correct policy prescription • Issues where the underlying facts are contested
• Clear trade offs, with consequences that are identified and relatively certain	• Issues where the consequences of different choices are uncertain or unknown – as these are much more difficult for participants to grapple with and weigh against one another
• Complex subjects where citizens' **values** matter for choosing between options	• Purely technocratic decisions

• Issues where citizen priorities are likely to change with new information
  • Exposure to alternative viewpoints,
  • Understanding consequences and trade offs
	• Issues where citizens' views are both highly informed and deeply entrenched are unlikely to be amenable to deliberation

• Understanding which facts, arguments and viewpoints might shape the views of highly **engaged** citizens	• Seeking to understand how an issue might play out amongst the general public ○ Deliberative participants pay much more attention and engage much more closely than would be likely when an issue becomes "live" in the national media debate
• Demonstrating deep and meaningful engagement	• Providing legitimacy to decisions already taken

Deliberative research and the public value impacts of spectrum allocation

Whilst the value of commercial and personal uses of electromagnetic spectrum (such as mobile and commercial television) can be expressed in monetary terms through economic analysis, other uses - such as maintaining reserved spectrum for use by Public Service Broadcasters, the emergency services, defence or air traffic control – are much harder to value in purely economic terms. Furthermore, valuations of uses of spectrum (whether commercial or otherwise) often fail to 'price-in' the widespread positive and negative externalities associated with each use. The implication is that decisions around how best to allocate finite spectrum between different uses currently lack a systematic way of weighing up the true value of different uses against one another.

The DCMS Spectrum Panel has been convened by HM Government to develop a framework for measuring the social value of Spectrum as an aid to Spectrum allocation decisions. In particular, DCMS' UK Spectrum Strategy challenges the panel to "*… ensure that easy to understand procedures [for valuing different uses of spectrum] like monetization are not permitted to dominate other methods which may be less coherent but which nevertheless articulate important public values".* As part of their work, the panel are looking at a range of ways of understanding how members of the public themselves value different uses.

The use and allocation of electromagnetic spectrum is a very low-engagement topic for members of the general public. As such, standard valuation or preference ranking techniques may only access a 'top of mind' understanding of the relative value of different uses of spectrum. Regardless of the technique used – for example revealed or stated preference, willingness to pay, willingness to accept - it is likely that in the absence of additional information and consideration, public preferences will allocate higher value to the uses of spectrum whose benefits are more clear, immediate and personal to them (such as mobile telephones, broadband and Digital Television), and under-value those where the benefits are less tangible, or more collective in nature (such as emergency services, scientific research, or public service broadcasting). Similarly, while they might find it easy to imagine the incremental benefit of faster or more capacious mobile services, they may find it difficult to envisage what the incremental benefit might be of allocating more bandwidth to, say, defence, or emergency services.

Taken alone, deliberative approaches will not provide a robust estimate of the value of non-commercial uses of spectrum. However, these approaches can go some way to understanding how and why relative valuations of different uses of spectrum might change when members of the public consider these uses in greater depth, and learn more about the less widely-known impacts that each has on individuals and society. Taken together with other approaches such as stated preference (or, where sufficiently fine-grained data exists, 'revealed' value via differential wellbeing evaluations) deliberative techniques may offer a means of understanding how these valuations differ when people's thinking and consideration shifts from a more 'consumer' to a more 'citizen' mindset.

Potential approaches

At BritainThinks, we see two potential roles for deliberative research in relation to this challenge:

1. Exploratory deliberative research to inform the broad approach to assessing non-monetary valuation
2. Case-by-case deliberation to examine particular allocation decisions

Each of these is discussed in turn, below.

1. Exploratory deliberative research to inform the broad approach

The objective of this approach would be to understand if and how the way that citizens' value different uses of spectrum change when they are given the time and space to consider the issue in real depth. The research would engage with the full range of uses of spectrum and develop a set of "citizens' criteria" for each use – setting out what the minimum standards to be maintained might be for each use, and the criteria for assessing the relative benefits of allocating additional spectrum to each non-commercial use.

- Alongside developing these overarching guidelines, the deliberative research would be invaluable in the development of any survey-based quantitative approaches such as stated preference questionnaires. The insight from the deliberative work could be used to shape and structure the questionnaire in order to ensure that it provides respondents with a clear explanation of spectrum allocation as a concept, and sufficient information to make an informed assessment of the relative value of different uses.

A possible approach might involve running a small series of two or three workshops in multiple locations across the country. Each might involve around 20 participants recruited to be reflective of the population in that area in terms of age, gender, social class, rurality, housing tenure, etc. Each workshop would last up to two days, and would incorporate a series of group and plenary discussions, knowledge building sessions, and expert presentations. The precise content would, of course be developed alongside DCMS and the Spectrum Panel, but an outline flow might include:

- **Session 1: Background knowledge and views** - An initial discussion to understand what knowledge, if any, participants have of spectrum, what it is used for, and how it is allocated.
- **Session 2: Knowledge building:** An information session, carefully designed to ensure that all participants share a common baseline of

knowledge: What is spectrum? How does it work? How do we use it now? How do we allocate it at the moment? Why does it matter?

- **Session 3: Deep dive into current and future uses of spectrum:** Taking each use at a time and working to think through the personal and social benefits of each. For each use, participants would understand:
    - Which individuals and groups benefit from allocating spectrum to that use
    - Any developments in technology or changes in demand levels predicted for this use of spectrum, and the share of spectrum required to deliver these
    - What the implications would be of reducing the spectrum available to that use
    - What the implications would be of assigning more spectrum to that use
- **Session 4: Allocation game:** Interactive 'game' whereby participants could allocate and reallocate finite spectrum across uses, to develop their own 'optimum' allocation
- **Session 5: Developing a set of "citizens' criteria" for evaluating potential allocations in the future:** Developing a common set of rules by which to think about future allocation questions.

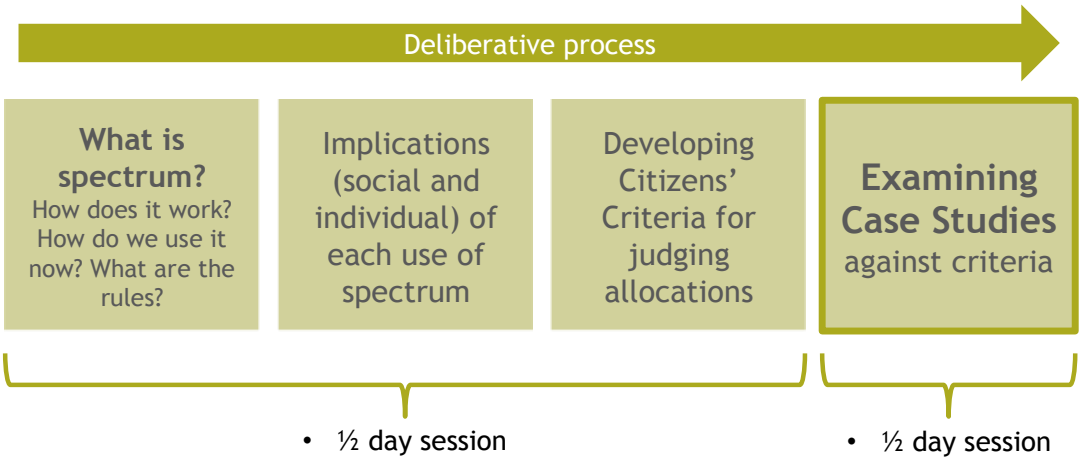
2. Case-by-case deliberation to examine particular allocation decisions

Deliberative approaches could also be invaluable when evaluating specific allocation decisions on a case-by-case basis. The objective here would be to complement other methodologies such as stated preference techniques in order to understand how those valuations shift when citizens have spent time considering the issue in more depth.

One approach could involve creating a small 'comparison group', within a stated preference survey sample, of citizens who have been involved in a deliberative process prior to taking the stated preference survey. Their results could then be compared against those of the rest of the sample, to give an indication of where 'top-of-mind' responses may be systematically under-valuing a particular use of spectrum.

This approach might involve multiple, smaller, one day workshops – perhaps involving 100 participants across a series of five workshops – in which

participants would be briefed on the specifics of a particular allocation decision, and spend time considering the different options and their implications. The discussion guide and structure of the days would vary significantly according to the specifics of each allocation decision, however, the overall flow would likely be similar. The diagram below sets out this basic structure:



Following the deliberative workshop, participants could be included within the sample for the stated preference (or similar) survey work. While any significant differences in the valuations of deliberative participants compared with the sample as a whole would only ever be indicative, they could provide an invaluable indication of areas where 'top-of-mind' responses may not reflect the valuation offered by citizens who have considered the implications of a particular allocation more deeply.

Exhibit D1: Common forms of deliberative research and engagement

Type	Typical characteristics
Citizens' Summit	• Very large scale – 100s or even 1000s of participants • One off events • Usually focused on broad-brush principles, rather than specific decisions • Demonstrating engagement, as well as practicing it
Citizens' Jury	• One event (or sometimes two) • Usually between 10-30 participants, recruited from across the country (or geography of interest), to be broadly reflective of the population parameters along key social and demographic axes • Multi-day events, often reconvened • Information presented 'live' by experts in the form of evidence sessions – usually involving Q&A sessions, and sometimes involving the opportunity for Jurors to call outside witnesses of their own. • Complex subjects, often very 'low engagement' for the general public

Deliberative workshops	• Multiple, smaller workshops, usually held in a number of locations across the country
	• 10-20 participants at each workshop – recruited locally, to be reflective of the population of interest
	• Usually one or two days in length, but can be as little as half a day.
	• Focussed on one or two very specific decisions or questions
	• Emphasis on repeatability of the process:
	  ○ Highly structured discussion guide
	  ○ Evidence from fact sheets or video, in order to ensure consistency across multiple locations
	  ○ Tasks and allocation exercises – to allow comparison across locations

Deliberative Polling	• Rarely practiced in the UK • Focussed on individual responses to new information, with less emphasis on the debate/discussion aspects of deliberation • Iterative survey process involving a baseline survey, followed by a process of information provision (often via the web, or postal), with repeated rounds of surveys and further information. • Can involve hundreds or thousands of participants • Can take weeks or months to complete

Type	Typical characteristics
Co-creation	• Workshops or events in which experts and policymakers work alongside members of the public to develop and refine ideas together • Less interested in replicability/balance of process, more interested in harnessing the thoughts, ideas and values of citizens into the policy-making process itself.

Exhibit D2: Further Reading

Ackerman, B and Fishkin, J. 2004, *Deliberation Day.* New Haven, Conn: Yale University Press

AmericaSpeaks, 2007. *Engaging Citizens in Governance*, (www.americaspeaks.org)

Cooke, V., *Participation and Legitimacy: The case for good deliberation*. In Creasy, S., (ed). 2007. *Participation Nation: Reconnecting Citizens to the Public Realm*, London, Involve

Creighton, J.L. 2012. *The Public Participation Handbook: Making better decisions through citizen involvement*. Jossey-Bass

Gastil, J., and Levine, P., (eds). 2011. *The Deliberative Democracy Handbook: Strategies for effective civic engagement in the 21st century*, Jossey-Bass

Gutmann, A and Thompson, D. 2004. *Why Deliberative Democracy?* Princeton

Involve, 2005. *People and Participation*, London

Mansbridge, J., Hartz-Karp, J., Amengual, M. and Gastil, J. 2006. *Norms of deliberation: and inductive study.* Journal of Public Deliberation 2(1):1-47

National Consumer Council, 2008. *Deliberative Public Engagement: Nine Principles*. London

Schuman, s. (ed). 2005. *Creating a culture of collaboration*. Jossey, Bass and Wiley.

Sciencewise & BIS, *The Government's Approach to Public Dialogue on Science and Technology*, London

Warburton, D., Wilson, R., and Rainbow, E. 2007. *Making a difference: A guide to evaluating public participation in Central Government*. London: Involve

Examples of deliberative approaches in action

Department of Health. 2006. *Evaluation of your health, your care, your say: an independent report commissioned by the Department of Health*. London: DoH, 78.

DWP, 2006. *Security in Retirement: towards a new pensions system*, London, DWP (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/272299/6841.pdf)

PwC and BritainThinks, 2010. *Dealing with the deficit: the citizens' view*. http://www.pwcwebcast.co.uk/dpliv_mu/dealing_with_the_deficit/citizens_review.pdf

PwC and BritainThinks, 2012. *A Question of Quality: The Citizen View of Quality in the NHS* http://www.pwc.com/gx/en/psrc/united-kingdom/citizens-jury-health-full-report.jhtml

PwC and BritainThinks, 2014. *Taxation in the UK: A citizens' view*. http://www.pwc.co.uk/issues/futuretax/assets/pwc-tax-citizens-jury-final-report300631.pdf

Appendix E. Economic approaches to valuing spectrum

By: Daniel Fujiwara, Susana Mourato, Ricky Lawton

Executive summary

Background

This report examines the potential for **employing economic approaches for monetary valuation** to radiospectrum, with the objective to help inform radiospectrum allocation decisions. The focus of this paper is on valuing the benefits of spectrum to society. This is the value that Spectrum creates for individuals in society in terms of improvements in their quality of life. The paper does not discuss the economic contribution of Spectrum. The aim is to discuss how methods can be designed and applied to the valuation of Spectrum, how their results can be used and interpreted, and highlight the relative advantages and disadvantages of the methods. We discuss the application of revealed preference, stated preference and wellbeing valuation methods to Spectrum, with a focus on the latter two methods.

Economic approaches for the valuation of Spectrum

Spectrum can be defined in two ways. The first sees spectrum as a **resource** or **input** and the second in terms of a set of related **outcomes** that are valuable to society, such as the internet, emergency services, scientific research etc. **The focus of this paper is on the valuation of outcomes in relation to Spectrum, whereby a change in the provision of Spectrum is valued according to the value of the resulting changes in the provision of final outcomes**.

The value of a good or service relates to the impact that it has on human welfare and this can be expressed in terms of **compensating or equivalent welfare measures** (Hicks 1934).[9]

Revealed preference valuation methods

Revealed preference methods uncover estimates of the value of non-market goods by using evidence of how people behave in the face of real choices. The basic premise is that non-market goods affect the price of market goods

[9] Compensating surplus is the amount of money, paid or received, that will leave the agent in their initial welfare position following a change in the good. Equivalent surplus is the amount of money that will leave the agent in his subsequent welfare position in absence of a change in the good (Bockstael & McConnell 1980).

in other well-functioning markets. Of most relevance to Spectrum is the *hedonic pricing method,* which elicits the value of a non-market good as part of a bundle of attributes of a market good, for instance house property prices. It would be possible to include some Spectrum-related outcomes that vary at the geographical level in hedonic price models, for instance free-to-view television broadcasting and high-speed internet connectivity if these impact on house prices. The benefit of revealed preference methods is that they are based on observable market behavior, eradicating problems related to the hypothetical bias inherent to contingent valuation methods (Carson and Louviere 2011). However, very often well-functioning direct or indirect markets do not exist for the outcomes we are interested in and this is likely to be the case for many of the Spectrum outcomes.

Stated preference valuation methods

Stated preference techniques are survey-based methods that elicit monetary values of non-market goods and services by directly asking people what economic value they attach to specified changes in those goods and services. Two main types of stated preference methods exist: **contingent valuation methods** and **choice modelling techniques**, such as choice experiments.

Contingent valuation (CV) asks respondents directly to report their maximum willingness to pay (WTP) (for positive outcomes) or minimum willingness to accept (WTA) (for negative outcomes) for the hypothetical policy change. In the case of Spectrum, the policy change is any change in the provision of non-market final outcomes resulting from a change in Spectrum allocation. The main advantage of CV is that it is extremely flexible and capable of valuing a wide range goods and services, including future or planned changes, and to capture non-use values (stated preference methods provide the only means available for this). This is advantageous in the case of Spectrum given the multiplicity of goods and services it supports and the fact that many of these policy changes have not yet happened. However, we need to acknowledge common types of bias in CV studies, such as hypothetical bias, insensitivity to scope, framing effects and focussing biases. There are now best-practice solutions for many of these problems and these should be considered in any CV studies related to Spectrum.

Choice modelling (CM) is a multi-attribute preference elicitation technique used extensively in marketing, transportation and environmental valuation. Respondents are presented with a series of scenarios, each composed of different attributes, varying at different levels. Respondents are then asked to choose their most preferred scenario. If a monetary cost is included as one of the attributes, it is possible to value of the component attributes, in other words the implicit value of each of the attributes (i.e., the marginal WTP). The

major advantage of CM is that it allows for simultaneous analysis of the influence of several attributes on individual choice. For example, changes on mobile communication outcomes, television and radio broadcasting, and meteorological services would be presented as attributes of alternative Spectrum scenarios, varying at different levels. CE is also ideally suited for situations where trade-offs between the various policy characteristics are of particular interest: for example, trading off improvements in mobile communication outcomes at the expense of meteorological services outcomes. However, CE also presents greater cognitive burden on respondents and the associated problems of learning and fatigue effects which may lead to errors. In addition, CM tends to lead to a significant over-estimation of the value of the whole good/service, compared to CV.

Wellbeing valuation method

The wellbeing valuation (WV) approach relies on measures of subjective wellbeing (SWB), such as life satisfaction and happiness. Values (i.e., compensating and equivalent welfare measures) for non-market goods can be derived from estimates of the impacts of the goods and money on people's SWB, by looking at how much money would have the same impact on SWB as the non-market good. The main advantage of WV is that it can overcome many of the survey related biases found in stated preference, such as hypothetical bias, framing effects and focusing biases, because people are not asked to state a value directly. Also, WV is a highly cost-effective method because it can be used with pre-administered national survey data, eliminating the need to collect primary data as in stated preference methods. However, the WV approach cannot measure non-use values or future changes (because the method is based on data whereby individuals have to experience the policy outcomes directly during the course of their lives). WV is also reliant on rigorous statistical methodology to estimate the causal impact of different factors on SWB, which is not always possible and the method has a narrower application than stated preference methods, because in the latter we can develop valuation surveys about any good/service that we like. As with stated preference methods there exist some solutions for some of these problems and these should be taken into account in any WV study of Spectrum.

Application to Spectrum

Revealed preference methods will be limited by the fact that not many Spectrum related outcomes are likely to impact on house prices. Therefore, stated preference and wellbeing valuation methods are likely to be required for the valuation of Spectrum outcomes.

Stated preference methods will require primary data collection which can be costly and time-consuming, but it would be possible to assess many, if not all, Spectrum related outcomes using the method due to the flexibility of the approach. We recommend using a mix of ex-ante and ex-post corrective strategies, such as cheap talk scripts, to minimise issues related to hypothetical bias, whereby stated WTP values are higher than what people would actually be willing to pay. This includes entreaties and certainty scales. Researchers should also be mindful of the possibility of insensitivity to scope in the case of Spectrum-related outcomes and at the very least, respondents should be given adequate information about the service as a whole, before being asked to place a value on a smaller attribute of the service. Best practice guidance recommends the use of reminder statements to ensure that respondents give full consideration to *substitute* goods. Respondents should also be given sufficient time to form a WTP response. These latter two strategies will help respondents to reveal more meaningful and truthful WTP/WTA amounts.

Wellbeing valuation can be undertaken with pre-administered secondary survey data provided that the outcomes of interest (or proxies for them) can be found in the current data, which on many occasions should be the case. The UK has around 15 different datasets that include quality of life measures such as life satisfaction. For the purposes of valuing Spectrum outcomes we would recommend the British Household Panel Survey, Understanding Society and the Annual Population Survey since these are large nationally representative datasets that contain the life satisfaction question as well as a very rich set of questions on people's lives in general. Wellbeing valuation can also be undertaken with primary data whereby surveys are developed and administered to collect data on Spectrum-related service usage and wellbeing so that the impact and value of Spectrum outcomes can be estimated. The key to wellbeing valuation is to derive robust estimates of the impact of non-market goods and money on people's wellbeing. Here caution must be applied in the statistical analysis of wellbeing data since estimates of the impact of Spectrum outcomes on wellbeing can be biased. Methods such as instrumental variables should be used to improve the validity of the results. Care must also be taken to ensure that the variables used in the model are close proxies for the outcomes we are interested in valuing.

Given the relative pros and cons of the different approaches it is likely that the economic valuation of Spectrum outcomes will ultimately require a mix of different methods. We recommend the use of online surveys in stated preference and wellbeing valuation (where required by the latter). Online surveys are very cost-effective and quick and they facilitate the presentation of information and enable the use of alternative media such as images, film or

sound. An important concern with online studies that will need to be addressed is the potential for producing non-representative samples. Groups that have reduced access to the internet will typically be under-represented. We thus recommend that online surveys either be administered using quota sampling, whereby harder to reach groups would be targeted to ensure that the sample is representative or that sampling weights are estimated and used in any subsequent analysis.

D1. Background

This paper examines the potential for **employing economic approaches for monetary valuation to radio spectrum**. This is with the objective of helping inform radio spectrum allocation and policy decisions. It is important to make clear at the outset a distinction between different concepts of value.

Economic contribution refers to the impact of a changes in a good or service on economic indicators, which is often valued in terms of changes in GDP or income. This is also sometimes referred to as economic value, but we do not use that terminology here, and instead we use the more formal interpretation of economic value.

Economic value refers to the impact of changes in a good or service on human welfare (or wellbeing), measured in monetary terms. Values are derived using market or non-market valuation methods. This encompasses a much wider range of impacts covering society more widely, by looking at the value that individuals place on a good or service. The aggregation of economic value over individuals in society produces the **social value** of the good. Thus whereas economic and social are often used to refer to *types* of impact (e.g., income effects for 'economic' and health effects for 'social'), we use the more formal definition in economics where economic value is the value that an individual places on a good or service and social value is the aggregation of these individual values across society. Economic value covers all types of benefits to the individual and is a measure of the improvement in the quality of life of the individual.

The focus of this paper is on economic and social value for valuing the benefits of spectrum to society. A good discussion and application of methods for measuring the economic contribution of spectrum can be found in Kende et al., (2012).

In particular, we discuss **stated preference** and **wellbeing valuation** methods for spectrum, but also recognise that **revealed preference** methods may offer a useful method for valuing spectrum too. As far as we are aware

stated preference and wellbeing valuation methods have not been used before for spectrum valuation.

We discuss how the methods can be designed and applied to the valuation of spectrum, how their results can be used and interpreted and to highlight the relative advantages and disadvantages of the methods in the context of spectrum valuation.

D2. Economic approaches for the valuation of Spectrum

D2.1. Defining Spectrum for the purposes of economic valuation

Understanding the value of Spectrum to society is a complex issue. On the one hand, spectrum has a large number of uses in different activities and on the other, economic valuation has many dimensions and methods. The key to understanding the value of spectrum is to define spectrum in two ways. The first is Spectrum as a **resource** or **input** and the second is in terms of a set of **outcomes** related to spectrum that are valuable to society such as the internet, emergency services, scientific research and so on. **The focus of this paper is on the valuation of outcomes in relation to Spectrum**.

In order to value Spectrum we first need to investigate how Spectrum generates wellbeing (or welfare, utility) for individuals in society (see discussion of the theoretical foundations of economic valuation theory in section 2.1.). This requires identifying all of the multiple different channels through which changes in Spectrum allocation result in changes in welfare. This will help us to identify the most appropriate valuation techniques (market and non-market) to value these changes in wellbeing. There are a number of general difficulties involved that should be further researched (a full discussion of their implications for Spectrum valuation is out of the scope of this discussion paper) and that are relevant for the discussion of methods that we present later on.

i. Distinguishing between intermediate and final Spectrum goods and services

Following Maddison and Day (2015) we define *final goods and services* as those that enter a household utility function or a firm production function. *Intermediate goods and services* are instead inputs in the production of final goods and services. The distinction is important as generally households do not have preferences for intermediate goods and services and are only capable of valuing final outcomes. Hence it does not make sense to try to elicit individuals' willingness to pay for intermediate services and such attempts could lead to double counting (Bateman et al., 2011).

The distinction between intermediate and final services is particularly relevant in the context of Spectrum valuation as Spectrum itself is an intermediate good or service and hence does not enter household utility functions (e.g. people do not value airwaves directly). Moreover, many services supported by Spectrum are also intermediate in nature. For example the use of spectrum by the police, courts, prisons and probation service is unlikely to be valued directly by the public. But individuals do value the increased safety levels (final outcome) that might result from this intermediate use of Spectrum. **Therefore, a change in the provision of Spectrum is valued according to** the value of the resulting changes in provision of final outcomes. This relates to the concept of **Spectrum-using services** which are bought by households and other end-users as inputs. We are focusing on the value of the final goods and services that are derived from this use of Spectrum by households and other end-users. Table D1 contains a summary of the main Spectrum-related outcomes.

Table D1. Outcomes of Spectrum usage

Spectrum supports	Which enables/provides:	Outcome
Mobile communications	- Contact with/availability to friends/family - Broadband enables constant access to internet/social media - Social connectivity	- More interactions with friends and family (possibly closer relationships?) - Access to ideas/developments - Feel safe and secure
Television and radio broadcasting	- Entertainment - Information - Travel news - Awareness campaigns e.g. smoking, drinking, dangerous driving etc	- Engagement in the arts - Avoid disruption and reduce contributing to bigger problem (e.g. traffic) - Increased health awareness to promote healthy/ preventative behaviour
Defence and security communications	- Intercept/prevent terrorism or threats to national security	- Prevention of terrorist attacks - National security - International relations?
Emergency services communications	Communication between and rapid, appropriate response from: - Police - Ambulance - Fire service	- Feelings of safety and security - Prevention of crime - Reduction in damage or injury/death from accidents or incidents
Meteorological services	- Accurate weather forecasts - Monitoring drivers for climate change	- Pre-empt extreme weather (e.g. floods/storms) and minimise damage and disruption

Spectrum supports	Which enables/provides:	Outcome
		- Inform behaviour change to reduce impact of climate change
Radar for coordinating transport including air traffic control	- Safe travel - Smooth running of transport systems	- Prevention of chaos/crashes/death - Reduction in stress - Feelings of security
Smart metering	- Machine-to-machine communications	- Manage energy consumption - Cost savings

It is recognised that the relationships between changes in Spectrum and changes in final outcomes might be complex and adequate models may be required to disentangle the portion of the final outcome change that is due to Spectrum changes. This shares similarities with the valuation of ecosystem services (in work conducted as part of the UK National Ecosystem Assessment (NEA 2011)), where it is necessary to isolate the contribution of ecosystem services to the production of final goods and services that produce wellbeing benefits. Here too, disentangling the contribution of Spectrum to final outcomes is essential for the various methods that are proposed below.

ii. Demand versus supply side of the economy

The Green Book focuses almost entirely on valuing changes experienced on the consumption side of the economy (i.e. the demand side) and very little is said about how to value changes that impact on productive enterprises in the economy (i.e. the supply side) (Maddison and Day, 2015). This is relevant for the valuation of Spectrum as in some cases firms' production and profits will be affected by changes in Spectrum (e.g., high-speed broadband provision). Values can be established on the production side of the economy by examining how changes in provision of Spectrum impact on firms' producer surplus via methods such as the production function approach[10]. Although this review focuses only on the consumption side of the economy, it is important to point out that there may be scope in some cases to use production side methods as well.

iii. Distinguishing between marginal and non-marginal changes in Spectrum provision

If the changes in Spectrum allocation are marginal then values based on prices or willingness to pay/willingness to accept measures will be

[10] This method estimates the technical relationship between a firm's production of output and levels of inputs such as Spectrum; it would then allow predictions of how changes in Spectrum will impact on producer surplus.

appropriate. But if the changes are large and non-marginal, then values should account for adjustments in human behaviour, which will be much more complex to model. The preference-based non-market valuation methods available and described here are best suited to value marginal changes, but we discuss how wellbeing valuation methods can be used for non-marginal changes too.

iv. Multidimensionality

Spectrum supports a very large number of final goods and services that affect wellbeing (see Table 1). Therefore, it is unlikely that a single method will be able to capture all the wellbeing changes resulting from changes in Spectrum allocation. A suite of different methods will be needed to capture the inherent multidimensionality of Spectrum-related outcomes. The methods we present in this paper can all contribute to mapping the value of Spectrum changes.

D2.2. The theory of economic valuation

The economic value of some good or service, as defined in the microeconomic theory that underlies the HM Treasury Green Book guidelines on cost-benefit analysis (CBA), is a measure of the change in human welfare, or *utility*, that results from it. Employing a Total Economic Value (TEV) framework (Pearce et al., 2006) – a typology of why individuals hold values for any given good, service or resource – we can identify a primary categorisation of use and non-use values associated with resources like Spectrum.

Use values are values associated with the **direct use** of spectrum. This will cover the various services related to spectrum including internet services and mobile communications, television and radio broadcasting, meteorological services, emergency services, and defence and security communications[11].

Non-use values can be described as: ***altruistic*** *values* – welfare increases from knowing that others living will benefit; ***bequest*** *values* – welfare increases associated with knowing that future generations will benefit; and ***existence*** *values* – associated with welfare enhancements from knowing that Spectrum exists even if an individual does not experience a use benefit now or in future.

Many of the multiple benefits listed here are by their nature bundled together and they are difficult to separate in a meaningful way. Partial separate identification of some of the broader benefits categories (e.g. use and non-use

[11] A so-called **option value** can also be attached to potential future use of the Spectrum related services, although there are arguments about whether option value constitutes a separate category of value (Maddison and Day, 2015).

values) may however be possible, with careful sample selection and survey design. Individuals may hold both use and non-use values related to Spectrum outcomes.

The value of a good or service relates to the impact that it has on human welfare (Freeman, 2003) and this can be expressed in terms of **compensating or equivalent welfare measures** as first devised by Hicks (1934). [12] [13]

Compensating surplus (CS) *is the amount of money, paid or received, that will leave the agent in his initial welfare position following a change in the good.*

Equivalent surplus (ES) *is the amount of money, to be paid or received, that will leave the agent in his subsequent welfare position in absence of a change in the good.*

In essence, CS and ES refer to the change in income that holds welfare constant in light of the change in the provision of the good (which could be a change in the quantity and/or quality of the good).

Formally CS is derived as follows:

(1) $u(Q^0, M^0) = u(Q^1, M^0 - CS)$ (for a welfare gain)

(2) $u(Q^1, M^0) = u(Q^0, M^0 + CS)$ (for a welfare loss)

where CS = compensating surplus; M = money or income; Q = the non-market good; and the 0 and 1 superscripts refer to before and after provision/consumption of the non-market good (Q). We focus here on CS since it has become the standard measure of welfare change used in cost-benefit analysis, but ES can be derived in a similar formal manner. See Bockstael and McConnell (1980) for a full discussion.

CS and ES measures are commonly rephrased in terms of **willingness to pay (for good outcomes)** or **willingness to accept (for bad outcomes)**.

---

[12] Definitions modified from Bockstael and McConnell (1980).

[13] We focus on compensating and equivalent surplus rather than variation measures. Surplus measures differ from variations in that the latter are calculated after the individual has made adjustments to his consumption set (Randall, 1982) and hence relate to price changes. Thus compensating/equivalent variation relates to price changes, whilst compensating/equivalent surplus relates to quantity or quality changes, which applies to our discussion of Spectrum outcomes here.

The Annex sets out the different measures of willingness to pay and willingness to accept.

D2.3. Valuing changes in Spectrum-related outcomes

Choosing an adequate valuation method for eliciting the value of changes in Spectrum allocation will require classifying changes in final Spectrum-related outcomes into one of several categories:

1. Goods and services that are *traded directly in a market*: **Estimate consumer surplus using market price methods** (adjusted for any market distortions) (e.g., broadband internet, mobile communications).

2. Goods and services that are *not traded in markets*: **Use non-market valuation techniques**. The most relevant technique to use depends on the specific characteristics of the outcomes of interest. A number of possibilities emerge:

    a. Goods and services that result in *observable changes in behaviour in indirect markets*: **Use revealed preference methods** (e.g., the value of free-to-view television broadcasting or of the emergency services may be revealed indirectly in housing markets across regions where the level or quality of provision of these services differs).

    b. Goods and services that *do not result in observable changes in market behaviour but are amenable to direct monetisation*: **Use stated preference methods** (e.g., prevention of accidents and reduction in stress associated with better transport management).

    c. Goods and services that *do not result in observable changes in market behaviour and are difficult to monetise*: **Use wellbeing valuation methods** (e.g., interactions with friends and family). We note that wellbeing valuation can also be used to value the types of goods and services described in a) and b) above.

The focus of this paper is on the non-market valuation techniques and within this category specifically on stated preference and wellbeing valuation methods. There is an important **normative** distinction between these methods. On the one hand revealed preference and stated preference methods employ what is known as the **preference satisfaction account of welfare**. On the other, the wellbeing valuation approach relies on measures related to the **mental state account of welfare**.

D2.3.1. Preference satisfaction account of welfare

The preference satisfaction account is based on the premise that we can infer welfare from people's choices because "*what is best for someone is what would best fulfil all of his desires*" (Parfit, 1984: 494). Modern-day economic theory is based on this account of welfare (although an increasing number of economists now also use mental state accounts of welfare too). In economics the 'information' that preferences reveal is called *utility*.

There are a number of important criteria for the preference account of wellbeing. The fundamental premise is that under a small set of rationality assumptions embodied in the *axioms of revealed preference* we are able to map choices over a number of binary options on to a well-defined utility function. Here rationality implies that preferences are coherent and stable (see the Annex for a discussion of the rationality assumptions). Economists working in applied policy areas also often require that preferences be **well-informed**.

Preference-based valuation methods strictly rely on these assumptions in order to derive welfare economic-consistent measures of value. However, numerous studies have shown that individuals can exhibit irrational preference orderings, making non-market valuation difficult. These issues are discussed in more detail in the section on preference-based valuation methods.

D2.3.2. Mental state accounts of welfare

We use the term mental state accounts loosely to refer to people's subjective experiences of their own wellbeing, which is usually measured through self-reports in a survey. It looks at how the individual feels and thinks about their life. There is a large range of subjective wellbeing (SWB) questions and these include questions on happiness, emotions, life satisfaction, worthwhile/purpose in life, sadness, anxiety and goal attainment. Each taps into different theoretical concepts of wellbeing.

When we seek to measure value with preferences we gauge which state of the world or outcome people prefer, but with SWB measures the question becomes one of assessing the impacts of different outcomes on people's self-reported wellbeing. This is a key distinction: with preferences we look at what people want, but with SWB we look at what things make people feel their lives are going better. Now of course on many occasions this could be the same thing, but it does not have to be. There are three broad categories of SWB:

I. **Evaluative subjective wellbeing**: global assessments of people's wellbeing such as life satisfaction.

II. **Experience subjective wellbeing**: measures of people's feelings or *affect* over single points in time. This could be measures of happiness, worry, anxiety, sadness etc.

III. **Eudemonic subjective wellbeing**: relates to people's psychological needs, such as autonomy and the feeling that things in life are worthwhile.

The requirement on SWB measures for the purpose of valuation is that they accurately reflect a person's welfare. We will focus on evaluative measures of SWB – specifically life satisfaction - here since life satisfaction is the main measure used in wellbeing valuation.

Life satisfaction is usually derived from the following type of question (example taken from the British Household Panel Survey): *"How dissatisfied or satisfied are you with your life overall?"* and responses are made on a scale of 1-7 or 0-10. Life satisfaction can be seen as being made up of a balance of affect (positive and negative emotions and feelings) together with a cognitive assessment of how well one's life measures up to aspirations and goals (Diener, 1984; Kahneman and Krueger, 2006). In responding to these questions problems may arise if people do not accurately recall how they felt during previous activities and events in their lives and also there is evidence that people's feelings can be influenced by contextual factors present at the time of the survey and biases can also arise in the stage of verbally reporting life satisfaction scores (Bertrand and Mullainathan, 2001; Kahneman and Krueger, 2006; Schwarz, 2010; Schwarz and Strack, 1999). We will discuss these issues in more detail in the section on wellbeing valuation.

D3. Revealed preference valuation methods

Revealed preference methods uncover estimates of the value of non-market goods by using evidence of how people behave in the face of real choices. The basic premise is that non-market goods affect the price of market goods in other well-functioning markets. The price differentials in these markets can be used to provide estimates of WTP and WTA. Of most relevance to Spectrum is the *hedonic pricing method,* which elicits the value of a non-market good as part of a bundle of attributes of a market good, through for instance house property prices (Pearce et al. 2006). Applied hedonic analysis recovers the marginal valuations or 'implicit prices' of the separate housing attributes from a regression of housing transaction sales prices on the component attributes of the house sold - its structural characteristics, amenities, neighbourhood services etc. (Gibbons et al. 2013). It would be possible to include some Spectrum-related outcomes that vary at the

geographical level, under the assumption that this attribute affects house prices.

The benefit of revealed preference methods is that they are based on observable market behavior, eradicating problems related to the hypothetical bias inherent to contingent valuation methods (see below for a discussion of this issue) (Carson and Louviere 2011). Hedonic pricing models rest on the assumptions embodied in the axioms of revealed preference and the assumption of market equilibrium. This is rarely the case in housing markets where transaction costs are high and supply is restricted.

Hedonic studies have been applied to a range of factors, including environmental amenities (Garrod and Willis 1992; Geoghegan 2002; Waltert and Schläpfer 2010), sports facilities (Ahlfeldt and Maennig 2008; Feng and Humphreys 2008; Tu 2005), and national infrastructure projects like transport networks (Forrest et al. 1996; Haider and Miller 2000; Kanemoto 1988) and airport expansion (Lipscomb 2003; Nelson 2004). Their use in the valuation of Spectrum outcomes is more limited, but there are some potential areas of use. For example, the value of free-to-view television broadcasting and high-speed internet connectivity may be revealed in housing markets.

However, very often well-functioning direct or indirect markets do not exist for the outcomes we are interested in and this is likely to be the case for many of the Spectrum outcomes. Our focus in this paper is therefore on the other two methods for valuing non-market goods - stated preference and wellbeing valuation methods – as policy makers will need to rely on them to derive values for many of the outcomes related to Spectrum.

D4. Stated preference valuation methods

Stated preference techniques are survey based methods that seek to elicit the monetary value of non-market goods and services by directly asking people what value they attach to specified changes in those goods and services (Bateman et al. 2002). They offer the only way to measure non-use values. There are two main types of stated preference methods: the **contingent valuation method** and **choice modelling techniques**, such as **choice experiments**. The former is likely to be more relevant in the context of Spectrum related policy changes and hence this review discusses contingent valuation in greater detail.

D4.1. Contingent valuation method

D4.1.1. Introduction

Contingent valuation involves asking respondents directly to value a specified policy change (Mitchell and Carson, 1989; Bateman et al., 2002). In the case of Spectrum, the policy change would be any change in the provision of the final outcomes resulting from a change in Spectrum allocation. By means of an appropriately designed questionnaire, a hypothetical market is described where the outcome in question can be traded (Mitchell and Carson, 1989). This contingent market defines the policy change, the institutional context in which it would be provided, and the way it would be financed. A random sample of people is then directly asked to express their maximum willingness to pay (WTP) or minimum willingness to accept (WTA) for the hypothetical policy change. Contingent valuation (CV) assumes that the stated valuations are related to respondents' underlying preferences in a consistent manner.

D4.1.2. Key assumptions

The critical assumptions embodied in the CV methodology are that individual behaviour is in line with the preference axioms and that respondent behaviour in a hypothetical situation will be similar to that in an equivalent real-life situation. This assumption is supported by attitude-behavioural models developed in the psychological literature, such as Fishbein and Ajzen's (1975) theory of reasoned action, which link hypothetical willingness to pay, a behavioural intention, and actual payments. In this respect the key element of a CV survey is the contingent valuation scenario. It provides respondents with information regarding the proposed policy change to be valued (including the means of provision, method of payment, timescale of payments, and extent of the market) and presents the elicitation question. In all cases, the challenge is to ensure that the scenario is comprehensible, plausible, and meaningful, such that respondents are willing and able to provide valid and reliable estimates of the values attached to the change of interest (Mitchell and Carson 1989).

D4.1.3. Study design issues

The scenario description must clearly identify the **key policy outcomes** and **how these will change following a possible Spectrum allocation change** (Bateman et al. 2002). This is done by describing the conditions under the status quo and comparing these with the conditions under the policy change in a comprehensible manner. An important point to note here is that the purpose of the valuation exercise is to estimate the value of a *change* in Spectrum-related outcomes, rather than valuing those outcomes in full. Understanding and describing those changes properly may require input from experts in the relevant technical fields.

Since CV estimates have been found to be insensitive to the scope of the proposed change, often the result of poor survey design (Mitchell & Carson 1989), it is also important that the extent of the policy change is made clear to respondents. In the context of providing Spectrum-related outcomes defining the scope of the change may be particularly complex given the wide range of goods and services that rely on Spectrum, as noted above. One can value either a **full set of outcomes** (e.g. all the outcomes in Table D1) or, instead, a **subset of those outcomes** (e.g. outcomes related to mobile communications only): the choice depends on what is the relevant policy question that the valuation exercise is trying to answer. If a subset of outcomes is chosen for valuation, care must be taken to contextualise it within the larger set of possible outcomes so that respondents are made aware that the outcomes they are asked to value are part of a broader set of goods and services.

The scenario also needs to describe the **institutional context** in which the policy change and payment takes place (Pearce, Atkinson, & Mourato 2006). This is not necessarily a neutral part of the scenario as respondents may have perceptions regarding the effectiveness, ethical implications, reliability and trustworthiness of different institutions, such as government, TV companies, mobile phone providers, and so on.

In all cases, respondents should be **reminded to consider substitute goods and services**[14], as well as their **budget constraint**, and information should be provided on how the Spectrum policy change relates to other **alternative investment opportunities**.

The final element of the contingent scenario is the **value elicitation question**. The choice of valuation question to ask - WTP or WTA - depends on the initial property rights. In theory both value measures should be similar, but in practice empirical evidence shows that WTA values can be significantly larger than the corresponding WTP values (Bishop and Heberlein 1986, 1984, 1979; Hammack and Brown 1974; Heberlein and Bishop 1986; Mitchell and Carson, 1989). Several hypotheses have been put forward to explain the disparity: the loss of an established property right will require higher compensation than the acquirement of a new property right as per the loss aversion hypothesis (Tversky and Kahneman 1991); the absence of close substitutes for the valued goods and services will lead to greater disparity between WTP and WTA (Hanemann 1991); uncertain respondents tend to state low WTP and high WTA values as a result of their

[14] In the case of Spectrum one may require considerable input to determine what the substitute services may be (if any), but without this WTP values will likely be overstated.

unfamiliarity with the elicitation procedure or the good (Bateman et al. 2002; Hoehn and Randall 1983); respondents who are asked to state a compensation to forgo their initial property rights, may state very high WTA values as a form of protest (Mitchell and Carson 1989); and poor design of WTA studies can lead to an overestimation of stated compensation amounts by failing to remind respondents that the welfare measure required is the *minimum* compensation that would produce the same (not higher) wellbeing level as the change they are asked to forgo (in the case of a wellbeing-enhancing policy) (Bateman et al., 2002). Fortunately, in the case of Spectrum-related outcomes, respondents can simply be asked for their WTP (for a welfare enhancing change or to avoid a welfare reducing change) as they are unlikely to have an entitlement to any particular Spectrum allocation. This is the least problematic measure of value. But it is also conceivable that a WTA format (to avoid a service deterioration) could be asked successfully as even though respondents might not hold a right to the current situation, they may nevertheless perceive that they have that right. In the latter case, careful survey design is needed to minimise the potential for overstatement.

In terms of the **elicitation format** for the WTP question, Bateman et al. (2002) recommend **dichotomous choice formats**. For smaller sample sizes, **payment cards** might be an acceptable alternative. Mitchell and Carson (1989) highlight the importance of ensuring that an incentive-compatible mechanism is used; they consider that true preferences are best revealed when respondents believe provision of the service is dependent on the stated payment. Another important consideration is the **length of period over which the goods or services are provided** as WTP can differ for goods provided over different time horizons. A final consideration is the **extent of the market**, that is, who else will be asked to pay?

Apart from the valuation scenario, contingent valuation surveys also collect a wide range of **ancillary information**. Before the valuation section, respondents are normally asked a set of attitudinal, behavioural and knowledge questions regarding the particular goods and services of interest. This serves both as a warm-up to the valuation section and as a validity test, by uncovering factors which may explain responses to the valuation questions. It may also be used to uncover policy relevant information about public attitudes towards Spectrum related outcomes. The final section of the survey typically investigates the socio-economic and demographic profile of the respondent. The information obtained is used to assess the representativeness of the sample, and also the validity of the resulting welfare estimates, for example, to check whether key socio-demographic variables such as income influence WTP in the expected way.

D4.1.4. Advantages and limitations of contingent valuation

The hypothetical nature of the CV method can act as both an advantage and a disadvantage. The main **advantages** of CV (as with other stated preference techniques) is that it is extremely **flexible** and capable of **valuing a wide range goods and services**, including future or planned changes, and is able to **capture non-use values**. This ability to uncover the value of a wide range of changes is very advantageous in the case of Spectrum given the multiplicity of goods and services that it supports. And clearly, the ability to measure benefits associated with changes that have not yet happened is essential when valuing future Spectrum allocation changes.

As for non-use values, as noted above, we consider that use values are probably predominant in this case, however, if there is interest in calculating non-use values associated with changes in Spectrum allocation, then stated preference methods provide the **only available means** to do so.

Another advantage worth mentioning is that contingent valuation now has a considerable **history of research in economics**. In particular, the rise in popularity of stated preference methods in the early 1980s was accompanied by a very active debate and critical assessment of the merits and limitations of the techniques and the underlying conceptual framework (Smith, 2000). As a consequence, a lot more is currently known about the problems of this particular method, ways of testing for them and techniques for addressing them, than for most alternative valuation methods.

Key **areas of concern** for empirical methodologies such as contingent valuation relate to their susceptibility to various **biases**. Typically, the further from reality and the less familiar the scenario is, the harder it will be for respondents to act like they would in a real market setting. In the case of Spectrum, the scenarios will probably be based upon plausible future changes in allocation and many of the final outcomes to be evaluated will, in all likelihood, be familiar to respondents. This is particularly the case with outcomes that generate use values. Arguably, these are the large majority of the Spectrum-related outcomes listed in Table 1. There may, however, also be some element of non-use value attached to providing better services to others (altruistic and bequest motivations - e.g., related to emergency service provision) and even some form of existence values (e.g., national pride associated with having state-of-the art communication services). Arguably, however, such non-use values will be confounded and dominated by use values in most policy-relevant scenarios. The likely focus on Spectrum use benefits facilitates economic valuation, as respondents are more likely to have prior preferences for such goods and services (or be able to discover economically consistent preferences throughout the survey exercise process)

(Bateman et al., 2011). However, we do need to acknowledge the common types of bias in CV studies (discussed, for example, by Bateman et al. (2002)). In the case of Spectrum-related changes, the most concerning issues are **hypothetical bias**, **insensitivity to scope**, **framing effects** and **focussing biases**.

Hypothetical bias

Unsurprisingly, given the hypothetical nature of stated preference scenarios, the criticism of CV that has perhaps received the most attention is hypothetical bias (Arrow and Solow, 1993; Champ and Bishop, 2001; Hausman, 2012), where individuals have been found to systematically overstate stated WTP (when compared with actual payments) due to the hypothetical nature of the survey.

Hypothetical bias tends to arise mostly when valuing distant, complex and unfamiliar goods and services, where people may not have well-defined prior preferences and may be unable to establish their preferences within the duration of a (one-off) survey. It is a problem that might affect some types of non-use values for less known and distant policy changes. In the case of Spectrum, we argued that many relevant outcomes predominantly have use-related values and are goods and services that people are generally familiar with and hence the types of outcomes affected by changes in Spectrum are arguably less prone to hypothetical bias than other more unfamiliar goods and services.

However, it is still worth employing methods that will help to ensure that hypothetical bias is kept to a minimum. First, hypothetical bias is more prevalent when voluntary payment mechanisms are used as respondents have incentives to free-ride (Carson, et al., 1997). The evidence suggests that there is a strong incentive to overstate WTP in the survey context and to free-ride on actual contributions (a phenomenon known as strategic bias). This is because overstating WTP increases the chances of provision of the desired public good without having to pay for it. The implication for Spectrum valuation is to avoid using voluntary payments and select instead compulsory payment mechanisms such as taxes, fees or prices. Given the types of goods affected, these are likely to be the most appropriate and realistic types of payments anyway.

Second, a range of counteractive treatments or corrective adjustments can be made. Counteractive (i.e., ex-ante) treatments, are often employed through so-called entreaties in the survey text. Famously, Cummings and Taylor (1999) developed a *cheap talk entreaty* for reducing hypothetical bias, whereby a script describes the bias problem and a plea is made to

respondents that they do not overstate their true willingness to pay. The evidence suggests that use of cheap talk reduces, but not completely eliminates, hypothetical bias (e.g., Atkinson et al, 2012; Aadland and Caplan, 2006; Carlsson et al., 2005; Carlsson and Martinsson, 2006; List and Lucking-Reiley, 2000; Lusk, 2003, Murphy et al., 2003). Another entreaty is the *oath script,* which typically asks respondents to agree to promise that they will respond to questions or state values honestly. Within economics, however, the oath script has seen very few applications. In a recent large scale CV study that we conducted with a cultural institution we found that whilst cheap talk has an impact the oath script had no effect on WTP values for visits to the cultural institution (Bakshi et al. 2015, *forthcoming*).

Some changes are difficult to convey and respondents might be uncertain about their true values for that change. Uncertainty typically occurs for goods and services which are complex and unfamiliar. In terms of *ex-post adjustments*, Champ and Bishop (2001) tested the use of *certainty questions* (e.g., “how certain are you that you would really pay the amount indicated if asked”) in an experiment with real payments. They found that respondents with a higher level of certainty regarding their stated WTP values were more likely to actually pay the amounts stated when asked to do so, meaning that the predictive accuracy of results may be increased by, for example, recoding uncertain WTP responses as zero payments. Although typically ignored in many valuation studies, identifying certainty in valuation responses seems to be crucial to the validity of the resulting estimates.

We recommend using a mix of ex-ante and ex-post corrective strategies to minimise any remaining tendencies towards hypothetical bias within Spectrum outcomes valuation. This could include entreaties and certainty scales.

Insensitivity to scope

Insensitivity to scope relates to the lack of sensitivity in respondents’ valuation estimates towards changes in the scope of the good or service being valued. More formally, insensitivity to scope occurs when stated welfare measures do not vary proportionally to the scope of the provided benefit (i.e., larger benefits should be associated with larger WTP values) (Mitchell and Carson, 1989, Bateman et al. 2002; Desgouves et al. 1993). One important point to note here is that, because of income constraints and sometimes strongly diminishing marginal utility, WTP is not expected to vary linearly with the scope of a change; but it is nevertheless expected to show some variation. Poorly designed and administered surveys are arguably the primary cause of instances of insensitivity to scope, for example, the use of vague descriptions of the good to be valued and the failure to adequately convey the information about the scope of the change (Carson, Flores, & Meade 2001). Others still

have argued that lack of sensitivity to scope could occur because of 'warm glow' effects, typically associated with donations, where people receive a benefit from the act of donating to a good cause independent of the cause's details or scope (Kahneman and Knetsch, 1992). Avoiding the use of donations as a payment vehicle would clearly minimise this possibility. But sometimes the nature of the good or service to be valued does make it more susceptible to scoping invariance, for example small changes in risks or small percentage changes, where respondents find it cognitively difficult to distinguish between what are, in absolute terms, very small variations in scope.

However, well-designed state of the art surveys should be capable of overcoming such insensitivity problems in many cases. One possible way to address the issue is via a **top-down approach**, where respondents are first asked to value the larger good/service, and are subsequently asked to allocate a proportion of that value to the smaller component goods/services. Researchers should be mindful of the possibility of insensitivity to scope in the case of Spectrum-related outcomes and at the very least, respondents should be given adequate information about the larger good, before being asked to place a value on the smaller good. The increase in popularity of online CV surveys makes it arguably easier to communicate information, test understanding and indeed to tailor information to respondents that might be having difficulties understanding the details of what they are being asked to value. Scope tests can be included in the survey to ascertain whether valuations are varying according to changes in the magnitude and scope of the outcomes.

Framing bias

The quality of CV responses is crucially dependent on the *information* provided in the contingent scenario, namely on the accuracy and plausibility of the scenarios in order to engage respondents in the revelation of truthful preferences or to incentivize their formation. Nevertheless, despite an extensive literature on **information effects** in CV (e.g. Hoehn and Randall 2002; Blomquist and Whitehead 1998; Ajzen, Brown and Rosenthal 1996; Hoehvagel and van der Linden 1993; Bergstrom, Stoll and Randall 1990, 1989; Samples, Dixon and Gowen 1986) empirical evidence about the 'right' amount of information within a survey remains limited.

Best practice guidance recommends the use of **reminder statements** to ensure that respondents give full consideration to *substitute* goods (Bateman et al., 2002; Arrow and Solow, 1993). If respondents are not reminded about other similar goods they may overestimate their WTP for a specific good or instead state the value they hold for the general type of good (Arrow and

Solow, 1993; Loomis et al., 1994). In this respect, information overload concerns occur because in order to ensure respondents adequately consider substitutes it is necessary to provide a similar amount of information about substitutes, as the good and service of interest (Rolfe, Bennett, & Louviere 2002). In the case of Spectrum, this is a real concern because if one is interested in valuing the multiple outcomes of interest, a lot of information needs to be provided.

The increased use of online CV surveys has facilitated the presentation of information, expediting the tailoring of information to respondent's needs (and level of understanding), measuring the time spent reading the information, testing understanding, and enabling the use of alternative media such as images, film or sound. We would recommend that any stated preference study related to Spectrum be carried out online to take advantage of these new developments in the presentation of information. An important concern with online studies that will need to be addressed is the potential for producing non-representative samples. Groups that have reduced access to the internet will typically be under-represented. We thus recommend that online surveys either be administered using quota sampling, whereby harder to reach groups would be targeted to ensure that the sample is representative or that sample weights are estimated and used in any subsequent analysis.

Another important area concerning the presentation of information relates to whether policy changes are presented in isolation or in relative terms. Single modes of evaluation can elicit different preference rankings and monetary values to joint or multiple modes of evaluation because information is used differently when a point of comparison is available (Hsee, 2001). This can result in **preference reversals**, whereby for instance A is preferred to B and then B is suddenly preferred to A just because there is now some other point of comparison available. Preference reversals have been found in CV surveys in, for example, the valuation of environmental goods and amenities (Brown 1984; Gregory et al., 1993; Irwin, et al. 1993) and safety programmes (Slovic et al., 2002).

Issues related to preference reversals could surface in a number of settings with respect to Spectrum since policy changes could be presented on their own or in relative terms. This is problematic as preferences become inconsistent. There is no best-practice guidance to speak of here, but CV surveys should use a consistent mode of presenting information to ensure that preference reversals are eradicated.

Focussing bias

If preferences are to be accurate indicators of our welfare then clearly people need to accurately predict how much they will like the good/service that they are willing to pay something for (Kahneman and Ritov 1994). But numerous experiments have shown that people are unable to accurately predict the pleasure or benefits they will get from different goods and services and this is true even for everyday goods such as music and ice cream (Kahneman and Snell, 1992; Wilson and Gilbert, 2003; Nisbett and Kanouse, 1969; Read and van Leeuwen 1998). One of the drivers of this phenomenon is that people are unable to predict how much they will *adapt* to different things and circumstances in the future, with the result that they tend to over-estimate the utility gain that will result from events, circumstances or outcomes (Kahneman and Thaler, 2006; Loewenstein and Adler, 1995).

Asking people about how something will affect their lives or about their preferences between different states of the world often leads to a **focussing illusion** (Kahneman et al., 2006; Schkade and Kahneman, 1998), whereby at the time of preference elicitation people are focusing only on the salient aspects of the condition and this may not reflect in any way how people would actually experience these conditions or states in real life. The fundamental problem is that what we focus on in a preference question is often not what we focus our attention on in the actual experiences of our lives, where lots of other phenomena vie for our attention and we may adapt to certain things. (Dolan and Kahneman, 2008). In the context of CV this is supported by a study by Whittingham et al. (1992), which shows that WTP falls as respondents are given more time to think and respond to the WTP question. Giving respondents the chance to go home and think about the survey for 24 hours had a significant negative impact on WTP values as respondents we able to reflect on the importance of the issue in the wider context of their lives.

Again there is no best-practice guidance on how to avoid focussing biases, but some of the solutions already discussed for other areas will also be appropriate here. Stated preference surveys in the context of Spectrum should be careful not to over-emphasize the importance of each outcome and they should discuss Spectrum-related outcomes in the wider context of people's lives and experiences. This re-iterates the importance of describing substitute goods and services and giving respondents extended periods of time (up to 24 hours is optimal) to think about the issue and their WTP values may also be beneficial.

D4.2. Choice modelling methods

We provide a very brief introduction to choice experiments (CE) here as the focus here is on CV. CE is a multi-attribute preference elicitation technique used extensively in the marketing and transportation literatures (Louviere,

1988). In recent years, CE has become a popular alternative to CV for environmental valuation (Hanley et al., 2001; Bennett and Blamey, 2001; Louviere et al., 2000). In CE, respondents are presented with a series of scenarios (typically 2 or 3), each composed of different attributes, varying at different levels. Respondents are then asked to choose their most preferred scenario. If a monetary cost is included as one of the attributes, it is possible to: (i) estimate the total welfare change provided by various scenario options; (ii) the value of the component attributes, in other words the implicit value of each of the attributes (i.e., the marginal WTP); and (iii) calculate trade-offs between attributes.

The method is derived from Lancaster's (1966) characteristics of value theory which states that any good may be described by a bundle of characteristics and the levels that these may take. The technique is underpinned by the random utility framework and relies on the application of statistical design theory to construct the choice scenario combinations. In order to ensure the estimates derived are consistent with welfare theory a baseline or opt-out alternative must be included, this avoids the problem of respondents being forced to choose options.

There are several advantages in using this methodology compared to CV. First, CE is particularly well suited to value changes that are multidimensional (with scenarios being presented as bundles of attributes) and where trade-offs between the various dimensions are of particular interest. Second, since choice experiments infer an individual's preferences from choice-based decisions rather than by directly asking about willingness to pay, they also offer the advantage of de-emphasising the monetary aspect of the valuation task, since the price attribute is typically only one of several attributes which describe the good. This may help in reducing protest responses, strategic behaviour and yea-saying (Hanley, Mourato & Wright, 2001). Third, the technique is also considered to offer advantages in dealing with framing issues, through its ability to explicitly incorporate substitutes (and complements) into the decision process (Bennett & Blamey 2001). Furthermore, by offering a range of substitute goods, the good of interest is effectively disguised, which may help to reduce focussing biases. A fourth advantage includes providing automatic tests for (within sample) scope effects. Sensitivity to scope is assessed by examining the statistical significance of the parameter estimates for the attributes presented in the models; insignificance indicates insensitivity (Bennett & Blamey 2001). Because all the different attributes and levels are presented simultaneously, CE facilitates internal consistency of choices and it has been found to result in greater internal sensitivity to scope than CV (Foster and Mourato, 2002). It

should however be noted that some of these potential advantages remain empirically unproven.

The technique is also associated with a number of limitations. One of the primary issues relates to the greater cognitive burden placed on respondents and the associated problems of inconsistency, learning and fatigue effects which may lead to the adoption of non-utility maximising heuristics and random errors. In addition, in estimating the aggregate value of the good/service the approach relies on the implicit assumption that the total value is equal to the sum of its parts. This raises two key concerns: (1) the problem of ensuring all relevant attributes are included and what to do about missing attributes; and (2) whether the attributes are indeed additive in this way. It has been shown that values of whole bundles of attributes may be valued less than the sum of component values (Hanley et al., 2001; Hanley et al., 1998). Findings by Foster and Mourato (2002) suggest that CE might lead to a significant over-estimation of the value of the whole good/service, when compared to CV. The technique is also susceptible to sensitivities relating to the study design as is the case with other stated preference techniques. Moreover, CE studies are typically much more complex to design and to analyse statistically than CV experiments (Bateman et al., 2002; Hanley et al., 2001).

In the case of Spectrum, the major advantage of CE is that it allows for simultaneous analysis of the influence of several attributes on individual choice. So for example, one could look simultaneously at scenarios comprising impacts of Spectrum changes on mobile communication outcomes, television and radio broadcasting, and meteorological services. These would be presented as attributes of alternative Spectrum scenarios, varying at different levels. As noted above CE is also ideally suited for situations where trade-offs between the various policy characteristics are of particular interest: for example, trading off improvements in mobile communication outcomes at the expense of meteorological services outcomes. This information could then be used to determine which combination of mobile communication and meteorological services levels would provide welfare optimising solutions for users.

D4.3. Review of related stated preference studies

We are unaware of any studies that have directly valued Spectrum but there are some studies that may be of some relevance. Here we provide a brief review of some of the literature on contingent valuation (CV) and choice modelling (CM) for outcomes associated with Spectrum usage.

D4.3.1. Contingent valuation

Arinloye et al. (2015) administered a CV survey of 285 smallholder farmers in Ghana for WTP for mobile phone-based information on agricultural market prices and product quality. Most farmers using mobile phones were WTP up to US$2.50 for market price and quality information.

Yamori and Tanaka (2004) looked at WTP for guaranteed minimum bandwidth. WTP increases linearly as the minimum guaranteed bandwidth speed for download/streaming services increases.

Terzis and Bates (2000) finds a WTP of £10.40 month to keep the existing TV service, giving consumers' surplus of just over £2.00 per household/month. The valuations of services obtained among satellite TV viewers range from £16.00 to £26.00 per household/month. Results for radio listeners show an average valuation of £6.20/month per household.

The value of public weather services has been the subject of numerous CV studies since the early 1990s (see Chapman 1992 for the USA, and; Teske and Robinson 1994 for the UK). Kenkel and Norris (1995) apply CV for real-time weather information in the US. Nguyen et al. (2013) apply CV to a tropical cyclone warning service in cyclone-prone areas of Australia. Mean WTP ranges from A$32- A$52/year.

We found no examples of stated preference studies related to emergency service communications. Also, no studies were found in the literature relating to CV of the benefits of the use of radar for coordinating transport including air traffic control.

D4.3.2. Choice modelling

Lee et al. (2004) investigates WTP for mobile broadband using choice modelling (CM) methods of broadband plans of varying attributes of speed, price, and mobility. Kim and Sugai (2008) apply CM to levels of service quality for Japanese mobile content providers compared to PC subscribers.

Nguyen and Robinson (2013) apply CM for improved cyclone warning services. Potoglou et al. (2014) apply CM experiments for security, privacy and surveillance services across 27 EU countries with attributes relating to privacy and security implications.

Ida et al. (2014) apply CM for smart equipment, including smart meters in Japan. Pepermans (2014) applies CM for 6 attributes of smart metering: comfort, functionality, privacy, visibility, cost savings and investment outlay in the Flemish-speaking regions.

D5. Wellbeing valuation method

D5.1. Introduction

In his pioneering work on the theory of value, Hicks did not initially propose a specific measure of welfare to be used in calculations of the compensating and equivalent welfare measures. And so how these measures of value and welfare change would be assessed in reality was not clear until economists started to adopt a standard measure of welfare in empirical work. This came to be the preference satisfaction account of welfare. A recent and growing trend in economics has been to use self-reported subjective wellbeing (SWB) measures of welfare (Diener 2009; Dolan et al., 2011; Fujiwara and Dolan 2015; Hicks et al., 2013; Kahneman and Krueger 2006).

Wellbeing valuation

The premise of the WV approach is to estimate measures of welfare change from data on people's experiences as measured by their SWB. In this case the compensating measure of welfare change (for a welfare gain) can be depicted as:

(3) $$SWB(Q^0, M^0) = SWB(Q^1, M^0 - CS)$$

Measures of welfare change can be estimated from the marginal rates of substitution (MRS) between the non-market good and money in the SWB function. This type of SWB function can be estimated using a range of statistical methods but WV studies to date have predominantly employed multivariate regression models to estimate equation (3), such as:

$$LS_i = \alpha + \beta_1 \ln(M_i) + \beta_2 Q_i + \beta_3 X_i + \varepsilon_i \quad (6)$$

where LS = life satisfaction, M = income, Q = the non-market good being valued and X = other determinants of life satisfaction. ε is the error term and the i subscripts denote individual i. The MRS can be valued using β_1 (the effect of money on life satisfaction) and β_2 (the effect of the non-market good on life satisfaction). This can be estimated using cross-sectional data or with panel data, whereby it is common to add a time-invariant term in ε_i and model equation (4) with fixed effects.

From models like equation (4) we can derive compensating and equivalent welfare change measures as follows.

Table D3. CS and ES in wellbeing valuation

	Compensating Surplus (CS)	Equivalent Surplus (ES)
Welfare gain	$CS = M^0 - exp^{\left[\ln(M^0) - \frac{\beta_2}{\beta_1}\right]}$	$ES = exp^{\left[\frac{\beta_2}{\beta_1} + \ln(M^0)\right]} - M^0$
Welfare loss	$CS = exp^{\left[\frac{\beta_2}{\beta_1} + \ln(M^0)\right]} - M^0$	$ES = M^0 - exp^{\left[\ln(M^0) + \frac{\beta_2}{\beta_1}\right]}$

A full description of the methodology can be found in Fujiwara and Campbell (2011) and in the Annex of Fujiwara et al. (2014a), which discusses the application of the WV method to the case of heritage valuation.

The first paper on WV was published in 2002 in *Health Economics* by Ferrer-i-Carbonell and Van Praag (2002) who looked at the valuation of various illnesses. The WV method has since been used to value a wide-range of outcomes such as environment and environmental amenities (e.g., Carroll et al., 2009; Ferreira and Moro, 2010; Rehdanz and Maddison, 2008; Welsch, 2007, 2002; Welsch and Kühling, 2009); health (e.g., Ferrer-i-Carbonell and Van Praag, 2002; Groot and van den Brink, 2006); crime (e.g., Cohen, 2008; Moore, 2006); public sector corruption (e.g., Welsch, 2008); civil conflicts (e.g., Welsch, 2008); care-giving (van den Berg and Ferrer-i-Carbonell, 2007); terrorist attacks (e.g., Frey and Luechinger, 2004); housing quality (Fujiwara, 2013a); social relationships (e.g., Powdthavee, 2008); employment (e.g., Clark and Oswald, 2002); macroeconomic events (e.g., Blanchflower and Oswald, 2004); human life (Deaton, 2008; Oswald and Powdthavee, 2008); commuting (Stutzer and Frey, 2004); adult learning courses and qualifications (Dolan and Fujiwara, 2012); income inequality (Beja, 2011); cultural activities and events (Fujiwara 2013b; Fujiwara et al. 2014a, 2014b); and heritage sites (Fujiwara et al. 2014c).

D5.2. Key assumptions

The key assumption in WV is that the SWB measure that is employed in the analysis (life satisfaction here) is a robust measure of human welfare. As

discussed above the retrospective element of the life satisfaction measure can be a source of measurement problems. For example, experiments have shown that people‘s remembered utility can be biased due to their tendency to adopt a peak-end rule; people place greatest weight on the peak (most intense part) and the end of an experience. They attach less weight to the duration of an experience. There is therefore often a mis-match between people‘s actual experiences at the time and their retrospective evaluations of these experiences (Kahneman et al., 1993; Schwarz, 2010; Wirtz et al. 2003).

Important contextual factors can also come into play during the survey. Studies have found that when asked about their wellbeing, individuals may base their judgement on information that is most accessible at the time (Schwarz and Strack, 1999). An implication is that the research instrument can influence responses to life satisfaction questions. For example, information that was used to answer a preceding question is more likely to come to mind when a respondent comes to answer the life satisfaction question (Bertrand and Mullainathan, 2001). This results in a question order effect on life satisfaction. A similar process can explain why reports of satisfaction with life have been found to be influenced by the weather, finding a small amount of money beforehand, spending time in a pleasant room and watching a football team win (Schwarz and Strack, 1999). While such factors are likely to influence current mood, they should not have notable effects on true overall life satisfaction.

Finally, individuals may adjust their life satisfaction scores when reporting them in order to give more socially desirable responses. For example, reported wellbeing is higher in face-to-face surveys than in postal surveys (Smith, 1979). This results in respondents providing assessments of their wellbeing that do not reflect the true experiences of their lives (Dolan and Kahneman, 2008).

However, on the other hand there is also a variety of evidence to suggest that overall life satisfaction is a good measure of well-being and actually many studies have been unable to replicate the results from Schwarz and Strack's seminal work on the contextual biases in life satisfaction, hinting that these issues may not be such a concern as first thought (Haybron, 2010; Diener and Suh, 1997). Pavot and Diener (1993), Pavot et al. (1991), Eid and Diener (2003), Fujita and Diener (2005) and Schimmack and Oishi (2005) find mood, question order and contextual effects to be limited and that any problems are not so serious as to invalidate life satisfaction measures (Pavot and Diener 1993). Diener et al. (1989) find social desirability influences to be minimal in life satisfaction responses.

A variety of studies evidence strong positive associations between evaluative wellbeing scores and emotions (e.g., smiling and frowning); brain activity (in the left pre-frontal cortex, which is the area associated with sensations of positive emotions and pleasure); and health (Sandvik et al., 1993; Shizgal, 1999; Ekman et al., 1990; Urry et al., 2004; Kimball and Willis, 2006; Sales and House, 1971; Huppert, 2006; Cohen et al., 2003; Kiecolt-Glaser et al., 2002). Furthermore, many studies have found that wellbeing and life satisfaction are good predictors of future behaviour and choice (Frijters, 2000; Clark et al. 2008; Scollon et al. 2003; Haybron, 2010; Ferrer-i-Carbonell, 2012; Benjamin et al., 2012).

Finally, there is evidence that the general public also favours evaluative measures of wellbeing for policy making decisions. In terms of government resource allocation decisions SWB (and especially, life satisfaction) was ranked as being more important that preference satisfaction or objective wellbeing measures (Dolan and Metcalfe, 2011).

As with preferences, SWB measures suffer from a number of potential problems. The evidence on their gravity is mixed and fairly balanced and so it should not deter the use of the life satisfaction measure in WV. Use of the WV method for Spectrum outcomes will, however, need to consider and caveat these potential measurement problems.

D5.3. Study design issues

Three key areas we will discuss here concern what **types of outcomes** can be estimated using the WV approach, **survey instruments** and issues related to the **statistical methodology**.

Types of outcomes

As with stated preference methods we must be able to clearly identify the **key outcome changes as a result of a possible change in Spectrum allocation.** The difference between stated preference and WV is that in the latter this information on final outcomes is not at any time conveyed to the survey respondents. Instead it suffices for the analyst to understand them for the purposes of the statistical analysis. Once the key final outcomes (e.g., increased interactions with other people) have been confirmed the next step in WV is to incorporate these outcomes as the variable Q_i in equation (4) so that welfare change measures can be estimated.

$$LS_i = \alpha + \beta_1 \ln(M_i) + \beta_2 Q_i + \beta_3 X_i + \varepsilon_i \qquad (4)$$

Since the variable Q_i must impact on life satisfaction for it to be valued, it must show up in people's experiences. Hence, we can rule out the possibility of

measuring non-use value using WV methods. **The WV method can only measure use values**.

The second point about types of outcomes is the question of whether Spectrum-related outcomes will show up in people's experiences and hence their SWB reports. This develops from Haybron's (2010) concerns that life satisfaction may be inert to many life circumstances and events. This would make these outcomes impossible to value using WV. These concerns, however, are generally not supported by the available evidence. In actuality when looking empirically at the large amount of academic work in this field it is extraordinary that a response to a short life satisfaction question, which takes on average a few seconds to muster, is highly sensitive to nearly everything that we would expect and in the right direction – it varies with short, medium and long term factors and life events, including anything from cinema visits, gardening and playing sport, to smoking, winning the lottery, CO^2 emissions, and finally to marriage, health, employment and wealth (Pavot and Diener, 1993; Schimmack and Oishi, 2005; Dolan and Peasgood, 2008). We can be confident, therefore, that if a Spectrum-related outcome is a non-trivial factor in the experience of people's lives it will show up in their life satisfaction responses.

The interpretation of the value estimated from a model like equation (4) will depend on **how the variable Q_i and its references cases have been defined**. At the simplest level Q_i is a vector of one single outcome related to Spectrum. But it is also possible to include a number of outcomes related to Spectrum in the vector Q_i or to include a single aggregated variable that indicates whether the individual benefits from all of the outcomes jointly.

Whatever the format of the variable Q_i it is critical to get right what the relevant reference cases are in the model. For most outcomes Q_i can be formatted as a **binary variable** that takes on the value 1 if the outcome is true. For example, Q_i = 1 if individual interacts with friends and family online (0 = otherwise), or Q_i = 1 if individual engages with art and culture online (0 = otherwise), or Q_i = 1 if individual feels safe (0 = otherwise). For values related to the prevention of bad outcomes (like terrorist attacks) we can estimate the costs related to these outcomes whereby Q_i now signifies a negative outcome – for example, Q_i = 1 if individual had an accident, Q_i = 1 if individual suffers from a health condition, Q_i = 1 if individual experienced a terrorist attack, or Q_i = 1 if individual experiences extreme weather conditions (and in all cases: 0 = otherwise). For these negative outcomes the costs would show the potential costs avoided from improved services in these areas (e.g., preventing a terrorist attack or pre-empting and preparing for an extreme weather episode).

For each Q_i variable the alternative of the binary variable (the '0 = otherwise' case) should reflect the conditions in the status quo such that moving to the condition Q_i = 1 represents the policy change under discussion. In this case the values estimated from equation (4) will represent values for the outcome of interest.

In cases where the outcome is more naturally defined in a non-binary or continuous format, we still recommend that the variable be converted into a binary format that reflects the outcome of interest, where the null outcome (0 = otherwise) reflects the status quo. For example, if better transport control leads to shorter commuting times, the average impact on commuting times should be estimated. Say that average commuting times reduce from 50 minutes to 40 minutes, then the variable Q_i should be formed such that it takes on a value of 1 if the individual's commute is 40 minutes, and 0 = if the individual's commute is 50 minutes. This will align the value estimated by variable Q_i with the actual policy outcome.

One distinct approach that would in theory be possible under the WV is that where data permits we would define variable Q_i as equalling 1 if the individual has Spectrum services (all outcomes), and 0 = otherwise. This would be possible in situations where one region or area of the country lacks or suffers a restriction in Spectrum, which results in a total loss of all Spectrum-dependent services. This seems highly implausible, but a less extreme version of this approach would arise if say one area lost/does not have internet and mobile communication connectivity. In this situation we could value all outcomes related to the use of internet and mobile communications by comparing the life satisfaction scores of people who live in such an area against those who do not (after controlling for other factors in regression analysis). This type of analysis may be possible in certain areas of London, for example, that have suffered loss of high-speed broadband (e.g., Brixton in 2014). This allows us to value Spectrum outcomes without having to specifically define what those outcomes are and would get over any problems related to non-availability of those specific outcomes in the datasets.

Survey instruments

WV studies are usually conducted using **pre-administered secondary data sources**, such as the British household Panel Survey, which contains a wealth of data on people's life circumstances plus their wellbeing. The UK has around 15 different datasets that include quality of life measures such as life satisfaction. For the purposes of valuing Spectrum outcomes we would recommend the **British Household Panel Survey** (BHPS), **Understanding Society** and the **Annual Population Survey** (APS) since these are large

nationally representative datasets that contain the life satisfaction question as well as a very rich set of questions on people's lives in general.

The advantage of these datasets is that they have been administered and hence do not require any resource in terms of time and funding to derive data for use in the WV method. In effect they can be used immediately for valuation analysis. Also these three datasets contain post code data (accessed through a special licence) which means that we can locate with a high degree of accuracy where the respondent lives which opens up the possibility of doing analysis that requires geographical or location-specific data, such as extreme weather conditions, terrorist attacks, crime levels, and internet connectivity. Where Spectrum-related outcomes are measured in these types of datasets it makes the WV approach a very **cost-effective** one, costing far less than stated preference methods. The problem with the data, however, is that the datasets – although very wide-ranging – may not include measures for *all* of the specific outcomes we are interested in.

However, this problem can be overcome through the administration of **primary data**. Surveys can be developed to ascertain data on the outcomes of interest (Q_i), where data on these outcomes is not available from secondary sources. Primary data is rarely used in WV but we have developed wellbeing surveys for specific non-market goods and services on a number of occasions before – for example for the valuation of visits to the Natural History Museum (Bakshi et al. 2015 *forthcoming*), the valuation of visits to the Tate Liverpool gallery (Bakshi et al. 2015 *forthcoming*), the valuation of free-to-attend adult learning courses (Dolan and Fujiwara, 2012) and the valuation of social programmes in Mexico (Fujiwara et al., 2015 *forthcoming*). Another study we are aware of that uses primary data in WV is Dolan and Metcalfe (2008) for the valuation of urban regeneration projects.

The survey should follow standard best-practice survey methodology and it should aim to minimise the potential biases discussed above by, for example, using the same neutral survey environment for each respondent and the same survey mode. Question order effects can be eradicated by incorporating SWB questions right at the start of the survey. The survey should also contain data on income (M_i) and the relevant set of control variables (X_i), such that the full regression model in equation (4) can be run. X_i should be composed of a vector of variables that ensure that the two variables of interest: the outcome (Q_i) and income (M_i) are conditionally exogenous. For each type of outcome (Q_i) the set of control variables in X_i should in theory, therefore, change. This is the optimal approach that we would recommend here. However, as a second best approach X_i should contain, at the very least, the main determinants of life satisfaction outside of Q_i and M_i. Fujiwara and

Campbell (2011) provide a standardised list of these determinants composed of: age; gender; marital status; employment status; health status; income; education; quality of social relationships; religious affiliation; housing status; local and environmental conditions; number of children and other dependents (including caring duties); and geographic region. As with the stated preference methods we recommend that primary data be collected through the use of online surveys to minimize costs and time, to maximise sample sizes and to ensure a consistent survey format and environment for all respondents.

Indeed, we believe that there is the potential to administer both stated preference and wellbeing survey questions as part of one overall survey, which would allow the derivation of both stated preference WTP values and wellbeing values for different Spectrum-related outcomes. This could follow survey procedures we developed for our studies of the Natural History Museum and the Tate Liverpool gallery.

Statistical methodology

A particular problem in the WV approach is that it heavily relies on statistical analysis based on observational datasets (i.e., where people have not been assigned to different conditions in a controlled experimental setting). This can be the cause of a number of problems, including **selection bias**, **reverse causality** and **measurement error**. Thus cause and effect relationships are *approximated* using statistical methods, as causation cannot be directly inferred. This is because there are likely to be a number of unobserved factors correlated with the variables of interest that differ initially between the different groups and which influence the outcomes we observe. For example, if we were to assess the wellbeing impact (and value) of living in an area that is abundant with Spectrum-related services the effect we see on life satisfaction may be due to the presence and benefits of those services but it may also be saying something about the types of people that choose to live in those areas. There is the very real possibility that certain types of people select into certain areas *because* of the quality of the services on offer. If we can control for all of these factors in the statistical analysis then it is not a problem and our variables of interest become conditionally exogenous. However, causation cannot be fully inferred unless *all* of these confounding factors are controlled for.

The standard approach in the WV literature has been to employ multiple regression analysis with a full set of control variables for the main determinants of life satisfaction. However, a common outcome is that values estimated using this method tend to be too high because the income coefficient (the impact of income on life satisfaction) is downwards biased (Dolan et al., 2008; Fujiwara and Campbell, 2011). It seems that the problems

related to endogeneity bias discussed above are especially problematic for the income variable in regression models. For example, in some studies the value of employment has been estimated to be an implausibly high £23,000 per month to the individual in addition to their wage income (Clark and Oswald, 2002), and the costs associated with drug and alcohol problems have come out at as high as £9 million per year per person (Powdthavee and van den Berg, 2011).

To counter this problem a number of methods involving instrumental variables (IV) for the income variable have been proposed in WV (e.g., Luechinger, 2009; Fujiwara, 2013c). A well-implemented IV study can eradicate selection bias, reverse causality and the effects of measurement error bias producing an unbiased estimate of the causal effect of income on life satisfaction. The research in this area shows that using an IV for income systematically increases the coefficient on income, which in turn leads to a reduction in the magnitude of the values estimated using WV, resulting in much more plausible values.

We recommend the use of an IV approach for the income variable in any WV study employed for Spectrum outcomes. A well-researched area of IV in the wellbeing literature is on income windfalls, such as unexpected inheritances and lottery wins. These factors produce exogenous changes in people's income and hence are ideal for use as instruments. An IV methodology developed specifically for WV is Fujiwara's (2013c) *Three Stage Wellbeing Valuation* approach.

This implies that any primary data collection should include questions on income windfalls. Furthermore, since IV estimation is an asymptotic approach (i.e., requires large sample sizes) primary data surveys with income windfall questions will need to be carried out on large samples.

D5.4. Advantages and limitations of wellbeing valuation

The main **advantages** of WV is that it can overcome many of the survey related biases found in stated preference because values (WTP/WTA) are not elicited directly from survey respondents. The advantages are driven mainly by the fact that values are derived from people's actual experiences in WV.

Specifically for Spectrum valuation **issues concerning hypothetical bias do not arise**. Because we do not elicit values directly there is no opportunity to free ride or use strategic bias in WV. Also issues concerning uncertainty are eradicated because the values estimated in WV are based on actual experiences rather than based on the respondents' beliefs about what may happen and what they might experience as a result of the policy change.

Critically, in WV we do not need to inform respondents about hypothetical policy changes and so concerns about conveying the right information to respondents (**information effects**) are also eradicated. Problems related to **preference reversals** should also be eradicated because we do not need to ask people about their preferences. Indeed, the WV approach is not constrained by the preference axioms because wellbeing is elicited directly from self-reports rather than from preference orderings. **Framing biases** that impact directly on valuations are therefore not problematic for WV. However, different types of framing effects may come into play in the WV method at the point of eliciting life satisfaction ratings as discussed above (e.g., question order effects).

Finally, and possibly most importantly, WV also eliminates issues related to **focussing biases**. This is because statistical analysis is conducted to assess the importance of a factor in someone's life without having to ask them to think about the importance of that factor. The WV approach is based on real experiences and not – as in stated preference approaches – on how people *imagine* they might be affected by a change. We can assess people's actual experiences of Spectrum outcomes when they are living life as they normally do, and attach values to these outcomes and services.

As with any valuation methodology there are also a number of **problems** that we must acknowledge. Many of these issues have already been discussed in detail above and so we will just recap them here.

Non-use values

The WV approach cannot measure non-use values because the method is based on data where individuals experience the policy outcomes directly during the course of their lives.

Application

Overall stated preference offers a more wide-ranging and flexible approach because it can be very specific in terms of defining policy changes, whereas WV is reliant on people having experienced the policy change in question. Consequently, clearly WV also cannot be used to measure benefits associated with changes that have not yet happened, which in many cases will be important when valuing future Spectrum allocation changes. Also where there are small or non-personal changes involved this may not show up in the experience of people's everyday lives (e.g., improvements in national security) and hence these types of changes may have to be assessed through stated preference.

Statistical methodology

The WV method is reliant on robust estimation of the impact of the policy outcomes and income on life satisfaction. This can be problematic when using observational (i.e., non-experimental data). As discussed, it means that values may be biased and the evidence suggests that the biases are likely to overstate values. We discussed methods for deriving unbiased estimates of the causal effect of income on life satisfaction but there is no similar general solution for the policy outcome variable and hence unless changes in the policy outcomes are assessed through controlled experiments there is the concern that values may be biased to some degree.

Interpretation

There are two important issues here. The first is that it can be difficult to accurately pinpoint what outcome is being valued in WV. This is because the outcome variable (Q_i) may capture a lot of additional factors. For example, a positive coefficient on a variable for interactions with friends using social media may also capture the value of having a large circle of friends (large enough to warrant using a social media account) in the first place. These are serious problems but can be dealt with effectively by adding the appropriate control variables in the model. Thus, in the example of social media usage we should also control for the number of friends that the individual has so that we can narrow the value down to the use of social media only. This is simple to do if the data permits. With secondary data there may be times when we cannot resolve this problem, but it can be relatively easily addressed with primary data provided that the right variables are collected.

Second, values derived from the WV method do not necessarily represent actual amounts that people would be willing to pay. We include a discussion of this issue here but it is not necessarily a disadvantage of the WV approach. Values derived from WV can in theory at least provide valid estimates of compensating and equivalent welfare measures, which are exactly the estimates in which we are interested. The fact that WV values may not represent actual WTP figures is only important if we are actually interested in having people pay for the changes, which nearly never is the case in policy making. Therefore, values from WV should be seen as compensating or equivalent welfare change amounts, rather than actual WTP figures.

Recent approach

Finally, WV is a newly developed approach that is still in development in many aspects. It does not have the similar history of research in economics as

stated preference methods have and hence there is currently very little best-practice guidance available and there are likely to be new problems that develop of which we are currently unaware.

D5.5. Review of related wellbeing valuation studies

We are unaware of any studies that have directly valued Spectrum before but there are some studies that may be of some relevance. Using the British Household Panel Survey (BHPS) and Understanding Society datasets regular access to the Internet is estimated to be valued at £1,875. per person per year in the UK (Trotter et al., 2014).

In relation to defence and security Frey et al. (2008) analyse the Euro-Barometer Survey from Britain and France. They find that terrorist attacks have a large negative effect on people's life satisfaction, which is estimated to have a cost of between 26%-38% of annual income to a resident in Northern Ireland and 4%-8% of annual income to a resident in Paris.

Using the Euro-Barometer Survey Luechinger and Raschky (2009) find a significant negative impact of natural disasters like floods on life satisfaction. The prevention of flooding is estimated to be valued at around 24% of average household income. A study by Carroll et al. (2009, ref) found similar results for flooding in Australia.

While there are studies discussing the relationship between television viewing and life satisfaction in the literature (Frey et al. 2007; Stutzer and Frey 2010) and the benefits of different types of emergency service (eg, helicopter ambulances compared with on the ground ambulances, see Ringburg et al. 2009; Taylor et al. 2010), none go as far as to assign a monetary value to that impact. No studies related to the wellbeing value of radio broadcasting, emergency services, use of radar for coordinating transport or smart meters were found in the WV literature.

D6. Conclusion

This paper has set out the main issues to acknowledge when valuing Spectrum-related outcomes using economic valuation methods. We have discussed the application of the three main non-market valuation methods to the valuation of Spectrum outcomes.

We have set out the relative pros and cons of each approach and some recommendations for carrying out the different valuation methods. These are methodological recommendations based on best-practice for the implementation of stated preference and wellbeing valuation methods in the context of Spectrum. We have not, however, recommended any particular

approach over another for all aspects of Spectrum valuation. Indeed given the relative pros and cons of the different approaches it is likely that the economic valuation of Spectrum outcomes will ultimately require a mix of different methods.

The main advantage of stated preference, in that it is a very flexible method, which in theory can be applied to any non-market good/service is offset somewhat by the fact that the mechanism which engenders this flexibility (i.e., directly asking people to state values for non-market goods) is what also causes its problems, such as hypothetical bias and framing effects. Wellbeing valuation is a newly developed method that provides a solution to many of these biases as it does not require that we ask people directly about the values that they hold for non-market goods. Instead we derive values based on how the non-market good impacts on self-reported measures of wellbeing (SWB) such as life satisfaction and happiness. The problem is that this is a less flexible approach and it is statistically challenging to estimate the impact of different goods and services like Spectrum on people's SWB. The literature on which methods *in practice* perform better under different circumstances is very much in its infancy and so an open approach to the question of the economic valuation of Spectrum seems sensible. And as we have suggested here it is possible to run both methods in tandem for some of the outcomes related to Spectrum, which may provide a more holistic assessment of the social value of Spectrum.

Annex

DA1. The relationship between compensating and equivalent welfare measures and WTP and WTA

Depending on whether the change in the non-market good is positive or negative for welfare, under the preference account CS and ES can be rephrased in terms of willingness to pay (WTP) or willingness to accept (WTA).

	Compensating Surplus (CS)	**Equivalent Surplus (ES)**
Welfare gain	*WTP for the positive change*	*WTA to forego the positive change*
Welfare loss	*WTA the negative change*	*WTP to avoid the negative change*

DA2. Rationality assumptions for preferences

The fundamental premise is that under a small set of rationality assumptions embodied in the *axioms of revealed preference* we are able to map choices over a number of binary options on to a well-defined utility function. Rationality here implies that preferences are:

I. **Complete** – individuals are able to express a preference for any good or say they are indifferent between any pair of goods;

II. **Transitive** – individuals who prefer (or are indifferent to) good x over good y, and who prefer (or are indifferent to) good y over good z, must also prefer (or be indifferent to) x over z; and

III. **Reflexive** – individuals are indifferent between x and x.

If these assumptions are met then people will behave *as if* they are maximising some utility function. Through this formulation preference becomes synonymous with welfare in economics. Although economists are generally reluctant to make normative claims about agents, it is not uncommon for those working in applied policy areas to also require some

further substantive assumptions and restrictions on preferences, namely that they be **well-informed** or **laundered preferences**.

For the purposes of non-market valuation we also need to add two further assumptions:

I. **Non-satiation** – that preferences are never fully satiated such that the individual always places a positive value on more consumption; and

II. **Substitutability** - if the quantity (or quality) of one good decreases it is possible to increase the quantity (or quality) of another good sufficiently to make the individual indifferent between the two states of the world.

References

Aadland, D., & Caplan, A. J. (2006). Cheap talk reconsidered: New evidence from CVM. *Journal of Economic Behavior & Organization*, *60*(4), 562–578. doi:10.1016/j.jebo.2004.09.006

Ahlfeldt, G. M., & Maennig, W. (2008). Impact of sports arenas on land values: evidence from Berlin. *The Annals of Regional Science*, *44*(2), 205–227. doi:10.1007/s00168-008-0249-4

Ajzen, I., Brown, T. C., & Rosenthal, L. H. (1996). Information bias in contingent valuation: Effects of personal relevance, Quality of Information, and Motivational Orientation. *Journal of Environmental Economics and Management*, *30*(1), 43–57. doi:10.1006/jeem.1996.0004

Arinloye, D. A., Linnemann, A. R., Hagelaar, G., Coulibaly, O., & Omta, O. S. W. F. (2015). Taking profit from the growing use of mobile phone in Benin: a contingent valuation approach for market and quality information access. *Information Technology for Development*, *21*(1), 44–66. doi:10.1080/02681102.2013.859117

Arrow, K., & Solow, R. (1993). *Report of the NOAA Panel on Contingent Valuation*. National Oceanic and Atmospheric Administration Washington, DC. http://www.cbe.csueastbay.edu/~alima/courses/4306/articles/NOAA%20on%20contingent%20valuation%201993.pdf. Accessed 28 May 2014

Bateman, I. J., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., et al. (2002). *Economic Valuation with Stated Preference Techniques: A Manual*. Cheltenham, UK: Edward Elgar.

Bateman, I., Mace, G., Fezzi, C., Atkinson, G., & Turner, K. (2011). Economic analysis for ecosystem service assessments. *Environmental and Resource Economics*, *48*(2), 177–218. doi:10.1007/s10640-010-9418-x

Beja, E. J. (2011). *Subjective Well-Being Approach to the Valuation Of Income Inequality* (MPRA Paper). http://mpra.ub.uni-muenchen.de/34177/. Accessed 27 November 2014

Benjamin, D. J., Heffetz, O., Kimball, M. S., & Szembrot, N. (2012). *Beyond Happiness and Satisfaction: Toward Well-Being Indices Based on Stated Preference*. National Bureau of Economic Research.

Bennett, J., & Blamey, R. (2001). *The Choice Modelling Approach to Environmental Valuation*. London, UK: Edward Elgar Publishing.

Bergstrom, J. C., Stoll, J. R., & Randall, A. (1989). Information effects in contingent markets. *American Journal of Agricultural Economics*, *71*(3), 685–691. doi:10.2307/1242024

Bergstrom, J. C., Stoll, J. R., & Randall, A. (1990). The impact of information on environmental commodity valuation decisions. *American Journal of Agricultural Economics*, *72*(3), 614–621. doi:10.2307/1243031

Bertrand, M., & Mullainathan, S. (2001). Do people mean what they say? Implications for subjective survey data. *The American Economic Review*, *91*(2), 67–72. Accessed 27 November 2014

Bishop, R. C., & Heberlein, T. A. (1979). Measuring values of extra market goods: Are indirect measures biased? *American journal of agricultural economics*, 926–930.

Bishop, R. C., Heberlein, T., Welsh, M., & Baumgartner, R. (1984). Does contingent valuation work? Results of the Sandhill experiment. In *Invited paper presented at the 1984 AERE conference, Ithaca, New York*.

Blanchflower, D. G., & Oswald, A. J. (2004). Well-being over time in Britain and the USA. *Journal of Public Economics*, *88*(7–8), 1359–1386. doi:10.1016/S0047-2727(02)00168-8

Blomquist, G. C., & Whitehead, J. C. (1998). Resource quality information and validity of willingness to pay in contingent valuation. *Resource and Energy Economics*, *20*(2), 179–196. doi:10.1016/S0928-7655(97)00035-3

Bockstael, N. E., & McConnell, K. E. (1980). Calculating equivalent and compensating variation for natural resource facilities; Measuring the worth of natural resource facilities: comment and reply. *Land Economics*, *56*(1; 4), 56–63; 482–490.

Brown, T. C. (1984). The concept of value in resource allocation. *Land Economics*, 231–246.

Carlsson, F., Frykblom, P., & Lagerkvist, C. (2005). Using cheap talk as a test of validity in choice experiments. *Economics Letters*, *89*(2), 147–152. doi:10.1016/j.econlet.2005.03.010

Carlsson, F., & Martinsson, P. (2006). Do experience and cheap talk influence willingness to pay in an open-ended contingent valuation survey? In *Working Papers in Economics 109*.

Carroll, N., Frijters, P., & Shields, M. A. (2009). Quantifying the costs of drought: new evidence from life satisfaction data. *Journal of Population Economics*, *22*(2), 445–461. doi:10.1007/s00148-007-0174-3

Carson, R. T., Flores, N. E., & Meade, N. F. (2001). Contingent valuation: controversies and evidence. *Environmental and Resource Economics*, *19*(2), 173–210. doi:10.1023/A:1011128332243

Carson, R. T., Groves, T., & Machina, M. J. (1997). Stated preference questions: Context and optimal response. In *National science foundation preference elicitation symposium, University of California, Berkeley*.

Carson, R. T., & Louviere, J. J. (2011). A common nomenclature for stated preference elicitation approaches. *Environmental and Resource Economics*, *49*(4), 539–559. doi:10.1007/s10640-010-9450-x

Champ, P. A., & Bishop, R. C. (2001). Donation payment mechanisms and contingent valuation: An empirical study of hypothetical bias. *Environmental and Resource Economics*, *19*(4), 383–402. Accessed 28 May 2014

Chapman, R. E. (1992). *Benefit-cost analysis for the modernization and associated restructuring of the National Weather Service*. National Institute of Standards and Technology.

Clark, A. E., & Oswald, A. J. (2002). A simple statistical method for measuring how life events affect happiness. *International Journal of Epidemiology*, *31*(6), 1139–1144. doi:10.1093/ije/31.6.1139

Clark, W. C., Mitchell, R., Cash, D., & Alcock, F. (2002). *Information as Influence: How Institutions Mediate the Impact of Scientific Assessments on Global Environmental Affairs* (SSRN Scholarly Paper No. ID 357521). Rochester, NY: Social Science Research Network. http://papers.ssrn.com/abstract=357521. Accessed 29 September 2013

Cohen, M. A. (2008). The effect of crime on life satisfaction. *The Journal of Legal Studies*, *37*(S2), S325–S353. doi:10.1086/597200

Cohen, S. (2003). *Maximum Difference Scaling: Improved Measures of Importance and Preference for Segmentation* (Sawtooth Software Conference Proceedings). Sequim, WA: Sawtooth Software.

Cummings, R. G., & Taylor, L. O. (1999). Unbiased value estimates for environmental goods: A cheap talk design for the contingent valuation method. *The American Economic Review*, *89*(3), 649–665. Accessed 2 June 2014

Deaton, A. (2008). Income, health and wellbeing around the world: Evidence from the Gallup World Poll. *The journal of economic perspectives: a journal of the American Economic Association*, *22*(2), 53.

Diener, E. (2009). *Well-being for Public Policy*. Oxford, UK: Oxford University Press.

Diener, E. D. (1984). Subjective well-being. *Psychological Bulletin*, *95*, 542–575. doi:10.1037/0033-2909.95. 3.542

Diener, E., & Suh, E. (1997). Measuring quality of life: economic, social, and subjective indicators. *Social Indicators Research*, *40*(1-2), 189–216. doi:10.1023/A:1006859511756

Diener, E., Suh, E. M., Lucas, R. E., & Smith, H. L. (1999). Subjective well-being: three decades of progress. *Psychological Bulletin*, *125*(2), 276–302. doi:10.1037/0033-2909.125.2.276

Dolan, P., & Fujiwara, D. (2012). Valuing adult learning: comparing wellbeing valuation to contingent valuation.

Dolan, P., & Kahneman, D. (2008). Interpretations of utility and their implications for the valuation of health. *The Economic Journal*, *118*(525), 215–234. doi:10.1111/j.1468-0297.2007.02110.x

Dolan, P., Layard, R., & Metcalfe, R. (2011). Measuring subjective well-being for public policy.

Dolan, P., & Metcalfe, R. (2008). Comparing willingness-to-pay and subjective well-being in the context of non-market goods. Monograph. http://cep.lse.ac.uk/. Accessed 21 May 2014

Dolan, P., & Peasgood, T. (2008). Measuring well-being for public policy: preferences or experiences? *The Journal of legal studies*, *37*(S2), S5–S31.

Dolan, P., Peasgood, T., & White, M. (2008). Do we really know what makes us happy? A review of the economic literature on the factors associated with subjective well-being. *Journal of Economic Psychology*, *29*(1), 94–122. doi:10.1016/j.joep.2007.09.001

Eid, M., Langeheine, R., & Diener, E. (2003). Comparing typological structures across cultures by multigroup latent class analysis a primer. *Journal of Cross-Cultural Psychology*, *34*(2), 195–210. doi:10.1177/0022022102250427

Feng, X., & Humphreys, B. R. (2008). Assessing the economic impact of sports facilities on residential property values: A spatial hedonic approach. *International Association of Sports Economists*, 08–12.

Ferreira, S., & Moro, M. (2010). On the use of subjective well-being data for environmental valuation. *Environmental and Resource Economics*, *46*(3), 249–273. doi:10.1007/s10640-009-9339-8

Ferrer-i-Carbonell, A., & Van Praag, B. (2002). The subjective costs of health losses due to chronic diseases. An alternative model for monetary appraisal. *Health Economics*, *11*(8), 709–722.

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. Addison-Wesley: Reading, MA.

Forrest, D., Glen, J., & Ward, R. (1996). The impact of a light rail system on the structure of house prices: a hedonic longitudinal study. *Journal of Transport Economics and Policy*, 15–29.

Foster, V., & Mourato, S. (2002). Testing for consistency in contingent ranking experiments. *Journal of Environmental Economics and Management*, *44*(2), 309–328. doi:10.1006/jeem.2001.1203

Freeman, A. M. (2003). Economic valuation: What and why. In *A Primer on Nonmarket Valuation* (pp. 1–25). Kluwer Academic Publishers.

Frey, B. S., & Luechinger, S. (2004). Decentralization as a disincentive for terror. *European Journal of Political Economy*, *20*(2), 509–515. doi:10.1016/j.ejpoleco.2004.03.001

Frey, B. S., Luechinger, S., & Stutzer, A. (2007). Calculating tragedy: Assessing the costs of terrorism. *Journal of Economic Surveys*, *21*(1), 1–24.

Frey, B. S., Luechinger, S., & Stutzer, A. (2008). The life satisfaction approach to valuing public goods: The case of terrorism. *Public Choice*, *138*(3-4), 317–345. doi:10.1007/s11127-008-9361-3

Frijters, P. (2001). Interpretation problems with changes in indices based on categorizations. *Economics Letters*, *72*(3), 375–379. doi:10.1016/S0165-1765(01)00451-7

Fujita, F., & Diener, E. (2005). Life satisfaction set point: Stability and change. *Journal of Personality and Social Psychology*, *88*(1), 158–164. doi:10.1037/0022-3514.88.1.158

Fujiwara, D., & Campbell, R. (2011). *Valuation Techniques for Social Cost-Benefit Analysis: Stated Preference, Revealed Preference and Subjective Well-Being Approaches. A Discussion of the Current Issues* (pp. 1–76). London, UK: HM Treasury. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209107/greenbook_valuationtechniques.pdf. Accessed 13 April 2013

Fujiwara, D. (2013a). *The Social Impact of Housing Providers*. London, UK: HACT, Legal & General, Plus Dane Group.

Fujiwara, D. (2013b). *Museums and Happiness: The Value of Participating in Museums and the Arts* (p. 41). London, UK: The Happy Museum Project. http://media.wix.com/ugd/9ccf1d_35c943a360664351a930bc459891a060.pdf

Fujiwara, D. (2013c). A General Method for Valuing Non-Market Goods Using Wellbeing Data: Three-Stage Wellbeing Valuation. In *CEP Discussion Paper No 1233* (pp. 1–29). London, UK: Centre for Economic Performance, London School of Economics. http://cep.lse.ac.uk/_new/publications/series.asp?prog=CEP. Accessed 21 May 2014

Fujiwara, D., & Dolan, P. (2015). Happiness-based policy analysis. In M. Adler & M. Fleurbaey (Eds.), *Oxford Handbook of Wellbeing and Public Policy*.

Fujiwara, D., Kudrna, L., & Dolan, P. (2014a). *Quantifying and Valuing the Wellbeing Impacts of Culture and Sport* (p. 45). London, UK: Department for Culture, Media & Sport.

Fujiwara, D., Kudrna, L., & Dolan, P. (2014b). *Quantifying the Social Impacts of Culture and Sport* (p. 32). London, UK: Department for Culture, Media & Sport. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/304896/Quantifying_the_Social_Impacts_of_Culture_and_Sport.pdf

Fujiwara, D., Cornwall, T., & Dolan, P. (2014c). *Heritage and Wellbeing*. London, UK: SImetrica, English Heritage.

Garrod, G. D., & Willis, K. G. (1992). Valuing goods' characteristics: An application of the hedonic price method to environmental attributes. *Journal of Environmental Management*, *34*(1), 59–76. doi:10.1016/S0301-4797(05)80110-0

Geoghegan, J. (2002). The value of open spaces in residential land use. *Land Use Policy*, *19*(1), 91–98. doi:10.1016/S0264-8377(01)00040-0

Gibbons, S., Mourato, S., & Resende, G. M. (2013). The Amenity Value of English Nature: A Hedonic Price Approach. *Environmental and Resource Economics*, *57*(2), 175–196. doi:10.1007/s10640-013-9664-9

Gregory, R., Lichtenstein, S., & Slovic, P. (1993). Valuing environmental resources: A constructive approach. *Journal of Risk and Uncertainty*, *7*(2), 177–197. doi:10.1007/BF01065813

Groot, W., & van den Brink, H. M. (2006). The compensating income variation of cardiovascular disease. *Health Economics*, *15*(10), 1143–1148. doi:10.1002/hec.1116

Haider, M., & Miller, E. (2000). Effects of transportation infrastructure and location on residential real estate values: Application of spatial autoregressive techniques. *Transportation Research Record: Journal of the Transportation Research Board*, *1722*, 1–8. doi:10.3141/1722-01

Hammack, J., & Brown, G. M. (1974). *Waterfowl and Wetlands: Toward Bio-Economic Analysis*. Resources for the Future.

Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics*, *73*(4), 1255–1263. doi:10.2307/1242453

Hanley, N., Mourato, S., & Wright, R. E. (2001). Choice modelling approaches: A superior alternative for environmental valuation? *Journal of Economic Surveys*, *15*(3), 435–462. doi:10.1111/1467-6419.00145

Hanley, N., Wright, R. E., & Adamowicz, V. (1998). Using choice experiments to value the environment. *Environmental and Resource Economics*, *11*(3-4), 413–428. doi:10.1023/A:1008287310583

Hausman, J. (2012). Contingent valuation: from dubious to hopeless. *Journal of Economic Perspectives*, *26*(4), 43–56. doi:10.1257/jep.26.4.43

Haybron, D. (2010). *Happiness and the Importance of Life Satisfaction. 2001*.

Heberlein, T. A., & Bishop, R. C. (1986). Assessing the validity of contingent valuation: Three field experiments. *Science of the Total Environment*, *56*, 99–107.

Hicks, J. R., & Allen, R. G. D. (1934). A reconsideration of the theory of value. Part I. *Economica*, *1*(1), 52–76.

Hicks, S., Tinkler, L., & Allin, P. (2013). Measuring subjective well-being and its potential role in policy: Perspectives from the UK Office for National Statistics. *Social Indicators Research*, *114*(1), 73–86. doi:10.1007/s11205-013-0384-x

Hoehn, J. P., & Randall, A. (2002). The effect of resource quality information on resource injury perceptions and contingent values. *Resource and Energy Economics*, *24*(1–2), 13–31. doi:10.1016/S0928-7655(01)00051-3

Holden Permain. (2008). *Assessing the value of public service programming on ITV1, Channel 4 and Five* (p. 114). London, UK: Ofcom. http://stakeholders.ofcom.org.uk/binaries/consultations/psb2_phase2/annexes/annex6.pdf

Hsee, C. K. (2000). Attribute evaluability and its implications for joint-separate evaluation reversals and beyond.

Huppert, H. E. (2006). Gravity currents: a personal perspective. *Journal of Fluid Mechanics*, *554*, 299–322. doi:10.1017/S002211200600930X

Ida, T., Murakami, K., & Tanaka, M. (2014). A stated preference analysis of smart meters, photovoltaic generation, and electric vehicles in Japan: Implications for penetration and GHG reduction. *Energy Research & Social Science*, *2*, 75–89. doi:10.1016/j.erss.2014.04.005

Irwin, J. R., Slovic, P., Lichtenstein, S., & McClelland, G. H. (1993). Preference reversals and the measurement of environmental values. *Journal of Risk and Uncertainty*, *6*(1), 5–18. doi:10.1007/BF01065347

Kahneman, D., Fredrickson, B. L., Schreiber, C. A., & Redelmeier, D. A. (1993). When more pain is preferred to less: adding a better end. *Psychological Science*, *4*(6), 401–405. doi:10.1111/j.1467-9280.1993.tb00589.x

Kahneman, D., & Knetsch, J. L. (1992). Valuing public goods: The purchase of moral satisfaction. *Journal of Environmental Economics and Management*, *22*(1), 57–70. doi:10.1016/0095-0696(92)90019-S

Kahneman, D., & Krueger, A. B. (2006). Developments in the measurement of subjective well-being. *The Journal of Economic Perspectives*, *20*(1), 3–24. doi:10.1257/089533006776526030

Kahneman, D., Krueger, A. B., Schkade, D., Schwarz, N., & Stone, A. A. (2006). Would you be happier if you were richer? A focusing illusion. *Science*, *312*(5782), 1908–1910. doi:10.1126/science.1129688

Kahneman, D., & Snell, J. (1992). Predicting a changing taste: Do people know what they will like? *Journal of Behavioral Decision Making*, *5*(3), 187–200. doi:10.1002/bdm.3960050304

Kahneman, D., & Thaler, R. H. (2006). Anomalies: utility maximization and experienced utility. *The Journal of Economic Perspectives*, *20*(1), 221–234. doi:10.1257/089533006776526076

Kanemoto, Y. (1988). Hedonic prices and the benefits of public projects. *Econometrica*, *56*(4), 981–989. doi:10.2307/1912708

Kende, M., Bates, P., Stewart, J., & Vroobel, M. (2013). *Impact of radio spectrum on the UK economy and factors influencing future spectrum demand* (p. 140). London, UK: Business, Innovation and Skills & Department for Culture, Media and Sport. https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCkQFjAB&url=https%3A%2F%2Fwww.gov.uk%2Fgovernment%2Fuploads%2Fsystem%2Fuploads%2Fattachment_data%2Ffile%2F77861%2FImpact_of_radio_spectrum_on_the_UK_economy.doc&ei=rTsMVa32MsuR7AaR8oGoAw&usg=AFQjCNF9F4K4Cv1PQ5guyRim0h7ezRsILQ&sig2=L7msra4uANQfXOwqmp3-8Q

Kenkel, P. L., & Norris, P. E. (1995). Agricultural producers' willingness to pay for real-time mesoscale weather information. *Journal of Agricultural and Resource Economics*, 356–372.

Kiecolt-Glaser, J. K., McGuire, L., Robles, T. F., & Glaser, R. (2002). Emotions, morbidity, and mortality: New perspectives from psychoneuroimmunology. *Annual Review of Psychology*, *53*(1), 83–107. doi:10.1146/annurev.psych.53.100901.135217

Kimball, M., & Willis, R. (2006). Utility and happiness. *University of Michigan*.

Kim, D., & Sugai, P. (2008). Differences in consumer loyalty and willingness to pay for service attributes across digital channels: A study of the Japanese digital content market. *Telecommunications Policy*, *32*(7), 480–489. doi:10.1016/j.telpol.2008.05.003

Lancaster, K. J. (1966). A new approach to consumer theory. *The journal of political economy*, 132–157.

Lee, S. W., Kim, D. J., & Park, M. C. (2004). Demand for number portability in the Korean mobile telecommunications market: contingent valuation approach. In *Proceedings of the 37th Annual Hawaii International Conference on System Sciences, 2004* (p. 10 pp.–). Presented at the Proceedings of the 37th Annual Hawaii International Conference on System Sciences, 2004. doi:10.1109/HICSS.2004.1265501

Lipscomb, C. (2003). Small cities matter, too: The impacts of an airport and local infrastructure on housing prices in a small urban city. *Review of Urban & Regional Development Studies*, *15*(3), 255–273. doi:10.1111/j.1467-940X.2003.00076.x

List, J. A., & Lucking-Reiley, D. (2000). Demand reduction in multiunit auctions: Evidence from a sports card field experiment. *American Economic Review*, 961–972.

Loewenstein, G., & Adler, D. (1995). A bias in the prediction of tastes. *The Economic Journal*, *105*(431), 929–937. doi:10.2307/2235159

Loomis, J., Gonzalez-Caban, A., & Gregory, R. (1994). Do reminders of substitutes and budget constraints influence contingent valuation estimates? *Land Economics*, 499–506.

Louviere, J. J. (1988). Conjoint Analysis Modelling of Stated Preferences: A Review of Theory, Methods, Recent Developments and External Validity. *Journal of Transport Economics and Policy*, *22*(1), 93–119. Accessed 16 December 2014

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated Choice Methods: Analysis and Applications*. Cambridge University Press, Cambridge, UK.

Luechinger, S. (2009). Valuing air quality using the life satisfaction approach. *The Economic Journal*, *119*(536), 482–515. doi:10.1111/j.1468-0297.2008.02241.x

Luechinger, S., & Raschky, P. A. (2009). Valuing flood disasters using the life satisfaction approach. *Journal of Public Economics*, *93*(3–4), 620–633. doi:10.1016/j.jpubeco.2008.10.003

Lusk, J. L. (2003). Effects of cheap talk on consumer willingness-to-pay for golden rice. *American Journal of Agricultural Economics*, *85*(4), 840–856. doi:10.1111/1467-8276.00492

Maddison, D., & Day, B. (2015). *Improving Cost-Benefit Analysis Guidance: A Report to the Natural Capital Committee*. London, UK: Natural Capital Committee. https://www.naturalcapitalcommittee.org/advice-on-appraisal-guidance.html

Mitchell, R. C., & Carson, R. T. (1989). *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Resources for the Future.

Moore, S. C. (2006). The value of reducing fear: an analysis using the European Social Survey. *Applied Economics*, *38*(1), 115–117. doi:10.1080/00036840500368094

Murphy, J. J., Stevens, T., & Weatherhead, D. (2003). An empirical study of hypothetical bias in voluntary contribution contingent valuation: Does cheap talk matter? *Unpublished Manuscript*.

Nelson, J. P. (2004). Meta-analysis of airport noise and hedonic property values. *Journal of Transport Economics and Policy (JTEP)*, *38*(1), 1–27.

Nguyen, T. C., & Robinson, J. (2013). Analysing motives behind willingness to pay for improving early warning services for tropical cyclones in Vietnam. *Meteorological Applications*, n/a–n/a. doi:10.1002/met.1441

Nguyen, T. C., Robinson, J., Kaneko, S., & Komatsu, S. (2013). Estimating the value of economic benefits associated with adaptation to climate change in a developing country: A case study of improvements in tropical cyclone warning services. *Ecological Economics*, *86*, 117–128. doi:10.1016/j.ecolecon.2012.11.009

Nisbett, R. E., & Kanouse, D. E. (1969). Obesity, food deprivation, and supermarket shopping behavior. *Journal of Personality and Social Psychology*, *12*(4), 289–294. doi:10.1037/h0027799

Oswald, A. J., & Powdthavee, N. (2008). Death, happiness, and the calculation of compensatory damages. *The Journal of Legal Studies*, *37*(S2), S217–S251. doi:10.1086/597200

Parfit, D. (1984). *Reasons and Persons*. Oxford UK: Oxford University Press.

Pavot, W., & Diener, E. (1993). The affective and cognitive context of self-reported measures of subjective well-being. *Social Indicators Research*, *28*(1), 1–20. doi:10.1007/BF01086714

Pavot, W., Diener, E., Colvin, C. R., & Sandvik, E. (1991). Further validation of the satisfaction with life scale: Evidence for the cross-method convergence of well-being measures. *Journal of Personality Assessment*, *57*(1), 149–161. doi:10.1207/s15327752jpa5701_17

Pearce, D. W., Atkinson, G., & Mourato, S. (2006). *Cost-Benefit Analysis and the Environment: Recent Developments* (p. 315). Paris, France: Organisation for Economic Co-Operation and Development (OECD). http://www.lne.be/themas/beleid/milieueconomie/downloadbare-bestanden/ME11_cost-benefit%20analysis%20and%20the%20environment%20oeso.pdf

Pepermans, G. (2014). Valuing smart meters. *Energy Economics*, *45*, 280–294. doi:10.1016/j.eneco.2014.07.011

Potoglou, D., Robinson, N., Patil, S., Dunkerley, F., Fox, J., Lu, H., & Patruni, B. (2014). Privacy, security and surveillance: New insights into preferences of European citizens. In *2014 TPRC Conference Paper*.

Powdthavee, N. (2008). Putting a price tag on friends, relatives, and neighbours: Using surveys of life satisfaction to value social relationships. *The Journal of Socio-Economics*, *37*(4), 1459–1480. doi:10.1016/j.socec.2007.04.004

Powdthavee, N., & van den Berg, B. (2011). Putting different price tags on the same health condition: re-evaluating the well-being valuation approach. *Journal of Health Economics*, *30*(5), 1032–1043. doi:10.1016/j.jhealeco.2011.06.001

Randall, A. (1982). Economic surplus concepts and their use in benefit cost analysis. *Review of Marketing and Agricultural Economics*, *50*(2), 135–63.

Read, D., & van Leeuwen, B. (1998). Predicting hunger: The effects of appetite and delay on choice. *Organizational Behavior and Human Decision Processes*, *76*(2), 189–205. doi:10.1006/obhd.1998.2803

Rehdanz, K., & Maddison, D. (2008). Local environmental quality and life-satisfaction in Germany. *Ecological Economics*, *64*(4), 787–797. doi:10.1016/j.ecolecon.2007.04.016

Ringburg, A. N., Thomas, S. H., Steyerberg, E. W., van Lieshout, E. M. M., Patka, P., & Schipper, I. B. (2009). Lives saved by helicopter emergency medical services: An overview of literature. *Air Medical Journal*, *28*(6), 298–302. doi:10.1016/j.amj.2009.03.007

Rolfe, J., Bennett, J., & Louviere, J. (2002). Stated values and reminders of substitute goods: Testing for framing effects with choice modelling. *Australian Journal of Agricultural and Resource Economics*, *46*(1), 1–20. doi:10.1111/1467-8489.00164

Sales, S. M., & House, J. (1971). Job dissatisfaction as a possible risk factor in coronary heart disease. *Journal of Chronic Diseases*, *23*(12), 861–873. doi:10.1016/0021-9681(71)90015-4

Samples, K. C., Dixon, J. A., & Gowen, M. M. (1986). Information disclosure and endangered species valuation. *Land Economics*, 306–312.

Sandvik, L., Erikssen, J., Thaulow, E., Erikssen, G., Mundal, R., & Rodahl, K. (1993). Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. *New England Journal of Medicine*, *328*(8), 533–537.

Schimmack, U., & Oishi, S. (2005). The influence of chronically and temporarily accessible information on life satisfaction judgments. *Journal of Personality and Social Psychology*, *89*(3), 395–406. doi:10.1037/0022-3514.89.3.395

Schkade, D. A., & Kahneman, D. (1998). Does living in California make people happy? A focusing illusion in judgments of life satisfaction. *Psychological Science*, *9*(5), 340–346. doi:10.1111/1467-9280.00066

Schwarz, N. (2010). Meaning in context: Metacognitive experiences. *The mind in context*, 105–125.

Schwarz, N., & Strack, F. (1999). Reports of subjective well-being: Judgmental processes and their methodological implications. In *Well-Being: Foundations of Hedonic Psychology* (pp. 61–84). London, UK: Russell Sage Foundation.

Shizgal, P. (1999). On the neural computation of utility: implications from studies of brain stimulation reward. In D. Kahneman, E. Diener, & N. Schwarz (Eds.), *Foundations of hedonic psychology: Scientific perspectives on enjoyment and suffering*. Russell Sage Foundation. http://cogprints.org/740/. Accessed 12 May 2015

Slovic, P., Finucane, F., Peters, D., & McGregor, R. (2002). The affect heuristic. In T. Gilovich, D. W. Griffin, & D. Kahneman (Eds.), *Heuristics and Biases: The Psychology of Intuitive Judgment*. Cambridge University Press.

Smith, T. W. (1979). Happiness: Time trends, seasonal variations, intersurvey differences, and other mysteries. *Social Psychology Quarterly*, 18–30.

Stutzer, A., & Frey, B. S. (2004). Reported subjective well-being: A challenge for economic theory and economic policy. *Schmollers Jahrbuch*, *124*(2), 1–41.

Stutzer, A., & Frey, B. S. (2010). Recent advances in the economics of individual subjective well-being. *Social Research*, *77*(2), 679–714. Accessed 27 March 2015

Taylor, C. B., Stevenson, M., Jan, S., Middleton, P. M., Fitzharris, M., & Myburgh, J. A. (2010). A systematic review of the costs and benefits of helicopter emergency medical services. *Injury*, *41*(1), 10–20. doi:10.1016/j.injury.2009.09.030

Terzis, G., & Bates, J. (2000). *Survey to Determine the Consumers' Surplus Accruing to TV Viewers and Radio Listeners*. London, UK: MVA, Radiocommunications Agency, Ofcom.

Teske, S., & Robinson, P. (1994). The benefits of the United Kingdom Meteorological Office to the national Economy. *WMO-TD No*, *630*.

Trotter, L., Vine J., Leach M., Fujiwara D. (2014, March). Measuring the Social Impact of Community Investment: A Guide to using the Wellbeing Valuation Approach. HACT.

Tsuji, M., & Miyahara, S. (2007). Value of Japanese public broadcasting in the convergence of broadcasting and telecommunications. Unpublished manuscript.

Tu, C. C. (2005). How does a new sports stadium affect housing values? The case of FedEx Field. *Land Economics*, *81*(3), 379–395. doi:10.3368/le.81.3.379

Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. *The quarterly journal of economics*, 1039–1061.

UK National Ecosystem Assessment. (2011). *The UK National Ecosystem Assessment Technical Report* (Technical Report: Introduction to the UK National Ecosystem Assessment). Cambridge, UK: UNEP-WCMC. http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Urry, H. L., Nitschke, J. B., Dolski, I., Jackson, D. C., Dalton, K. M., Mueller, C. J., et al. (2004). Making a life worth living neural correlates of well-being. *Psychological Science*, *15*(6), 367–372. doi:10.1111/j.0956-7976.2004.00686.x

Van den Berg, B., & Ferrer-i-Carbonell, A. (2007). Monetary valuation of informal care: the well-being valuation method. *Health Economics*, *16*(11), 1227–1244. doi:10.1002/hec.1224

Waltert, F., & Schläpfer, F. (2010). Landscape amenities and local development: A review of migration, regional economic and hedonic pricing studies. *Ecological Economics*, *70*(2), 141–152. doi:10.1016/j.ecolecon.2010.09.031

Welsch, H. (2002). Preferences over prosperity and pollution: Environmental valuation based on happiness surveys. *Kyklos*, *55*(4), 473–494. doi:10.1111/1467-6435.00198

Welsch, H. (2007). Environmental welfare analysis: A life satisfaction approach. *Ecological Economics*, *62*(3–4), 544–551. doi:10.1016/j.ecolecon.2006.07.017

Welsch, H. (2008). The social costs of civil conflict: Evidence from surveys of happiness. *Kyklos*, *61*(2), 320–340. doi:10.1111/j.1467-6435.2008.00404.x

Welsch, H., & Kühling, J. (2009). Using happiness data for environmental valuation: Issues and applications. *Journal of Economic Surveys*, *23*(2), 385–406. doi:10.1111/j.1467-6419.2008.00566.x

Whittington, D., Kerry Smith, V., Okorafor, A., Okore, A., Long Liu, J., & McPhail, A. (1992). Giving respondents time to think in contingent valuation studies: A developing country application. *Journal of Environmental Economics and Management*, *22*, 205–225.

Wilson, T. D., & Gilbert, D. T. (2003). Affective forecasting. *Advances in Experimental Social Psychology*, *35*, 345–411.

Wirtz, D., Kruger, J., Scollon, C. N., & Diener, E. (2003). What to do on spring break? The role of predicted, on-line, and remembered experience in future choice. *Psychological Science*, *14*(5), 520–524. doi:10.1111/1467-9280.03455

Yamori, K., & Tanaka, Y. (2004). Relation between willingness to pay and guaranteed minimum bandwidth in multiple-priority service. In *The 2004 Joint Conference of the 10th Asia-Pacific Conference on Communications, 2004 and the 5th International Symposium on Multi-Dimensional Mobile Communications Proceedings* (Vol. 1, pp. 113–117 vol.1). Presented at the 2004 Joint Conference of the 10th Asia-Pacific Conference on Communications, 2004 and the 5th International Symposium on Multi-Dimensional Mobile Communications Proceedings. doi:10.1109/APCC.2004.1391663

Appendix F. Some perspectives beyond economics

The dominant – or only - social science discipline invoked to support spectrum allocation decisions is economics. But allocating spectrum and other scarce, publicly owned, resources in a democracy is an inherently interdisciplinary problem, especially if the aim is to incorporate broader social value as well as private use value and private external value. We therefore here discuss the potential role of other social science disciplines beyond economics.

As far as we know, none of these approaches has ever been applied to spectrum allocation, nor have we explored them in detail in this project. Rather, we see this as a potential area for further research involving input from academics in these other disciplines.

The two disciplines we discuss are political science and psychology. Within psychology, we first discuss behavioural economics, an extensive domain but one we see as having limited relevance to spectrum allocation because of its focus on individual 'consumer' choice (broadly defined). We then discuss what we call the 'economic psychology of citizens', which is more directly relevant but, at this point, not an extensively developed area within psychology.

The Potential Role of Political Science

Spectrum is always allocated within a political context. In principle, political scientists should be able to add value to the policy process in at least two ways (there may be others):

1. First, they have developed theoretical models of *voting systems* for situations where voters' preferences vary, within the wider framework of the theory of social choice.[15]
2. Secondly, a significant strand of political science has been devoted to the analysis of the 'regulatory state'. [16]

Both of these may be relevant to spectrum allocation. In relation to the first, one issue in deliberative research is how to aggregate different participants' preferences. More ambitiously, such methods might in principle be applied on a wider canvas to generate social choices over alternative allocations. The problems involved in such an exercise would be considerable, but it might help solve the valuation problems addressed in this report.

---

[15] The study of voting has a long pedigree going back to the 18th century and the work of Condorcet and Borda. Modern contributors to social choice theory include in particular Kenneth Arrow and Amartya Sen.

[16] Michael Moran, The British Regulatory State, Oxford University Press, 2003.

The study of regulation takes many forms, but the notion that outcomes are greatly influenced by the machinations of interest groups is a strong theme, as is the belief that institutional structure and interactions have a major impact on outcomes.[17]

Regulatory capture has been extensively studied, especially within an 'interest group' framework.[18]

There is also, of course, a large literature on the economics of regulation.[19] This starts from the hypothesis that regulation can be a powerful instrument for transferring wealth between different groups in society. Regulation is supplied by various agencies which aim to maximise their own utility and by politicians who want to stay in office. The market then clears.

One abiding result of such models is that consumers, almost all of whom have a diffuse interest in the outcome, often come off worse than producers, whose interest is more concentrated.

Why Behavioural Economics May Have Limited Relevance

A second complementary approach that might be expected to be helpful is behavioural economics (BE). BE aims to improve the explanatory and predictive power of economic theory by incorporating some known ways in which the behaviour of real-world consumers and other economic actors deviates from post-war neoclassical assumptions.

The term 'behavioural economics' is somewhat misleading, since the research methods it uses are those of experimental cognitive and social psychology rather than economics. Arguably, the 'behavioural' in BE also implies that mainstream economics is not about behaviour, which is a gross exaggeration. However, by framing BE as a sub-discipline of economics rather than psychology, this 'branding' has almost certainly encouraged its take-up by economics departments, policy-makers and regulators.[20]

---

[17] See Robert Baldwin et al. Understanding Regulation, Oxford University Press, 2011, ch. 4.

[18] For a recent example see D. Moss and D. Carpenter (eds) Preventing Capture: Special Interest Influence and How to Limit It, Cambridge, Cambridge University Press, 2013.

[19] Stigler, George, 'The Theory of Economic Regulation', *Bell Journal of Economics*, 2 (1971), 3-21; Becker, Gary, 'A theory of competition among pressure groups for political influence' Quarterly Journal of Economics, (1983), pp. 371-400. Robert Baldwin et al (eds.) The Oxford Handbook of Regulation, 2010, ch. 2.

[20] When the eminent social psychologist Robert Cialdini (a world expert on persuasion and behaviour change) was invited to a high-level, invitation-only US government workshop, he was surprised to be listed as a behavioural economist. When he questioned this, he was told

A further factor reinforcing the growth of BE and behavioural finance may have been the limitations of rational expectations models of risk exposed by the 2008 banking crisis.

Arguably, BE represents a return by economics to a classical and early neoclassical interest in the psychological processes underlying economic behaviour.[21] Further, classical economics sometimes acknowledged both the existence and the practical relevance of social value as well as private gain, as in Adam Smith's well-known statement that*, "How selfish so ever man may be supposed, there are evidently some principles in his nature, which interest him in the fortunes of others, and render their happiness necessary to him, though he derives nothing from it except the pleasure of seeing it".*[22]

This view is in line with our hope that the techniques we are recommending can, if executed right, help incorporate external and social value into policy decisions.

BE has been increasingly adopted by governments and regulators looking for better policies by incorporating its findings and methods (choice architecture, random controlled trials, etc) into efforts to influence behaviour. Typical policy contexts include health (smoking cessation, exercise, school meals and food labelling), tax collection, antisocial behaviour (e.g. littering) and prisoner reoffending rates. This influence seems likely to continue, partly because of the scale of current BE research, partly because, where it works, BE reduces costs at a time when the public finances are under extreme pressure.

BE has some relevance to spectrum allocation by highlighting the limitations of the ultra-parsimonious rational-economic model of modern neoclassical economics. BE also shows the practical impact of context (e.g. framing and choice architecture, social influences) and internal states and processes (heuristics, intuition, habit and, to a lesser extent, mood and emotion) as determinants of behaviour, including that of economic agents such as companies participating in an auction.

---

that, "We couldn't have justified bringing you here unless you were labelled a behavioural economist" (Source: Hollingworth, Crawford, 'Chief Behavioural Officer: The New 'Must-Have' Executive Role', *Market Leader*, Q2 2015, 46-9).

[21] Angner, Erik and George Loewenstein, 'Behavioral Economics', in Maki, Uskali, ed., *Handbook of the Philosophy of Science. Volume 13: Philosophy of Economics*, Elsevier, 2012, 641-689.

[22] Smith, Adam, *The Theory of Moral Sentiments*, Cambridge University Press, 2002, 11. (First published 1759).

Neoclassical economics can incorporate agency theory (eg that the outcome of an auction will partly reflect the career interests and financial incentives of the competing companies' managers as well as the interests of their shareholders) without drawing on any insights from psychology. Similarly, by treating different bidders' subjective estimates of an asset's value as exogenous, it can predict outcomes such as the winner's curse (ie that the 'winner' is the most overoptimistic bidder, with potentially negative unintended consequences). But to incorporate the idea that each bidder's subjective estimate of the value is influenced by what other bidders' bid (as is very likely to be the case), we would need a better understanding of social influence and other aspects of bidder psychology.

We see the relevance of BE to spectrum allocation as limited, however, especially in the context of broader social value. The reason is that its focus is almost entirely on *individual* choices, where these differ from neoclassical assumptions about clear, stable, consistently ranked preferences, risk judgements and inter-temporal choice.

BE may, at the margin, help policy-makers improve their estimates of, and approaches to, the private value created by alternative spectrum allocations (e.g. some of the reasons why small differences in the structure and context of auctions lead to such widely different outcomes[23]). What it cannot easily do is directly help them incorporate externalities and wider social benefits into these decisions, the aim of this project.

In other words, BE can help us improve our understanding of public resource allocation preferences among individual members of the public broadly defined as *consumers* - that is, based on their (conscious and unconscious) perceptions and evaluation of the possible consequences *for themselves and their families*.

But to help us address the even more challenging task of incorporating their views as *citizens* into these policy choices (ie based on their perceptions and evaluation of the possible consequences *for other stakeholders or society at large*, as well as for themselves) we need research on how they think about and evaluate the policy alternatives when considering externalities and social value as well as their personal private value.

We here refer to this as the *'economic psychology of citizens'* (EPC for short). In principle, EPC could be extremely helpful for incorporating the public's

[23] Klemperer, Paul, 'Using and Abusing Economic Theory', in Iain McLean and Colin Jennings, eds., *Applying the Dismal Science: When Economists Give Advice to Governments*, Palgrave Macmillan, 2006, 181-209.

views into spectrum allocation decisions that cover broader social value. In practice, the potential is unclear, partly because there has been so little EPC research but also because the main research that has been done largely emphasizes that the way the public thinks about policy decisions differs greatly from the rational policy-maker's perspective.

The Economic Psychology of Citizens (EPC)

The only EPC research we have found is that of Professor Simon Kemp (University of Canterbury, New Zealand) on the economic psychology of public expenditure.[24]

This research involves the application of psychological approaches to measuring citizens' valuation of public services such as hospitals, defence, foreign aid, etc. as an input to policy choices.[25] Based on our exchanges with Professor Kemp, neither he nor any of his associates have tried to apply an EPC approach to spectrum allocation, although he believes that this is worth exploring. To see why, consider some of his findings on public expenditure.

For a given level of total public expenditure (and subject to some provisos beyond the scope of this project, e.g. the protection of minority rights), the policy aim is to allocate resources in a way that maximises the total value of public services. As an input to that process, it clearly makes sense to take into account how the public values the alternative combinations of services.

Given the budget constraint, the key issue for each service is the relationship between its perceived value and its cost, the expectation being that it will have diminishing marginal value as expenditure is increased (also influenced by supply-side economies or diseconomies of scale).

For familiar, *market-supplied goods and services* that are consumed personally, the relationship between cost and perceived value is relatively straightforward, although not one-to-one: the subjective value scale is a compression of the cost scale, i.e. if item A has a market price double that of item B, its perceived value is typically less than double that of B. The relationship typically follows a power law with an exponent in the range 0.3-0.5. Figure F1 illustrates this for a sample of the NZ general public, with both

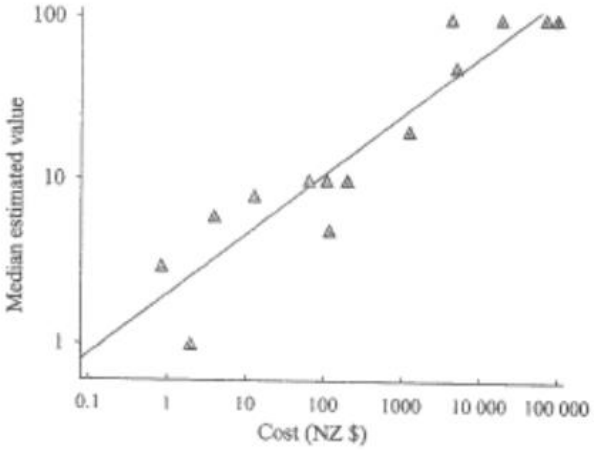
[24] Kemp, Simon, *Public Goods and Private Wants: A Psychological Approach to Government Spending*, Edward Elgar, 2002.

[25] Conceptually, BE is also, strictly speaking, a subset of economic psychology, but complementary to the much smaller subset here referred to as EP.

variables shown against log scales. The line of best fit implies a power-law exponent of 0.37. The correlation coefficient is 0.94.

For *public services*, however, the relationship between cost and perceived value is much less clear-cut, as illustrated by Figure F2, again for a representative sample of the NZ general public. The x-axis here shows the per capita cost of 27 public services and the y-axis their mean perceived value on an 11-point semantic scale from zero ('worthless') to 10 ('extremely worthwhile and useful'). The results differ dramatically from those in Figure F1:

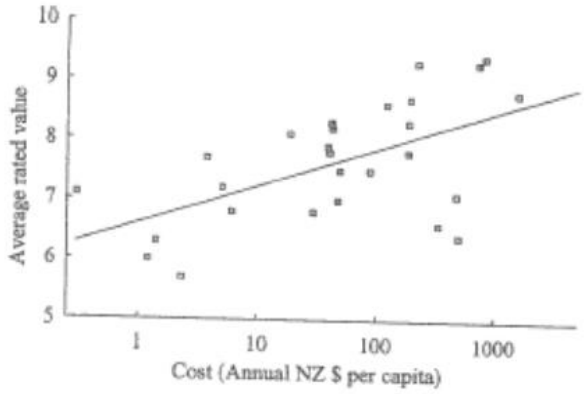
Figure F1: Perceived Value of Market-Supplied Goods as a Function of Price[26]



- **The relationship is much flatter.** No public service was rated below the mid-point of the subjective value scale. Almost all are, on average, rated between about 6 and 8.8, despite cost differences of over three orders of magnitude. Although Figures F1 and F2 are not directly comparable, because of the very different value scales, the latter suggests that the value scale for public services is even more compressed than for market-supplied products and services.
- **The correlation is much lower (0.62).** There are large deviations from the trend line, so that in some cases a service is valued more highly than another that costs more than 100 times as much to provide.

[26] Kemp, op. cit., p95.

Figure F2: Perceived Value of Public Services as a Function of Cost per Capita[27]



To see what this would mean in practice, it is helpful to see which services in Figure F2 fall above and below the trend line (Table F1). The results tell us a lot about how the public (in this case, New Zealanders in the late 1980s) see the relative value, and value for money, of different publicly funded services. For the biggest expenditure categories:

- The police, hospitals, schools and, to a lesser extent, universities and polytechnics are highly valued, even relative to their high predicted values
- Conversely, defence and most welfare benefits are valued much less than their – also high - predicted values
- Among the other high-cost services, the old age pension is valued just above trend, as are prescription subsidies (presumably seen as closer to healthcare than to welfare support), while family support is just below trend but much less so than for most welfare benefits. (A general pattern is of relatively strong support for public services that benefit children and young people).

Among the low-cost categories, and potentially relevant to DCMS, athletes' scholarships were valued well above trend. Conversely, support for the arts was the opposite - but still in a context where the NZ Symphony Orchestra, the least valued public service, was rated at 5.7 on the zero to 10 scale.

[27] Kemp, op. cit., p99.

Table F1: Deviations from the Trend Line in Figure F2[28]

Service	Rated Value	Cost (NZ$)	Predicted Value	Deviation
Police	9.3	220	8.1	**1.2**
Hospitals	9.4	811	8.4	**1.0**
Schools	9.3	714	8.4	**0.9**
Athletes' scholarships	7.1	0	6.2	**0.9**
Universities	8.7	190	8.0	**0.7**
Polytechnics	8.6	120	7.9	**0.7**
Environment conservation	8.3	41	7.6	**0.7**
Customs Department	8.1	19	7.4	**0.7**
Nurseries/childcare support	8.2	42	7.6	**0.6**
Prescription subsidies	8.3	185	8.0	**0.3**
National library	7.9	39	7.6	**0.3**
Old-age pension	8.8	1556	8.6	**0.2**
Agriculture Ministry	7.8	40	7.6	**0.2**
Meteorological Service	7.2	5	7.0	**0.2**
National Archives	7.1	4	6.9	**0.2**
Employment subsidies	7.5	49	7.6	**-0.1**
Family support	7.8	182	8.0	**-0.2**
Prisons	7.5	88	7.8	**-0.3**
Legal aid	6.8	29	7.1	**-0.3**
Women's Affairs Ministry	6.3	1	6.6	**-0.3**
Access courses (for unemployed)	7.0	47	7.6	**-0.6**
Arts Council	6.0	1	6.6	**-0.6**
State Housing Corporation	6.8	29	7.5	**-0.7**
NZ Symphony Orchestra	5.7	2	6.8	**-0.9**

[28] Kemp, op. cit., p101.

Service	Rated Value	Cost (NZ$)	Predicted Value	Deviation
Unemployment benefits	7.1	467	8.3	**-1.1**
Domestic purpose benefits	6.6	329	8.2	**-1.6**
Defence	6.4	490	8.3	**-1.9**

It would be interesting, and not expensive, to collect up-to-date data along these lines for the UK. Our hunch is that there would be many points in common, perhaps with defence valued somewhat more highly and a few other small differences in emphasis.

Many of the results correlate with the discourse of populist politicians and media. For instance, in criticising an opponent's investment project, a politician is far more likely to express its opportunity cost in schools and hospitals than in orchestras or warplanes.

Table F1 illustrates the recurrent finding that the public's way of thinking about resource allocation is very different from that of analysts and policy-makers. This contrast is even greater when we consider policies (including spectrum allocation) aiming to optimise a combination of services. Even without interaction effects (e.g. between community services, primary care and hospitals), optimisation requires an understanding of the diminishing marginal utility of each service, e.g. the extent to which, at least beyond a certain point, increasing expenditure on any public service produces diminishing returns.

However, contingent valuation studies have consistently found that the general public simply does not think in these terms. In the words of Jonathan Baron, "Judgments are often remarkably insensitive to the quantity or scope of the good provided".[29] That is, many respondents will *always* prioritise schools and hospitals over other expenditure, regardless of how many the country already has.

Taken together, these results illustrate why, in a representative democracy, policy-makers will always need to exercise judgement, preferably informed by public opinion but not following it slavishly or in a mechanistic way. Part of that judgement is about thinking through non-obvious, longer-term consequences – including unintended ones – that may not be apparent to the wider public.

The Potential Relevance of EPC to Spectrum Allocation

[29] Baron, Jonathan, 'Biases in the Quantitative Measurement of Values for Public Decisions', *Psychological Bulletin*, 122 (1997), 72-88. (The quotation is on p74).

As already noted, as far as we know, no one has tried to apply an EPC approach (as defined here) to spectrum allocation. So what is its potential relevance?

All three of the methods we discuss – deliberative research (DR), stated preference (SP) and subjective wellbeing (SWB) – are, in very broad terms, applications of EPC, interrelated as follows:

- Like DR, the methods of Kemp and his associates aim to help us understand the public's views on public resource allocation without forcing respondents into a framework that fits analysts' and policy-makers' ways of thinking but not the public's own perspective. The difference is that, with DR, the emphasis is on enabling a relatively small number of participants to reach well-informed and considered conclusions, whereas Kemp's EPC research aims for larger samples to provide statistical reliability, but perhaps with some sacrifice of validity because each respondent has much less information and time than under DR. The two may be seen as a continuum, with EPC being seen as a way of aggregating or scaling up the results of small-scale DR methods, especially where these gauge the strength of participants' preferences via techniques such as budget allocation.
- SP (contingent valuation) is one of the methods used in the EPC research but results such as those in Figure F2 and Table F1 reinforce our comments on the dangers of SP without extensive prior DR. The attractions of SP are that it is easy to do and provides relatively actionable answers expressed in financial terms. What EPC research can do is show why the results may be seriously misleading.
- The impact of policy choices, such as spectrum allocation, on the public's SWB clearly involves processes that can be described as falling under the general heading of EPC. However, the relatively simple survey methods of EPC research are unlikely to be of much value in explaining these complex, subtle and, currently, little understood processes.

The potential applicability of an EPC approach beyond SP, DR and SWB is unclear. In principle, it should be possible to draw on some of the empirical findings of Kemp and his associates to help improve these methods and perhaps supplement them with other measures. In practice, the jury is out and it may be difficult to apply this approach to the smaller value increments associated with spectrum allocation decisions.