Valuing Broadband Benefits:
A selective report on issues and options

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1 Introduction

This report looks at some of the methodological considerations in valuing the benefits of broadband. It has a particular focus on these considerations in the context of the planned National Broadband Network (NBN) project and in the context of any social cost benefit analysis of the NBN or other broadband project. While the underlying principles of valuation are transferable to a variety of project settings, here they are discussed primarily with reference to the planned NBN.

2 Why value the benefits of broadband?

There are at least three broad reasons for valuing the benefits of broadband:

1. To support decision making, projects can be analysed in a number of broad ways. Cost benefit analysis (CBA) is a prominent analysis tool for informing project selection decisions. CBA is the comparing of costs and benefits of a project or a range of alternative projects, with comparisons made in monetary terms where possible. Valuing benefits is an inherent component of a CBA. While a private CBA would normally focus on revenues, a social CBA would consider the value of benefits more broadly.
2. Prioritising and planning. The identification and valuation of broadband benefits can also help to identify any complementary investments and programs necessary to optimise the benefits of broadband. An understanding of the drivers of the underlying benefits can assist with efforts to get the most out of a broadband project. Careful consideration of the source and value of the benefits can lead to considerations of different rollout plans to optimise the broadband project. It can also lead to the identification and improved planning of concurrent activities such as increasing exposure to broadband possibilities and identifying training needs. In short, knowledge about the value of various benefits from broadband can inform strategies to optimise the gaining of those benefits from a prospective broadband implementation project.
3. Pricing decisions. The value placed on the benefits of incremental broadband improvements is a useful input to broadband pricing decisions.

3 Issues in valuing broadband benefits

3.1 The benefits in context

This report is looking at the benefits of broadband in a particular context. It is looking at the benefits of broadband with particular reference to the change in broadband availability planned under the Australian government's National Broadband Network project. It is not generally focusing on the benefits of broadband relative to a world in which no broadband is available. It is more focused on the benefits of broadband from the point of view of an analyst considering a social cost benefit analysis of the NBN. Accordingly the focus is on incremental benefits wherever possible, the increment of benefits due to the NBN.

3.1.1 How does the NBN affect broadband availability?

No definitive definition of broadband and its various speeds appears universally used. Generally we will use the following indicative descriptions:

- No broadband: < 2Mbit/s, asymmetric.[1]
- Basic broadband: 2-12 Mbit/s maximum download speed, asymmetric.
- Fast broadband: in Australia typically via best performed ADSL 2+, cable, future fixed-wireless & satellite; >12 Mbit/s maximum download speed, asymmetric.
- Very fast broadband >20 Mbit/s maximum download speed, "symmetric".[2]

Using these descriptions, the NBN consists of two distinct shifts in household broadband available to Australia (McKinsey-KPMG 2010):

1. For 93% of the population a move to very fast broadband of around 100 Mbit/s. Most of the households moving to very fast broadband availability are likely to be coming from fast broadband availability. Some households, such as those currently with low speed ADSL due to their distance from the exchange, will be moving from basic broadband or even no broadband.

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[1] Asymmetric speeds here refer to upload speeds being much less than the relevant download speed.

[2] Ethernet point to point technology allows full symmetry between download and upload speeds. GPON (Gigabit passive optical networking) is limited to a 2:1 ratio of download to upload speed (McKinsey-KPMG 2010, page 193-194). We believe NBNCo is proceeding with a mix of the two technologies (McKinsey-KPMG 2010, page 174).

2. For the remainder of the population there will be a move to fast broadband supplied by a combination of fixed-wireless broadband and satellite. These households will be coming from a variety of current internet access technologies, mostly in the non broadband and basic broadband categories.

It is important to recognise that this is talking about broadband availability. Not every household currently takes up available broadband services and nor will every household necessarily take up available broadband services under the NBN.

It is also important to recognise that these proposed speeds may be subject to limits in the short term. The speeds enjoyed by users will be affected by any persistence in bottlenecks elsewhere in the network. While backhaul improvements are part of the NBN, neither international links nor content-hosting servers are slated for improvement under the NBN itself. These bottlenecks are unlikely to persist forever and it is also possible that having high domestic speeds will actually encourage increased local data hosting within Australia. This would somewhat reduce the impact of international link bottlenecks.

3.1.2 How does changed broadband lead to benefits?

The rural and regional areas moving to fast broadband will essentially get access to similar broadband capabilities that many but not all enjoy in the cities today with download speeds of 12 Mbit/s. For households moving to this fast broadband the benefits in terms of potential applications are those already in place for many metropolitan users - fast email and web surfing, fast downloading of audio and standard definition video etc.

Moving from fast broadband to very fast broadband is qualitatively different. The move to very fast broadband using fibre is expected to have some advantages:

1 Existing broadband uses can be done faster. Email, web browsing, downloading video or audio content should all be able to be done faster. Now it is true that the increase in speed possible across fibre will not necessarily translate into that speed being available regardless of the particular web application. For example, the transpacific cable is currently a potential bottleneck for some international web browsing. However the bottleneck aspect of this segment is not set in stone. Future improvements to this infrastructure are likely, though some latency effect due to distance will

persist, and not all applications go through this current bottleneck. Intriguingly there is the potential for Australian based caching of information to become more attractive with the advent of the NBN, reducing the proportion of data currently accessed from overseas.

2 Existing broadband uses can be done with greater local multi-use. Households will be better placed to cope with multiple uses of the household broadband connection than they are today. So it will be more feasible for household residents to simultaneously be watching streaming video, answering email, downloading video/image content and engaging in videoconferencing.
3 Improvements in upload speed. ADSL and cable (HFC) are asymmetric, that is, they have much lower upload speeds even where their download speeds are good. Improvements in upload speeds from fibre make a number of applications more practical. Business use of high speed broadband provides some indication of the type of applications this can allow. For example fibre based businesses take advantage of high upload speeds in image processing and storage, audio-visual content development, high definition videoconferencing and cloud computing. These current business uses have potential applicability for households and SMEs with access to the upload speeds of fibre. There are signs that audio and visual content production and storage has the potential to take off at the household and SME level, given the growth of early forms of these applications e.g. YouTube. It is also plausible that touted government uses of the NBN for e-health and e-education will also benefit from improvements to uploading speeds.
4 Video applications, particularly video on demand applications.

3.2 Cost benefit analysis - private versus social CBA

Cost benefit analyses typically take two forms; a social cost benefit analysis (sometimes just termed a cost benefit analysis) and a private cost benefit analysis (also called a financial evaluation). Each type of cost benefit analysis typically follows a number of similar steps, with the main differences being in the application rather than the process. Detailed versions are available in standard cost benefit analysis texts, here is a short summary focusing on the parts most relevant to the issue of valuing broadband benefits:

1. Specifying options. This entails considering the variety of actions that could be taken, actions that will be the focus of the analysis. It includes working out what the reference, base or comparator case is. This reference case can take the form of a "do nothing, change nothing" scenario, all the way through to developing a detailed future counterfactual world without the impact of the actions being assessed. Developing this counterfactual world is generally conceptually preferable – after all, an analyst usually wants to see how the action will change the world from how the world might have been. Still, sometimes analysis is undertaken relative to the current world, with direct effects on how the results should be assessed.[3] It is also possible to compare two or more options within the same CBA framework; care in crafting comparisons between the options is crucial here. An analyst could design the analysis to compare each option with each other or to compare each option with a particular counterfactual.
2. Scope. What effects will be considered? Will only direct effects be considered or will indirect effects in other sectors also be analysed?
3. List costs and benefits for the world with the option and for the base case. This identification process alone can be useful to decision makers. Three conceptual considerations are key. First, the analyst should emphasise economic costs and benefits and not historical or sunk costs and benefits. Careful thinking about the counterfactual suggests that historical costs are the same under the project and the counterfactual and should not influence current or future resource allocation decisions. Second, is to avoid a 'before and after" analysis of a project's benefits and costs. Under a before and after analysis a project may appear to provide net benefits due to some other activities that were happening anyway. This emphasises the importance of doing CBA on a 'with or without' basis wherever possible. Third is to focus on real output effects that change the total welfare of society rather than pecuniary effects, that simply involve transfers between society members.
4. Estimate the substance of the costs and benefits.

[3] That is, assessing relative to the current world answers a different question – how does this project or policy change things relative to the current world, not how does this project or policy change things relative to other future scenarios.

5. Convert the costs and benefits into dollar equivalents.
6. Use a discount rate to bring costs and benefits into present value terms.

These steps are broadly similar for both private cost benefit analysis and social cost benefit analysis. The primary difference is in what costs and benefits are considered. Under private cost benefit analysis the focus is on the private costs and private benefits that accrue to the investor. Here private means the costs and benefits that are incurred or received by the investor. It excludes any costs borne by others and also excludes any benefits enjoyed by others. It focuses on the net private benefit of a given investment for the investor and ignores the costs and benefits of the investment for others.

This private cost benefit analysis approach is common in the commercial world where the aim is to determine which outcomes are best from the perspective of the private investor. It tends to view the value of the network as a function of its future cash flows – a function of the revenue it receives. The value of the network to a prospective (non-government) buyer is then also a function of the buyer's expected future private cash flows.

Social cost benefit analysis is particularly directed at the evaluation of public projects or policies. However it is not simply an analysis of the effects of a project or policy on public expenditures and public revenues. Instead the focus is on the costs and benefits for society as a whole. It is concerned with the net benefit to human welfare. Sometimes this net benefit to human welfare is limited to a single country or region – but the key is that it includes both the private costs and benefits of the investor and includes the costs and benefits of others. The benefits and costs to society are what matters here, rather than cash flows.

A social CBA is designed to inform a decision maker about one important aspect of the decision – its impact on allocative efficiency, or the overall efficient allocation of resources. Social CBA relies on the concept that a project or policy promotes efficiency when the benefits to society outweigh the costs to society, regardless of who gets the benefits, who bears the costs or whether the losers are compensated.[4] As

[4] This is an application of the Kaldor-Hicks criterion to standard Pareto efficiency considerations. For more detailed explanations, see for example; Boardman, Greenberg, Vining & Weimer (2001); Fuguitt & Wilcox (1999); Nas (1996); Johansson (1991).

long as net benefits to society are positive it is possible for winners to compensate losers, even if they do not actually do so.

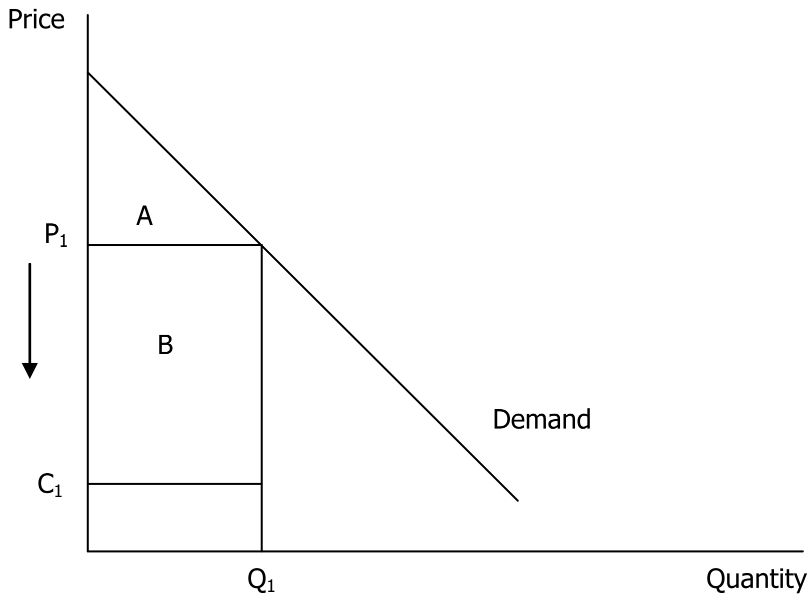
This leads to potential efficiency based decision rules. Say the relevant project or policy options are independent, that is, the adoption of one does not influence the costs and benefits of the others. Then a decision rule focused solely on efficiency would be to adopt all projects or policies that have positive net benefits. Where the relevant projects or policies are not independent or may be mutually exclusive then a decision rule focused solely on efficiency would be to choose the combination of project or policies that maximises the net of social benefits over social costs.

3.2.1 Social benefits and willingness to pay

How are social benefits evaluated in this setting? The fundamental concept underlying the measurement of social benefits is the aggregate willingness to pay of the population for the effects of the policy or project. In other words, social benefits are valued by summing individual's willingness to pay where willingness to pay refers to the amount a person would have to pay under the project or policy to be indifferent between the project or policy and the status quo. In effect the analyst would like to know how much each individual's wealth would need to be adjusted in combination with the policy or project for them to be indifferent between the project or policy and no project or policy. The sum of these changes in wealth measures the social value, or total economic value, of the project or policy. For example a person might have a willingness to pay for higher speed broadband of $40 per month relative to their current speed broadband. Social costs are valued by the opportunity cost of the resources used, defined as its value in the next best use of the resources. Reductions in social costs can also be considered as benefits.

Figure 1 illustrates. It shows a demand curve for a good or service. This demand curve results from the aggregation of the WTP of all consumers. Consumer surplus is the area between the demand curve and the price level, area A. Producer surplus is the area between the price and the opportunity cost of resources used to produce the good or service, area B. Total social welfare equals consumer surplus plus producer surplus, area A plus area B.[5] Changes in total social welfare due to a project or policy are the focus of social CBAs.

Figure 1 Simplified illustration of total social welfare



We tend to think of these benefits as the benefit from the planned or actual use of a good or service such as the NBN. It is also possible that the NBN will have an option value, whereby some people would be willing to pay for the option of using it in the future. It is not clear how significant this benefit is for the NBN or how much it is likely to be captured by the various benefit valuation methods discussed in this report.

This report cannot do justice to the debate over the aggregation of individual preferences (in the form of WTP) to reflect social welfare or social preferences. Suffice to say that the simple aggregation of individual WTP to give total social value troubles some people.[6]

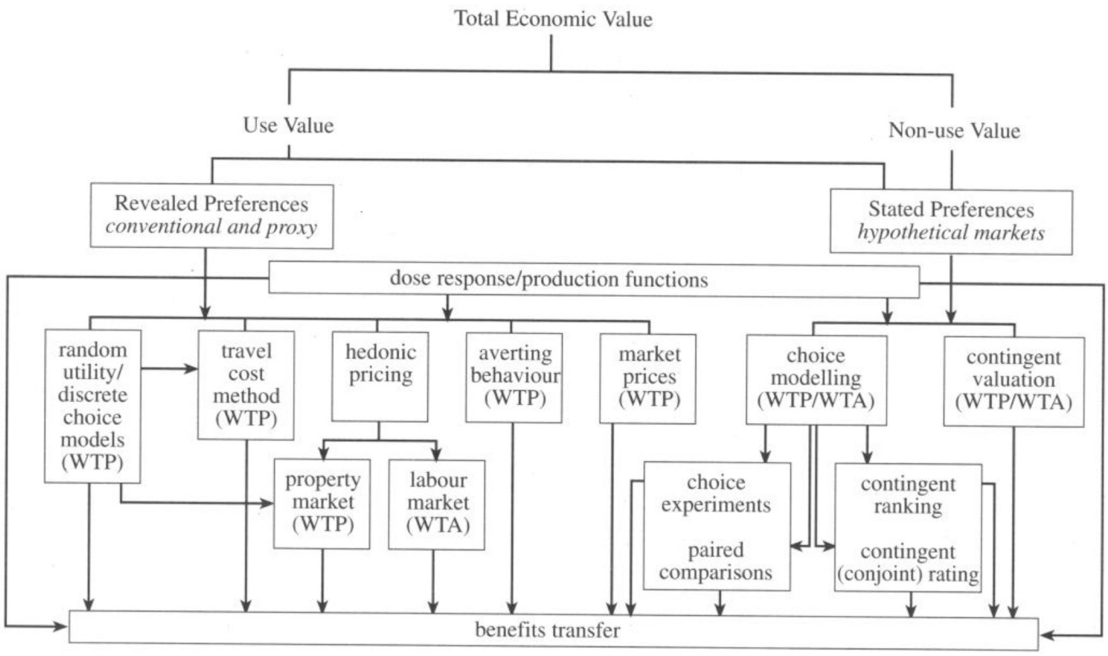
[5] For illustration purposes a simple linear demand curve and constant marginal opportunity cost are used. Other relationships are possible. See Boardman et al. (2001) for a fuller treatment.

[6] For example, the use of WTP as a monetary amount can favour the wealthy. WTP is constrained by income and so in general WTP increases with income. Simple summing of WTP across individuals may mean policies benefiting a small number of better off people appear to have higher social welfare than a policy providing similar benefits to a larger number of worse off people.

3.2.2 Economic valuation techniques

How is social value, or total economic value, determined in practice? Figure 2 outlines a general set of economic valuation techniques, adapted from Bateman et al. (2002).

Figure 2 General economic valuation techniques



Source: Bateman et al., 2002, page 30.

Several points of discussion on this figure follow:

1. Here we focus on value in use. Bateman et al. (2002) also covered "non-use values", referring to a WTP to keep a good or service in existence even where there is no actual, planned or possible use. Non-use values are controversial and appear more relevant in the contexts of environmental or heritage goods. We do not consider them here.

2. "Dose response / production functions" refers to the functions that link the project or policy change with the various responses. For example, if the NBN allowed better monitoring of chronic diseases there might be an improvement in patient wellbeing. The derivation or estimation of these kinds of functions can draw on a wide range of knowledge.

3. Two stated preference methods– contingent valuation and choice experiments - are particularly useful for when a cost benefit analysis is considering a policy or project

that is beyond the range of historical experience. These are survey based techniques aimed at estimating the value in money terms of benefits (and potentially costs) for individuals i.e. estimating their willingness to pay for benefits. They are the primary focus of this report.[7]

4. A range of revealed preference methods are used in economic valuation. A particular revealed preference method, hedonic pricing, will be examined. These hedonic pricing methods, at least in theory, could use revealed preferences in markets for other goods or services to estimate the value of higher speed broadband. Later we examine the potential for prices paid for real estate or for lower speed broadband to inform estimates of value for higher speed broadband.

5. Market prices are potentially a measure of benefit value. However they are not the preferred primary measure of value in the context of social cost benefit analysis. Why not? Where market prices are available they are potentially informative of WTP. However consumer expenditures are only a conservative estimate of WTP. This is because WTP includes actual expenditure and consumer surplus, where consumer surplus is the amount above market price that some consumers are willing to pay but which at the prevailing market price they do not need to.

For NBN enabled cost saving programs under the purview of government, careful analysis of the costs and benefits for that program could be examined. Some of these will involve market prices in the analysis, such as the price of medical labour in the case of e-health initiatives.

When assessing the benefits to individuals, marketed benefits have the advantage of having market prices that may be useful for benefit valuation purposes. For the NBN this is complicated. In some rural and regional areas, basic broadband may simply not be readily available and so relevant market prices may be missing. In metropolitan

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[7] The other stated preference methods in Figure 2 – contingent ranking, paired comparisons, contingent (conjoint) rating - are generally less useful for social cost benefit analysis. Contingent ranking is a ranking of a set of options. Paired comparisons involve choosing the preferred option out of two choices, indicating the strength of the preference on a numeric or semantic scale then analysed using ordinary least squares. Contingent (conjoint) rating has a number of scenarios presented one at a time and rated on a numeric or semantic scale. These last two methods are particularly avoided for economic valuation due to the problematic assumptions required in the form of cardinality of rating scales or an implicit assumption that ratings across individuals can be compared (Bateman et al. 2002).

areas the particular combination of speeds and reliability anticipated under the NBN may not be available and so the usefulness of current market prices may be limited.

Current market prices do not represent the benefits available to users under a situation where all of Australia has had an increase in broadband capability. That is current market prices do not necessarily reflect the valuation placed on benefits from higher speed broadband under the NBN.

The basic issue is that we do not have much revealed information about private willingness to pay for broadband under the future NBN setup. This is because the product essentially does not currently exist in Australia, and so market price information is limited. Having said that, some market price information does exist:

- Current Australian prices for broadband offerings closest in nature to the future broadband offering could be extrapolated in some way. However if future broadband is different enough from the broadband of today, then this is fraught.
- International prices could be adjusted in some way to predict the situation in Australia. So prices for high speed broadband equivalents in Japan, S Korea or USA could be adjusted. This is not straightforward – pricing may be opaque, user experience may differ and it is not clear in what ways other countries value placed on broadband may differ from Australia's.
- Prices for substitutes could be examined. There appears to be relatively few direct substitutes for broadband in general – though there may be prices for substitutes for particular broadband applications.

Adjusting these market prices in various ways to account for differences between their derivation and the prices that may exist under an NBN could give a prediction for prices under the NBN. This is not uncommon in cost benefit analyses. However direct revealed behaviour information on WTP via market prices and current consumer choice is generally more directly applicable to private CBA and the commercial case for broadband investment. So while this kind of revealed information is potentially useful for social CBA, it forms a lower bound when considering social welfare. We will not pursue direct revealed behaviour information via market prices in great detail. Instead we focus more on methods with advantages for valuing non-marketed items – in particular the stated preference techniques of contingent valuation and choice experiments.

6. In the literature on valuing non-marketed benefits the term "benefit transfer" is used to refer to estimating values for environmental or social trade-offs by transferring values in some way from existing valuation studies to a target study of interest.[8] A similar but more general concept is the idea of taking a benchmark valuation in one area and applying it in some way to another area. We will also use the more general term benchmark adjustment in the remainder of the report.

Benchmark adjustment takes estimates from other studies and adjusts them to make them more applicable to the study at hand. Understandably this is a widespread practice as it is potentially significantly cheaper than developing estimates from scratch. However it is difficult to assess the usefulness of these adjustments, except on a case-by-case basis. The potential for double counting, any weaknesses of the original studies and the difficult task of justifying the adjustments made are some of the elements that make this approach harder than it first looks. A later section looks at some reports valuing broadband benefits and describes some of the benchmark adjustment approaches used there.

7. The other revealed preference techniques mentioned are random utility / discrete choice models, the travel cost method and averting behaviour. Random utility / discrete choice models refer to models of consumers making actual choices. They are likely to be less useful here where the NBN does not yet exist, as actual choices made only face the current availability levels of broadband. The travel cost method is a method generally focused on the valuation of attributes of outdoor recreation sites via the trips taken to the sites. The averting behaviour approach considers what costs people incur to avoid a detriment and uses that as a proxy for their WTP for a similar health benefit. This approach is particularly aimed at health and safety situations. It could plausibly be part of the underlying valuation of some health benefits from higher speed broadband. These other revealed preference techniques are not developed further.

[8] The term "benefit transfer" does not appear to be commonly used outside of the environmental/social arena.

3.2.3 Counterfactual – choice of baseline

For CBA purposes an analyst needs to measure incremental benefits versus a baseline. Preferably this is against a counterfactual – what would have happened in the absence of the project ('with or without'). However a baseline of "do nothing, change nothing" is sometimes used due to difficulties in establishing a counterfactual. No matter what counterfactual or baseline is chosen, it is critical for CBA to determine the incremental costs/benefits of the project versus the baseline and to interpret findings considering the baseline chosen.

Under both a project scenario and a counterfactual scenario it may be necessary to consider developments in international cabling links and in mobile wireless offerings. The persistence or otherwise of international cabling bottlenecks has implications for download and upload speeds to overseas countries. This forms part of the development of the scenarios under both the project case and the counterfactual. The development of mobile wireless broadband offerings should be considered for any potential to act as a substitute for fixed line broadband.

3.2.4 Costs of complementary investments

Social cost benefit analysis can potentially include a wide range of benefits. In fact determining the scope of analysis, the scope of the project, is critical to the step of determining the relevant costs and benefits. The key is that if an analyst includes the benefits from an allied project or program then the costs of that project or program need to be included too. This is particularly the case for an enabling technology like the NBN, where the network is an enabler of other applications and uses. While an NBN can accelerate the development of e-health, e-education, e-government, e-business, on-demand entertainment and videoconferencing it is not the only investment required to realise these benefits. Other complementary investments are likely to be required for the realisation of much of the benefits.

This need for complementary investments to realise some of the benefits is critical when it comes to assessing the cost of obtaining the benefits. Strictly the inclusion of an incremental benefit in a CBA requires an inclusion in the CBA of the incremental costs to achieve that benefit. This greatly increases the challenge of doing a full social CBA. While it is "easy" to highlight potential benefits say in e-health or e-education, identifying the steps needed to implement the programs, and their associated costs and benefits, is not straightforward. It is however an essential step for any social CBA that seeks to include those benefits, to develop these plans to a sufficient state as to allow some reasonable prediction of the associated costs and benefits. It is also part of the thinking that can help government plan to ensure the maximisation of the benefits, via complementary projects and programs.

4 Classifying benefits

4.1 Framework

A key challenge in any CBA is thinking about how to distinguish different kinds of costs and benefits. This is particularly so for a technology like broadband that has the potential to have wide ranging effects. A framework for thinking about and classifying potential costs and benefits can help to keep the project scope in mind, avoid double counting, and assist in considering the complementary investments needed to maximise the benefits.

The following is a potential framework, adapted from one by Plum Consulting (2008), for considering benefits and costs:

1. Private to consumers – costs and benefits that are valued by individual consumers from their own use of broadband and are likely to be able to be expressed in money terms.
2. Private to business – costs and benefits that are valued by businesses and are likely to be able to be expressed in money terms.
3. "Private" to government (public services) - costs and benefits to government that are valued by government as agents for the population. Many can be expressed in money terms, and governments have made strides in addressing how they would value some benefits that would not normally be monetised e.g. health outcomes.
4. Wider economic – a range of economic externalities, some of which may be able to expressed in money terms but most of which are difficult to do so.
5. Wider social– a range of social externalities, most of which are extremely difficult to assess in money terms.
6. Excluded from CBA – changes in GDP, productivity.

The items in (6), while they may be interesting, are not normally the focus of a social CBA focused on social welfare. It would be easy for GDP or productivity effects to be double counted with private benefits. Computable General Equilibrium (CGE) models aim to estimate economic impacts such as the value of output produced and employment. They tend to measure the change in value of gross output. The additional output typically requires additional inputs of other resources such as land, labour and capital and typically does not directly consider non-marketed benefits or environmental impacts. Without considerable adjustment GDP is more a measure of activity than a measure of welfare.

The distinction between (4) and (5) is not always clear. In effect items in (5) are ones where people almost never try to express the value in quantitative terms and instead rely on qualitative descriptions. There is nothing to stop these qualitative factors being part of a CBA – their inclusion can be important as factors to consider in decisions following a CBA. For example (5) might include such items as a more informed democracy and greater social inclusion. These items are difficult to quantify let alone monetise. In contrast the items in (4) frequently can be quantified, but not necessarily easily monetised. Items in (4) could include externalities such as reduced congestion, and reduced pollution. It could also include other intangibles such as human life, time and environmental amenity where converting costs and benefits into dollar equivalents can be a difficult problem. Variants of concepts developed in this report of WTP, revealed preference and stated preference methodologies can be applied to these intangible benefits.

The concept of "private" to government costs and benefits (3) primarily refers to the purchase of public services by government. We argue that these costs and benefits are unlikely to be considered by consumers or business in their valuation of private benefits, in their own willingness to pay. Still they are potentially quite important and are private in the sense that government agencies can capture them and return them in the form of lower cost or improved quality of service provision. In the NBN case the private to government analysis consists mainly of programs where the NBN is a potential enabler e.g. e-education, e-health, e-government.

Private to business costs and benefits (2) have not been emphasised as much in the debate over the NBN. This is partly because most large businesses already have fibre for their own use. While they will benefit somewhat from upgrades to core parts of the network, it is not clear how much their own direct use of broadband would differ under the NBN versus the counterfactual. Small and medium sized businesses may benefit from some reduced costs of doing business via increased broadband availability. Business may benefit via a reduction in their opportunity cost of providing goods and services. Any such reduction in costs can be included in a social CBA, though care may be needed to avoid potential double counting and to ensure only incremental changes are included. In the NBN context a social CBA would also consider the reduced costs flowing from the retirement of the copper and cable network, though precise information on the impact on the private sector here may be difficult to obtain.

A key consideration in assessing costs and benefits that are private to consumers (1) is that there are different benefits in going from no broadband to basic broadband or fast broadband versus going from basic broadband or fast broadband to very fast broadband. It may be that the readily identifiable incremental benefits per consumer might be expected to be higher for those going to basic broadband, if only because many of the benefits of basic broadband have been demonstrated by those who already have it in the metropolitan areas. Having said that the number of consumers moving to basic broadband will be smaller than the numbers moving to very fast broadband, so it is not clear which group of consumers would be expected to contribute most to the overall private benefit of the NBN.

While we primarily focus on the valuing of benefits in this report, it is useful to emphasise that both costs and benefits need to be considered within the framework.

4.2 Benefits not classified

4.2.1 Equity

One potential benefit that is difficult to classify (and value) is reducing inequity. The NBN is designed to directly increase the access to broadband across the country and has equal wholesale pricing as a core feature. The NBN may later contribute to reduced inequity in Australian society more broadly. How much either of these potential benefits is worth is essentially a political question and we do not include it further in this report.

4.2.2 Ubiquity

Some benefits come from network or access ubiquity – some benefits are much more powerful if businesses and government can assume that there are minimum levels of data and connectivity for everyone. Take the case of government moving to provide some types of information and services almost exclusively via the internet. Any cost savings associated with this will be greater the more people can be assumed to have access. Similarly the potential consumer market for certain business opportunities such as in cloud computing and video on demand will depend heavily on more widespread household access to minimum broadband speeds. Once companies, governments, universities and so on can assume that most people can use high definition audio and video, exchange large files, etc , then each of these providers can build services that make use of these capacities.

This particularly points to new applications becoming more likely upon hitting sufficiently high access levels. The emergence of applications such as MySpace, Facebook and YouTube was dependent on the first wave of broadband reaching thresholds of download speeds and always on connectivity that allowed these platforms to take off. With sufficient numbers of households having access to very fast broadband, novel and currently unknown or unanticipated services and uses of the broadband network may become possible. Having said that, doing what we do now, only faster, will remain a key source of value for broadband in the short run.

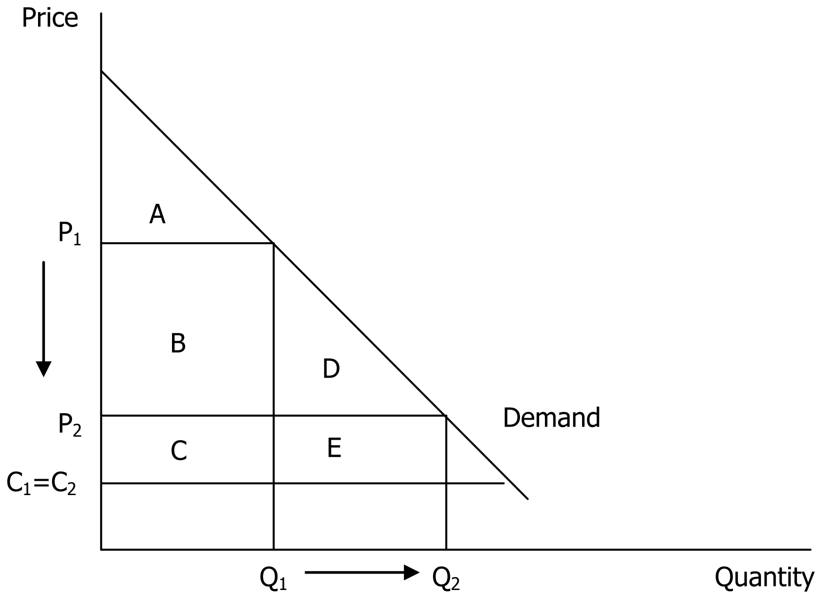
4.2.3 Competition

One potential benefit of the NBN as proposed is for it to increase competition levels in the telecommunications industry. A social cost benefit analysis could look at the effect of changes in competition, positive or negative, and any consequent effect on social welfare. A full development of the impact of the NBN on competition is beyond the scope of this document. Figure 3 is a simplified example to illustrate how a change in competition, in this example an increase in competition, could affect welfare. It only focuses on changes in welfare due to the assumed increase in competition. It assumes that a project leads to a change in competition, and that change in competition leads to a drop in prices and in increase in quantity consumed. In the figure we move from a situation with price P_1 and quantity Q_1 to a situation with price P_2 and quantity Q_2. So the effect is to move from a total social welfare of A

+ B + C to a total social welfare of A + B + C + D + E. The area A is the previous consumer surplus to the previous consumers. The area B is the incremental benefit to the previous consumers. The area D is the consumer surplus to new consumers.

The social welfare effects of any change in competition could be considered as part of a social cost benefit analysis. Ensuring any such effects are not in any way double counted is a major challenge for an analyst.

Figure 3 Simplified illustration of increased competition



5 What are some benefits of broadband?

This section describes some of the benefits of higher speed broadband. It generally focuses on the touted benefits of very fast broadband. A full social cost benefit analysis would need to look at the incremental benefits with respect to a specific selected counterfactual, considering households moving from no/basic broadband to fast broadband and households moving from fast broadband to very fast broadband. We have not developed such a counterfactual and so the discussion is more general.

This set of potential benefits focuses on benefits that are most immediate or appear to be most commonly considered. Why the general focus on more immediate benefits? For a large infrastructure project, benefits may well flow from the project over a very long timeframe. However as benefits become more speculative an analyst would face greater difficulties establishing the kind of benefits, the scale of the benefits and the likelihood of the benefits eventuating. Due to the time value of money benefits that are much further out in time would need to be much larger to have the same importance to a social cost benefit analysis as benefits that occur relatively sooner. So, other things being equal, an analyst would be likely to focus more on benefits that occur relatively earlier in the project's life.

5.1 Home entertainment and communication

In the home the availability of high speed, high bandwidth and high download limit broadband is likely to be a powerful enabler of home entertainment and other home based services in the shorter term. In a longer timeframe there is potential for high speed broadband to contribute to applications in home security, utility monitoring and control and home automation.

In the shorter term the dominant incremental advantage of very fast broadband over basic broadband in the home is likely to be video and its applications to entertainment and communication. Some video features are possible under basic or fast broadband, however high definition video, multiple concurrent instances of video and video on demand accessing a library of titles are more plausible with very fast broadband.

The so-called triple play of a bundle of voice, data and video is offered in many countries by both telecommunications and cable companies (OECD, 2006). The video component can take the form of Internet Protocol Television (IPTV), based on underlying ADSL or fibre. High definition video, including video on demand is more generally associated with fibre.

These have the potential to offer benefits over existing applications. Video on demand has the potential to replace other forms of video rental, with potential advantages in flexibility, availability and the cost of provision. For example NetFlix now delivers some films via the internet where bandwidth allows, rather than exclusively via mail. Videoconferencing advances increase the attractiveness of using this option for communication and interaction over the alternative of long distance travel. Distance education can reduce the need to travel to class, or even provide opportunities for postgraduate students to pursue courses or research more remotely.

Online photo and video sharing has the potential to benefit from very fast broadband. Sharing of photos and videos via YouTube, Picasa and Facebook is increasingly popular. Faster upload speeds permit faster sharing of higher and higher definition photos and videos. It is not clear how much current video and photo uploading for sharing is constrained by upload speed limits. It does appear that there is likely to be further demand for faster uploading and faster downloading due to preferences for higher and higher definition images. At the same time improved compression technologies are tending to reduce the upload speed, download speed and storage capacity requirements for images, at some cost to image quality. It is not clear how the interplay between compression technology improvements and consumer demand for still clearer images will be resolved.

Personal consumer electronics advances may further increase demand for uploading, downloading and storing data intensive images. For example the advent of HD TV and 3D HDTV appear to be precursors to the development of consumer level video recorders capable of producing recordings that can take advantage of these TV features. Very fast broadband may facilitate the online sharing and storage of such recordings. At the more extreme end any eventual moves towards technology based on 3D holographic TV images or beyond would doubtless be even more data intensive. The downloading, uploading and storage of such files via the Internet would also presumably be advantaged by faster broadband.

We have not been able to find definitive information on the incremental advantages of very fast broadband for internet gaming. At the very least peer to peer games would appear to benefit from higher upload speeds.

5.2 E-health

The NBN should extend the potential applicability of e-health. Large hospitals may well be currently well served by broadband. However under the NBN smaller hospitals and medical centres, individual doctors and private houses are likely to benefit from improvements to download speeds, reliability and upload speeds. These improvements should allow an extension of the scope of e-health.

Figure 4 gives a range of possible e-health applications, reported as part of the national e-health strategy by the Australian Health Ministers' Conference (2008). For a social CBA careful analysis would be needed to determine the benefits and costs of these and the extent to which they are dependent on the NBN or not. For example it may be that individual electronic health records is not particularly reliant on consumer level broadband, while being heavily reliant on hospital, GP and clinic broadband. In any event the benefits of this particular e-health initiative appear highly contingent on overcoming a range of regulatory, administrative and privacy issues.

Figure 4 Selection of possible e-health applications

National E-Health Strategy Summary

E-Health Solution Category	Priority Solutions	Description
Electronic Information Sharing	• Referrals • Event summaries including discharge summaries, specialist reports and notifications • Prescriptions • Test orders and test results • Care plans	Improving the capability of patient, clinical and practice management systems to support key electronic information flows between care providers. These key information flows provide a basis for improved care planning, coordination and decision making at the point of care.
	• Consumer demographics • Current health profile • Current medications list	The key datasets that provide the summary of a consumer's key health data and their current state of health, treatments and medications. These datasets will improve the quality of service delivery and will ensure that consumers do not have to remember or repeat this information as they navigate the health system.
Service Delivery Tools	• Decision support for medication management • Decision support for test ordering	Encouraging the development of specific tools that improve the quality of clinical decision making and can reduce adverse events and duplicated treatment activities.
	• Chronic disease management solutions. • Telehealth and electronic consultation support	Encouraging development of specific tools that improve the management of chronic disease and the accessibility of care delivery. Chronic disease management solutions enable timely identification and monitoring of individuals and support management of their condition by providing automated reminders and follow-ups. Telehealth and electronic consultation tools enable improved rural, remote and disadvantaged community access to health care services.
Information Sources	• Health care reporting and research datasets • Health information knowledge bases	Implementing improved datasets for health care management that provide access to longitudinal and aggregated information for analysis, reporting, research and decision making. Providing access to a set of nationally coordinated and validated health knowledge sources for consumers and care providers.
	• Individual electronic health records (IEHRs)	Implementing IEHRs that provide consumers with access to their own consolidated health information and provide care providers with a means to improve the coordination of care between multi-disciplinary teams. IEHRs can also support the collection and reporting of aggregated health information.

Source: Australian Health Ministers' Conference, 2008, page 12.

A particular potentially significant benefit that does not specifically appear on this list is in home monitoring of patients or the elderly. This is an application of e-health that appears directly dependent on residential access to better broadband.

Two further possible benefits in the health arena are the provision of health information to the public (patients and potential patients) and training and support of health professionals, particularly in remote areas. Careful assessment is needed to ascertain the incremental benefits in these areas, if any, of very fast broadband. Figure 5 outlines an example of one US medical organisation's use of faster broadband.

Figure 5 Kaiser Permanente use of videoconferencing

In the United States, Kaiser Permanente has experimented with using technology and videoconferencing to run 'microclinics'. From Wired Magazine 'The good enuf revlutn' 24 August 2009:

In the case of health care, the Good Enough mindset can be seen in a new initiative by Kaiser Permanente. The largest not-for-profit medical organization in the country, Kaiser has long relied on a simple strategy of building complete, self-sustaining hospitals—employing 50 doctors or more—in each region it serves. "It's an efficient model," says Michele Flanagin, Kaiser's vice president of delivery systems strategy. "It offers one-stop shopping: pharmacy and radiology and everything you want from health care in one building." But that approach forces patients who don't live near a hospital to drive a long way for even the most routine doctor's appointment.

As it happens, though, Kaiser has become one of the most technologically advanced health care providers in the country, digitizing everything from patient records and doctors' notes to lab data and prescriptions and putting it all online. The system is networked, so patients can email their doctor, check lab results, and make appointments from their PC or mobile Web device. Getting a referral doesn't mean carrying medical records from one doctor to another, as it does at many hospitals.

In 2007, Flanagin and her colleagues wondered what would happen if, instead of building a hospital in a new area, Kaiser just leased space in a strip mall, set up a high tech office, and hired two doctors to staff it. Thanks to the digitization of records, patients could go to this "microclinic" for most of their needs and seamlessly transition to a hospital farther away when necessary. So Flanagin and her team began a series of trials to see what such an office could do. They cut everything they could out of the clinics: no pharmacy, no radiology. They even explored cutting the receptionist in favor of an ATM-like kiosk where patients would check in with their Kaiser card.

What they found is that the system performed very well. Two doctors working out of a microclinic could meet 80 percent of a typical patient's needs. With a hi-def video conferencing add-on, members could even link to a nearby hospital for a quick consult with a specialist. Patients would still need to travel to a full-size facility for major trauma, surgery, or access to expensive diagnostic equipment, but those are situations that arise infrequently.

If that 80 percent number rings a bell, it's because of the famous Pareto principle, also known as the 80/20 rule. And it happens to be a recurring theme in Good Enough products. You can think of it this way: 20 percent of the effort, features, or investment often delivers 80 percent of the value to consumers. That means you can drastically simplify a product or service in order to make it more accessible and still keep 80 percent of what users want—making it Good Enough—which is exactly what Kaiser did.

Flanagin believes these clinics will enable Kaiser to add thousands of new members. And they'll do it for less. The per-member cost at a microclinic is roughly half that of a full Kaiser hospital. The first microclinic is set to open in Hawaii early next year. Medical care is now poised for its own manifestation of the MP3 effect.

Source: Capps (2009).

5.3 E-education

A selection of possible benefits of e-education includes:

- Enhanced remote education services.
- Possibility for clusters of small secondary schools to offer subjects on a shared basis, something they might not be able to do individually, but possible if delivered over high speed broadband.
- Online real time lectures or classes.
- Placement of a range of materials on the Internet, including notes and audio or visual learning aids.
- Increased flexibility and increased access to learning by reducing time and location constraints on receiving learning.

Improved broadband at schools will generally benefit most of these. Multiple student access to broadband in class can make heavy demands on the broadband service.

Improved broadband at the residential level is likely to have direct benefits for uses that are synchronous with in class activities. For example, residential level broadband will likely have an effect on the quality of experience for students participating in real time interactive learning from outside the classroom. With asynchronous uses such as downloading and using classroom materials, faster broadband may have less impact, though advantages in download times may still be welcome.

5.4 E-government

The government already provides citizens with some e-government services and, as with education, the establishment of a fibre-based broadband network may see the government improve and broaden the range of web services for which it is responsible. But governments face an issue with maintaining access to government services for all citizens, so the realisation of some of the cost savings possible may be difficult. Some options include:

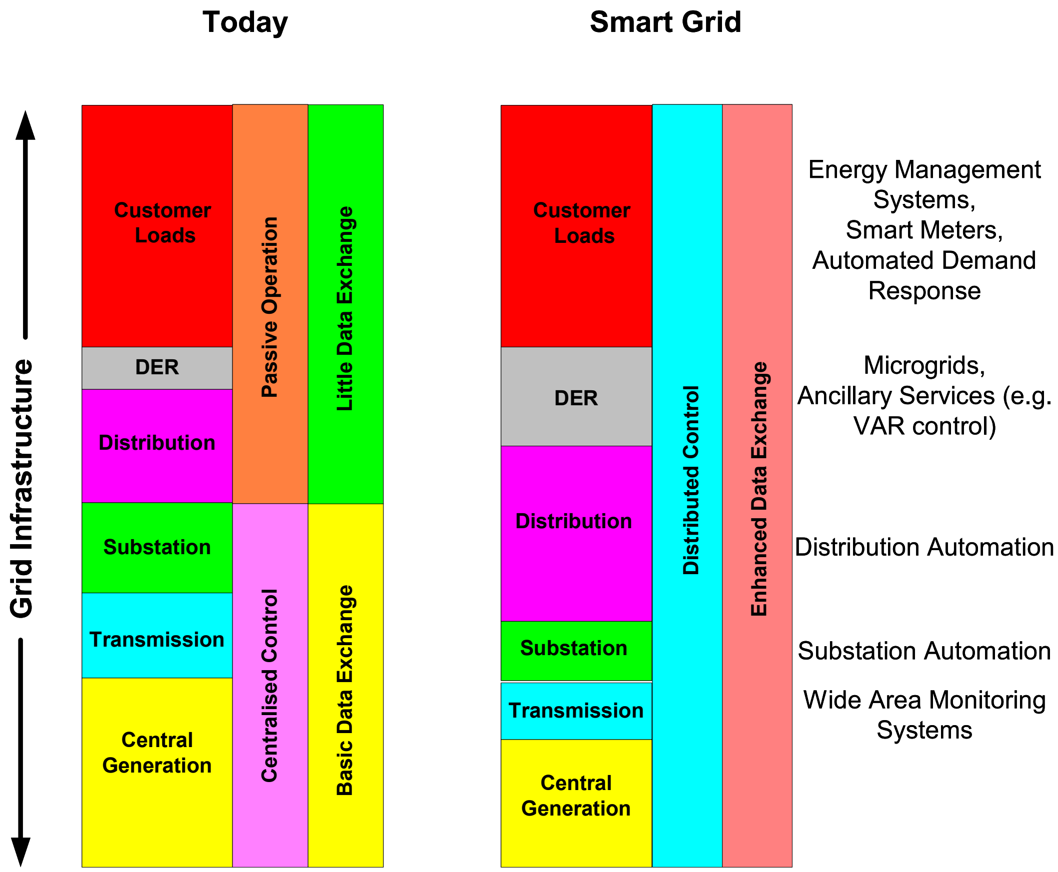
- Switching from check mail outs to electronic payments e.g. Centerlink mail outs. A key question here is whether or not it would be appropriate to compel people to go electronic. Any decision to encourage electronic payments here may need complementary investment of internet kiosks, training etc.
- Information and resource provision for citizens may be able to be increasingly provided online.
- Transactions between government and citizens such as income tax preparation and return, applying for licences and paying for tickets may all be increasingly done via the internet.
- Government use of electronic procurement systems when dealing with businesses is enhanced by broadband. The exchange of specifications, data and images may be more cost effective under faster broadband.

The first three points are all government citizen interactions. Generally the bandwidth needed for these applications is low, so faster residential broadband may not be critical here. However government may still benefit from more widespread broadband increasing the take up of these applications. Even if the government needs to continue providing these services offline to some citizens, the offline demand may decrease with greater residential broadband availability.

5.5 *Smart grids*

Balancing electricity supply, demand and transmission capability is challenging. Traditionally household demand has taken as much power as is needed from the grid with relatively little individual communication with the grid. The concept of smart grids is essentially about digital control of the electricity delivery network using 2 way communications between customers and the delivery network and between generators and the delivery network. Figure 6 is from Ngan (2008) and gives a stylised vision of the move to smart grids.

Figure 6 Changes anticipated under Smart Grids



Source: Ngan (2008).

The smart grid innovation is partly driven by the collection of information about customer loads and distributed energy resources (DER) via smart meters. Information can also be collected from other digital equipment e.g. devices on power lines. This information allows a greater degree of distribution automation, using smart sensors and automatic switching to control the routing of distribution in order to reduce outages and increase service reliability. At a more prosaic level, a smart grid system would likely enable remote meter reading and remote service connection and disconnection, along with improved information for consumers about their power use.

These smart grid applications do not appear to require particularly fast consumer level broadband speeds. What they do appear to depend on is for as many households as possible to have reliable network access and potentially for fast broadband availability at the distribution and substation automation hubs.

5.6 Transport

Closed circuit TV cameras currently provide information on traffic flows in Australia's major cities. The information they provide is potentially useful for trip planning and avoiding congestion and accident locations en route. Faster broadband could enhance these benefits in two ways. One possible improvement is any improvement in household and business trip planning and congestion avoidance from receiving the traffic information in more detail or more frequently. For example a movement from still images to video or a movement from hourly updates to minute by minute updates to second by second updates could all give incremental improvements in transport management. A second possibility is systems for centralised traffic monitoring and management by roads authorities benefiting from backhaul and other fixed line improvements.

5.7 Teleworking

Faster broadband has the potential to increase teleworking and the benefits that flow from it. Improvements to the capacity to use videoconferencing in the home and to transfer large files back and forth between the home office and the work office are the key areas where higher speed broadband supports telecommuting. Access to superior broadband is not the only constraint on increased teleworking, however it appears likely that enhanced broadband would likely enable an increase in teleworking.

Some of the benefits from increased teleworking are essentially private in nature and accrue to the teleworker. Examples include reduced travel time, reduced stress, and reduced travel costs such as parking, petrol and fares. Arguably these potential benefits would be captured in the estimation of household WTP.

Other benefits from teleworking are externalities such as reduced congestion and reduced environmental impacts flowing from reduced travel. These impacts are not as likely to be captured in household WTP for broadband and require separate estimation for social cost benefit analysis purposes.

There are also potential benefits to employers. Teleworking could lead to reduced costs for business in terms of real estate and office requirements. The potential for teleworking may decrease recruitment and retention costs for employers able to offer a wider range of flexible work options. Workers may also simply produce more under various teleworking arrangements, a potential benefit to employers. This could be due to any reduction in absenteeism or simply due to some people working more productively under these arrangements. More generally setting up for telework may reduce work hours lost when employers face strikes, emergencies or other disruptions to business office work.

5.8 Cloud computing

In different incarnations cloud computing has been a regularly recurring idea in software and storage. Cloud computing is an Internet based technology which stores information in servers and provides that information as an on demand service.

Cloud computing has potentially high impacts. Under cloud computing consumers can access all of their documents and data from any device with internet access such as a home or work PC or a mobile phone or other mobile internet enabled device. While this kind of access has become relatively commonplace for applications such as email and social networking sites, the ability to access all one’s documents and data is likely to increasingly need the capacity provided by high speed broadband networks.

Business may also take advantage of the option to procure cloud computing as a service, paying on demand for storage and potentially for computing power in the form of hardware and software. Aside from potential benefits in terms of security and service provision it has the potential to improve efficiency. This is particularly the case where specialised service provision is more efficient than firms going it alone.

Some of these benefits would likely overlap with benefits in e-health, e-education and e-government. Any cost benefit analysis would need to take care to avoid double counting benefits here. For example savings attributable to having healthcare information available in more remote areas could be classified as a benefit from cloud computing or e-health initiatives, but should not be double counted.

The nature of cloud computing means that it is likely to be difficult to accurately assemble its potential benefits under this heading. It appears likely that forcing the identification of more specific benefits (and the allied costs necessary to achieve such benefits) and analysing those benefits as resulting from individual projects is more likely to produce more robust estimates of the value of the benefits.

A further difficulty in the estimation of the value of benefits from cloud computing is that there are probable network effects in many areas of the provision of cloud computing services. Here network effects refers to the phenomenon where a consumer's use of a particular cloud computing service is more valuable to them the more other consumers use the same particular cloud computing service. For example, developing skills with Google's online word processing and spreadsheet applications requires some effort. However once that initial effort is made, the benefits from that effort increase as the network of users of Google's online applications increase.

A further difficult to quantify benefit from cloud computing is the probable decrease in the fixed costs of entry into business. This probable benefit assumes that the rental – "on-demand" - model of cloud computing provision of IT services allows a smaller outlay for required IT services for small and medium sized businesses versus internal provision of those same services. In particular one off or lumpy IT infrastructure expenditures are likely to be replaced by more scalable purchases from a cloud computing service supplier, where that supplier can more efficiently provide those services by aggregating demand.[9]

Small businesses and home based businesses may particularly wish to take advantage of business support and data storage bundled with their high speed broadband. Such hosted services may feature pay as you use models, whereby the service provider effectively aggregates demand from a variety of end users, spreading the fixed costs across many users.

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[9] This is more likely where demands are sufficiently uncorrelated for there to be efficiency benefits from aggregating demand this way.

6 Valuing broadband benefits – selected reports

A large number of reports touching on the valuation of broadband appear in the public domain.[10] Selected reports valuing aspects of the benefits of broadband have been reviewed, primarily to illustrate some of the approaches and issues in valuing broadband benefits. See Figure 7. They are categorised as:

1 Partial CBAs, some of which use a WTP approach and some also analyse particular sectoral benefits. The McKinsey-KPMG (2010) implementation study is included here, despite explicitly not being a cost –benefit analysis, because the type of information it contains is most closely associated with a private cost benefit analysis.

2 Sectoral approaches, usually looking at a subset of broadband benefits in a particular application.

3 Studies of macroeconomic impacts generally focused on assessments of nationwide impacts on economic activity.

Figure 7 Selected studies valuing broadband benefits

Study	Type	Notes
McKinsey-KPMG (2010)	Partial CBA	Explicitly not a social CBA. Has some elements of a private CBA
Plum Consulting (2008)	Partial CBA	Range of benefits considered, some valued, some not. Puts some value on more cost savings than most studies.
Columbia Telecommunications Corporation (2009)	Partial CBA	Seattle FTTP option.
PriceWaterhouseCoopers (2004)	Partial CBA	CBA for Europe, some benefits valued as gross rather than incremental to narrowband.
Ergas & Robson (2009)	Partial CBA	Appears to combine all benefits in a single median consumer WTP estimation. Hard to assess contribution of individual sources of benefit.

[10] Budde (2010) claims a list of more than 100 global cost/benefit studies was compiled by the International Telecommunication Union (ITU) for the report "Broadband: A platform for progress".

Study	Type	Notes
Allen Consulting Group & Dandolo Partners (2006)	Partial CBA	Potential double count of innovation and growth benefits in productivity measure. Relies on 2001 report on total benefits of high speed broadband. Consumer surplus calculation highly dependent on assumptions about demand.
Access Economics (2010a) (telehealth)	Sectoral	Performs preliminary benefit transfer from 2 US studies. Unclear what broadband levels required to obtain various benefits.
Access Economics (2010b) (teleworking)	Sectoral	Baseline comparison is with no current teleworking.
AT Kearney (2009) (digital inclusion)	Sectoral	Based on pilot scale program targeting disadvantaged areas.
Access Economics (2009a)	Macro impact	Based on FTTN option. Benefits expressed in terms of GDP and NPV of GDP.
Access Economics (2009b)	Macro impact	Based on FTTN option. Benefits expressed in terms of GDP and NVP of GDP.

McKinsey-KPMG (2010)

The McKinsey-KPMG (2010) implementation study is a massive source of information on the NBN. It explicitly does not perform a cost benefit analysis, private or social. Still we include it in the category of CBAs as some of the information it provides is indicative of assumptions about demand. In particular the study provides estimates of future subscriber numbers and prices (page 123) and some sensitivity analysis of the same (page 267). While not perfectly informative for a social CBA, these numbers could provide a starting point for an analyst exploring likely sources of incremental value. The indicative revenue split (page 123), for example, indicates that the consumer segment is the largest revenue source. Given it is also the segment that will have the greatest qualitative change in broadband availability by going to fibre, indicates that this is likely to be a priority segment for an analyst seeking to identify incremental benefits.

The study does not generally seek to put a value on the benefits of broadband, even where it specifically mentions broadband as a potential enabler of policy goals in e-education, e-health, smart infrastructure and government processes (page 167). While recognising that the broader economy may benefit from broadband-based innovation it does not assume that NBNCo would capture a share of any of these benefits in its revenue streams, nor does it assume any extra revenue due to new services or applications (page 356). In this sense its figures are probably appropriately conservative even from a private CBA point of view. Being prices they are also conservative from the point of view of being estimates of WTP.

The demand estimates presented may also have an element of conservatism as the take-up rates and prices are based on a unilateral build – that is they do not include effects from any final agreements with Telstra (or other telcos) on duct access and customer migration.

The information provided is generally more directly useful to a private CBA than a social CBA. However there is a tension here given that the study acknowledges that the NBN is designed to meet objectives that are not purely commercial, such as meeting a coverage target, providing a more desired competition structure and feeding through to benefits in health and education (page 371). Ultimately the study does not fully develop the arguments or valuations that might support these objectives as being worthwhile. If these are necessary aims of the project then they would imply that a social CBA could be restricted to considering options that can deliver these benefits.

Plum Consulting (2008)

This UK report first considers some revealed behaviour information about broadband benefits. While more directly useful for private CBA they note that revealed information on WTP can form a lower bound on WTP for private benefits. For consumers they go on to consider current ADSL and cable plans in the UK and proposed access pricing for some next generation broadband investments. They also consider US pricing of next generation broadband while downplaying the relevance of information from Japan and Korea since consumers there are said to not necessarily pay any premium for higher speed (page 54).

They then go on to consider the valuation of a range of benefits directly in the context of the UK moving to next generation broadband. Although they discuss a counterfactual it appears that the analysis of the benefits of next generation broadband is not generally in fact incremental relative to the counterfactual. This is no doubt partly due to the difficulty in assessing incremental benefits, and is a likely key difficulty facing any analyst pursuing a social CBA of such a wide ranging development. On a more optimistic note, at least some of the benefits are contingent on symmetric high speeds i.e. uploading, and these are benefits that would be less likely to be achieved under both the UK counterfactual and any likely Australian counterfactual – they are likely true incremental broadband benefits.

The benefits that are quantified include:

- Saving time online: They use estimates of time online, assume a 3% decrease due to next generation broadband, assume 80% network coverage and 50% of those get the decrease, and an opportunity cost of leisure time based on a previous transport study. It is unclear if the building blocks of information for this method are available in Australia. The authors highlight that 3% time saving is merely an assumption.
- Online backups: The potential for online backups is enhanced by faster broadband. They estimate the benefit of this by assuming that the WTP for the kind of fast, reliable and secure online backup available under higher broadband upload speeds is approximately the same as what people pay for virus protection (50£ per year). The cost per PC is assumed to be around 30 £ per year, giving a surplus of 20£ per PC per year.[11] They apply this to an assumed 50% penetration of households connected to next generation broadband. This is an example of using market pricing in an allied market to estimate benefits here.
- Business demand for fibre links – The exact baselines and assumptions are a little unclear here. However the basic method appears to use existing price points for point to point and GPON symmetric lines of various speeds as a baseline. They then assume a tripling of future demand all at around a future price equivalent to today's price for the fastest mentioned current GPON

[11] It is a little unclear what assumptions have been made about the number of PCs per household.

service.[12] In combination with elasticity assumptions a change in surplus is calculated. The authors note that this has the potential to overlap with other benefit values for specific applications in the paper.

- Video distribution- they assume the combined market for DVD retail and DVD rentals will have a cost saving of 25% by moving to downloads, with it taking some time to build up. They do not place any monetary value on any increased choice in the video market as a result of a shift to downloading, though they mention estimates of similar benefits from online book retailing.
- Time savings from reduced business flights – analysis uses time savings based on total air travel hours, 12% of which is business and then 10% of that which is avoided by the use of high definition videoconferencing. The 10% is less than an Australian study for Telstra that they mention assumed one third of business travel could be saved (Climate Risk, 2007). They assume each flight involves a loss of 3 hours of productive time and value that time at an estimate extrapolated from a UK Department of Transport estimate for working time value at 2002 values and prices. They also assume that the costs of videoconferencing and air travel plus accommodation are equal. In the increasingly connected world of today it is not clear how much productive time is lost from air travel. While all the numbers used are assumptions in a sense, this one is perhaps pivotal.
- SMEs moving to central server provision – based on 30% of small enterprise staff using IT, and avoiding IT support costs of 350 £ per person per annum by moving to central server provision, email, calendar and back-up.[13]
- "Spectrum efficiency"- a wider economic benefit attributed to "the substitution of local within building transmitters and next generation broadband connections for higher cost spectrum and base stations ... and/or the substitution of fibre carriage for terrestrial broadcasting with an accompanying release of UHF spectrum". The value of gains is estimated at a potential of 9B £, the entire current value of the spectrum. It is noted that the future value of

[12] Whether the tripling of demand is of GPON alone, or point to point and GPON combined is unclear.

[13] The derivation of the 350£ figure is uncertain. A footnote in the report says annualised server costs saved would be 100£ per person per annum and 50% of IT support costs of 600£ per person per annum. This implies 400£ per person per annum. We cannot explain the difference.

this is uncertain and in any event it would not be realised before the medium to long term.

A range of other costs and benefits are considered but not valued in money terms.

Columbia Telecommunications Corporation (2009)

The subtitle to this report is ‘Quantifying the business case for Fiber-to-the-Premises in Seattle’. Despite this subtitle the bulk of this report is not concerned with the business case, or private CBA, associated with a potential Seattle FTTP network. It is actually an attempt at valuing a number of benefits flowing to Seattle stakeholders, both to the City of Seattle (as investor) and to the people of Seattle, if the City were to build a fibre to the neighbourhood network and a private provider(s) built the ‘last mile’ to make a fibre to the premises network. In this sense it is not a real CBA – in most cases the capital costs required to achieve the benefits are not discussed, either for the City of Seattle FTTN, the further provision of FTTP or the complementary investments needed to achieve the benefits.

As well as benefits given an explicit value, a number of other benefits are discussed and indicative values estimated without them being included in the final tally of savings. Two direct benefits are measured. The first, revenue, is based on an assumed connection fee of $6 per month ‘per service per customer’ and market shares based on a prior survey. This is the revenue to the owner of the fibre to the neighbourhood network, the investor in this case. The second direct benefit claimed is a reduction in carbon emissions. These are not converted in to monetary terms.

What they term indirect benefits are put into three categories:

1. Cost avoidance by the city e.g. reduction in leased communications services. These estimates appear to be based on interviews with various city departments and to be contingent on many small programs e.g. transferring data services on to the FTTN, reduced payouts for damages due to storm water flooding via improved system control and monitoring. It would appear that many of these small programs would require some expenditure for the benefits to be realised e.g. replacing 12 meter readers with automatic meter reading talks about the cost savings without appearing to consider the costs of the meter reading equipment. Despite the number of areas mentioned no obvious areas of double counting appear here.

2. Monetary savings to stakeholders: This is made up of a number of individual benefits:

Increased teleworking is estimated to have a high value. This is based on a probably optimistic take up assumption based on a survey response where 57% of people said they 'would be willing telecommute at least one day per week if connection speed were not an issue'. Depending on the wording of the survey this would suggest that 57% is a maximum level of interest. So the calculation of benefits based on this figure is somewhat optimistic.

Fuel savings are based on average commute trip times, average fuel efficiency and average fuel cost estimates. Operating cost savings are calculated based on an Internal Revenue Service (IRS) mileage rate for businesses operating a vehicle. This has three potential issues. First is that this is likely to be a rate for business tax deduction purposes and so may or may not be an average figure for commuters. Second is that the IRS rate appears to include the cost of fuel, which the study has also calculated separately. There appears to be potential for double counting here. Third it is possible that using average costs will over estimate the savings as strictly it is the marginal cost of car use that is avoided by teleworking. For example insurance costs are unlikely to decrease linearly with mileage.

Time saved by the teleworkers is valued at $14.60 per hour, a figure from an earlier congestion study (Schrank & Lomax, 2007). Potentially more problematic is the calculation of congestion savings. This is based on an assumption that a 1% reduction in traffic reduces congestion by 3%, apparently relying on a claim by the founder of the Telework Coalition. It is unclear what this is based on. In any event these congestion savings are applied to costs of congestion from Schrank & Lomax (2007).

Electricity usage is assumed to decrease with teleworking as traditional offices are claimed to have higher electricity usage than home offices. This saving crucially relies on a one to one reduction in the use of traditional offices replaced by the use of the home office. Now the significantly higher traditional office electricity consumption quoted may be because many traditional offices in fact house more than one worker. So a one to one assumption seems likely to overstate the true electricity usage benefits. It may also be that traditional offices are more likely to meet minimum occupational health and safety standards for lighting and/ or to have more complete heating or air conditioning systems. So the switch to a home office may also come with a detriment in terms of worker lighting, comfort and safety.

FTTP is assumed to permit a 10% reduction in business air travel, with an assumed saving of $200 per trip in airfares, hotels etc versus the cost of videoconferencing.

A variety of healthcare savings are claimed. The largest is based on remote health monitoring being assumed to lead to a 63% decrease in hospital admissions and a 40% decrease in emergency room visits, figures drawn from a Veterans Administration study. No mention is made of whether the veterans study would necessarily be applicable to a wider population. For example, veterans could be older or the study may have included complementary investments to achieve these rates.

Other benefits based on reduced transportation, such as between emergency departments, from correctional facilities to emergency departments or physicians and from nursing homes to emergency departments and physician offices are also valued based on Center for Information Technology Leadership (2007) estimates. All of these estimates would appear contingent on good broadband at hospitals and physicians, not at households.

Moving to online health records enabled by broadband access is assumed to save $670 per household annually,[14] based on a figure by Rintels (2008). The authors perform a calculation to get a net benefit by considering likely costs in health IT likely to be incurred in moving to online health records. It would appear that the net benefits described are contingent on broadband in hospitals and physicians, not at the household level.

Remote monitoring is assumed to give medical cost savings due to a 30% reduction in hospitalisations for asthma, diabetes and cardiovascular disease. The 30% figure comes from an estimate by Litan (2005) of a 30% reduction for chronic illnesses. Litan's assumptions are also applied to benefits arising from increased potential for at-home care over nursing home care. Unlike the other medical benefits these appear to have a clear connection with household broadband availability.

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[14] Noting we have no particular expertise in this area, this number seems so high at first glance as to require caution in its use. Say this number was simply assumed to be relevant for Australia, with a parity exchange rate. At approximately 8 million households this would imply a saving of over $5B annually, which appears to be an excessive estimate simply for moving to online health records.

The authors assume that increased competition will decrease prices to consumers by $10 per month, and that these consumer savings are a benefit. No particular reasoning behind this figure is given. It is not clear that this can simply be considered a benefit as price decreases to consumers are also price decreases for producers. It may be possible that the authors have assumed that the telecommunications companies charging the prices are somehow outside Seattle and so any reduction in prices is an increase in Seattle consumer surplus only. In any event a much more detailed analysis is required to substantiate any likely price decrease and the resultant change, if any, in social welfare. A more reasonable estimate from a social CBA point of view would consider the effect of a reduction in price would have in encouraging more use of broadband. Extra users of broadband due to lower prices could be a benefit of any increased competition.

Several potential impacts on the level of economic activity are discussed, such as the potential for employment opportunities for seniors and the disabled. The authors (correctly) do not automatically include these as benefits but portray them as increases in economic activity. The calculations are based on applying assumptions from Litan (2005) that seniors staying in the workforce would lead to an increase in the workforce of 2% and disabled persons would have a 1% increase in employment. While 1% does not seem to be an aggressive estimate, it is not clear if the assumptions about the size of the disabled unemployment pool are reasonable or not.

3. Environmental impacts – estimated in terms of reduced emissions and congestion. They are not converted into monetary terms but are considered as impacts for consideration in the overall decision. For a social CBA there is nothing conceptually wrong with converting these benefits in to monetary terms, even if the investor could not capture the benefits for themselves.

This paper illustrates some of the difficulties and compromises made in estimating the value of benefits from broadband. While the authors list and estimate a wide range of benefits, they appear to realise that some are more speculative than others. They only place a subset of benefits within their key summary of total benefits to stakeholders. They also recognise that many of the benefits are not strictly incremental benefits from FTTP over say currently available cable or ADSL. While recognising this they provide little indication of how much of the value of the benefits might be achieved under current installed technology. As the preceding discussion suggests some of the claimed benefits do not appear dependent on household level broadband and most of the complementary investments required to achieve the benefits may be mentioned but are not quantified.

This is not intended as a criticism of the authors, who were directed at benefits valuation. However it does highlight the importance for CBAs of identifying the scope of the project and carefully considering the counterfactual in order to ensure incremental benefits are the emphasis.

PriceWaterhouseCoopers (2004)

This is a substantial study from 2004. It is subtitled 'A cost benefit analysis for broadband connectivity in Europe'. It is comprehensive in many ways, although it appears to contain an analytical error in the calculation of the incremental benefits of broadband. Similarly in its more detailed sectoral explorations it appears to allocate benefits to broadband even where the activity providing the benefit can also be obtained by narrowband. So from the perspective of a CBA of broadband over narrowband, this study appears to overstate the net benefits of a move from narrowband to broadband.

The study is aiming to do something akin to a social cost benefit analysis of extending broadband connectivity across Europe. This is suggested by the:

- Emphasis on WTP as the key measure of value for broadband subscribers.
- Inclusion of savings to government and savings to private providers of services.
- Inclusion of externalities that would normally be captured by no-one e.g. pollution.

The approach taken is to sum all of the benefits of broadband for each year. A similar sum of the costs of broadband for each year is made. These sums are based on forecasts of broadband take-up, broadband pricing and assumed technology mixes. [15] Although "broadband take-up" is slightly ambiguous, it appears that this refers to incremental increases in the number of broadband users brought about by increased

[15] Although the authors recognise WTP as the correct value concept they choose to use prices, at least in part due to the ready availability of forecasts, and correctly emphasise that the resultant value of benefits is a lower bound.

connectivity.[16] These new, incremental users of broadband are assigned a value from broadband equal to the average revenue per user.

Now it appears that the assessment of broadband is intended to be done in incremental terms (page 5, dot point 2). However the above approach is not fully congruent with that. This is because one particular incremental change appears to have been incorrectly accounted for – the direct benefits measured are calculated as the forecast take-up of broadband subscribers multiplied by the forecast average revenue per subscriber, but this ignores the fact that some new broadband subscribers would already have been receiving benefits from narrowband. Strictly the CBA should only consider the incremental benefits of broadband over narrowband for these consumers. Using the PriceWaterhouseCoopers methodology would mean that for these consumers the net benefit of broadband should be the net of their future broadband subscriptions over their current narrowband subscriptions. This does not appear to be what has been done and may lead to a potentially large overstatement of the benefits of moving to broadband. This is particularly concerning as it is plausible that many new broadband users were previously narrowband users.

Separately the study develops some valuations for some of the underlying sources of the benefits accruing to consumers, government and business. The study correctly does not add these estimates of consumer value to the value obtained via pricing, as the value of underlying benefits is assumed to be captured in the prices consumers pay for broadband access. The study asserts that these underlying sources of benefits are mostly considered only where there is an appreciable improvement from going to broadband. Having said that, in general there appears to be little discussion of what portion of the benefits might also be available under narrowband. The analytical error outlined above appears to recur here. The benefits of broadband are generally only valued relative to having no internet access at all, rather than considering the value of broadband relative to narrowband.

[16] We base this assumption on two things. Page 16 of the PriceWaterhouseCoopers study mentions 22.7 million ADSL and cable broadband subscribers at the end of 2003. The take-up figures presented in the graphs on pages 20-21 for 2004 add up to significantly less than this. This implies that the "take-up" figures used in the PriceWaterhouseCoopers report are incremental, not total, numbers of broadband users.

Valuation of the benefits of teleworking is based on reduced commuting costs in terms of transportation costs, time savings and reductions in pollution and congestion. The transportation cost savings depend on estimates of trip numbers, proportion of different modes of transport and the average distance and time involved commuting. Travel time was valued largely based on salary levels, assuming a salary elasticity of time of 0.8. Forecasts of the maximum number of jobs that can take up telework are made based on each country's distribution of job types that could be teleworked. It is assumed that 50% of that maximum is achieved in the forecast period and then 50% of that is assumed to be from (new?) broadband subscribers. This last assumption may overstate the incremental benefit of teleworking in going to broadband, as a proportion of the teleworking population may already have broadband.

Online grocery purchases were estimated to have value based on time savings and reduced retail costs. Estimates of the time savings were based in turn on estimates of the amount of time spent travelling and in store versus time spent in front of a computer for an online grocery shopping trip. The same number of shopping trips per month was assumed for either in-store purchases or online purchases. Delivery costs were estimated using information on delivery fees. The rate of take-up is difficult to forecast. The study first assumes current levels of online grocery shopping using survey data on willingness to shop online. This appears likely to overstate the current starting point. The study then forecasts European growth rates based on published forecasts of US growth rates. The study results again appear to calculate a gross benefit of broadband, not a net for broadband over any previous narrowband benefit.

Significant benefits are claimed for e-commerce. The basic issue with the analysis given is the claim that "the benefits of e-commerce attributable to broadband are proportionate to the take up of broadband usage compared to dial-up usage". This only appears to be supportable for estimating the gross benefits of broadband for e-commerce, not the net benefits over narrowband.[17] The rest of the estimate depends on a comparison of the difference in prices between some goods and services bought online and some bought through traditional channels. This difference was multiplied

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[17] An example to illustrate: Say a consumer can use basic email equally well using either broadband or narrowband. Further, say 70% of basic email is done using broadband. In this case 70% of the gross benefit of using basic email is enjoyed by those using broadband. But this says nothing about the incremental benefit of broadband over narrowband when using basic email.

by total sales revenues for each country. This appears to assume that the current differentials between online and in-store prices seen will apply to all retail. This appears optimistic, at least partly because online retailing may have entered in the segments where it has the greatest relative advantages first. European growth rates in e-commerce for 2004-2013 were assumed to equal that achieved by the US between 1999 and 2004.

Savings from two e-government initiatives are also calculated. Online vehicle licensing is forecast to provide benefits based on eliminating travel time to licensing offices, reduced waiting time at licensing offices, reduced costs for reminder notices and reduced costs for government to process applications. Moves to online tax returns are valued using a UK government estimate of the benefits of online transactions of over €5 per customer. It is not clear what components make up this saving. This figure is applied to estimates of take up rates based on population and "government e-readiness".

In e-education a variety of potential general benefits are described. Two are developed further. One is the benefit of increased educational attainment for those who leave school at 16. It is based on an estimate of the benefit of exposure to ICT improving examination performance. Further exploration would be needed to check if this estimate is sound. The immediate concern would be to determine if there was some other factor(s) correlated with higher ICT exposure that was responsible for the improved attainment, rather than ICT being the sole source of the reported benefit. The study estimated the impact of the increased attainment on average wages, with some future discounting. The study then attributed 25% of these benefits to broadband and the internet. This phrasing highlights the issue that appears pervasive in this particular study – is broadband the driver of the benefit or is it actually internet access? Is this benefit incremental over narrowband or is it simply the gross benefit of broadband? If it is the latter, how much of that benefit is achievable with narrowband? This is a critical distinction for those assessing major broadband projects.

A second e-education element is the online delivery of higher education. The study describes some of the costs and benefits of this approach. Here they focus on fully interactive learning. Although they do not point this out, a higher degree of interactivity is more likely to require the higher asymmetric speeds available under very fast broadband. Hence this may be one application where one might assume that the benefits really are incremental for broadband over narrowband, as narrowband may simply not be suited to this degree of interactivity. Ultimately the study assumes just 1% of higher education is delivered in this way, with that threshold met at different stages by different countries.

Two elements of e-health are developed. Online consultation is the first. It is analysed in terms of reduced costs of transport, savings in travel and waiting time for patients and reductions in costs to GPs if interactive consultations are less time consuming. These are offset by the time online of the patient and the doctor. UK estimates of travel and waiting time and value of the time of the doctor are used. A crucial assumption is that the study estimates that 37% of consultations are suitable for being done online, based on personal communication with medical practitioners. The study proceeds to assume that countries reach 75% of the maximum potential take up by the end of the forecast period.

The second e-health element explored is telemedicine for specialist treatment. Despite great optimism the authors find few robust studies to rely on in this area. They emphasise that results are likely to be quite case specific. This is a reasonable conclusion given the sheer variety of possibilities in this area. This is suggestive of a need for pilot scale developments initially, a path Australia may choose to follow.

The PriceWaterhouseCoopers study considers a number of indirect benefits. They place a value on the benefits of reduced pollution arising from teleworking and other broadband related reductions in travel. Due to higher travel distances the study anticipates higher benefits per rural consumer than for urban consumers (page 115). However this is not borne out in their table until the final forecast years (page 116). They find the total level of benefits higher for urban consumers due to their much greater numbers. They also mention several indirect benefits of improved educational levels, such as productivity gains from schooling not captured by wages, reduced crime rates, improved health outcomes and improved general mobility. These are not explicitly valued.

Ergas & Robson (2009)

This paper was prepared prior to announcements related to the Telstra agreement and to post election agreements giving higher priority to rollout in rural and regional areas. It was also prepared prior to the release of the McKinsey-KPMG (2010) implementation study suggesting a move to 93% fibre coverage as an objective. Understandably some assumptions used may not reflect the current NBN proposal.

The primary analysis performed appears to consider only FTTH developments for the project, covering 90% of the population (page 12). It is not clear what total capital cost or capital cost profile over time is assumed for the FTTH development. It is also not clear what operating expenditures are assumed. The paper says its cost estimates are developed using a cost model developed by Concept Economics. The paper mentions that the cost estimates are sensitive to a range of assumptions about consumer take-up rates and cutover arrangements, the extent of aerial deployment, the project cost of capital, achievable operational efficiency improvements and the quality of service provided. A range of unit per customer costs are suggested.

The paper describes a counterfactual, consisting of upgrading the current copper network, upgrading the HFC network, some upgrading to fibre optic (to the curb or to the premises) and some use of wireless. The description does not provide details of the proportional mix of technologies over time. Although plots showing the assumed "speed adoption path" are given, they are for the median consumer. As such the plots do not provide much information about the exact mix of technologies adopted over time or directly assist with working out the assumed capital cost profile over time.

The paper focuses on median WTP and median speeds. It appears the median speed considered is the median of maximum download speeds, the remaining discussion here assumes this is the usage. This use of median WTP and median of maximum download speed has two issues.

The first issue is that it does not appear that this use of median WTP allows any consideration of differences in WTP for the portion of the population moving from basic broadband to fast broadband (perhaps applying to many rural and regional users and some metropolitan users) versus the portion moving from fast broadband to very fast broadband (perhaps applying to most metropolitan users). It would appear that this use of median speed and median WTP has the effect of effectively only analysing the metropolitan consumer, potentially ignoring large changes in WTP for those moving to basic broadband or to fast broadband. It also ignores the possibility of a significant fraction of the population having much larger WTP under a future NBN, as the upper range of WTP could be quite high.

The second issue is that the use of the median of maximum download speed has issues that tend to overstate the future benefits of the baseline cases used. This has the effect of understating the incremental benefits of the project. The baseline case A without an NBN has median of maximum download speed increasing from 10 Mbit/s to 60 Mbit/s by year 6. It is hard to know exactly what technology is considered to represent the median here, though the earlier discussion of assumed technology changes suggests it is a move from ADSL now to improved cable (HFC) later (page 14). To the extent that the paper is being overly optimistic about the private provision of improved HFC in the baseline case there is a corresponding understatement of the incremental benefit of the project. In any event the improved HFC later would be subject to congestion and it is not clear that its average download speeds or its upload speeds are comparable to fibre. Use of the median of maximum download speed ignores average download speeds, congestion and upload speeds.

The measurement of benefits is generally described in terms of the median consumer's WTP. The paper appears to be combining all benefits in a single median consumer WTP estimation. This can have the tendency to make the assumed size and source of the benefits less explicit than approaches that separate the different types of benefits. For example, any productivity gains are expected to be reflected in consumers' and businesses' WTP for broadband use (page 26). However the analysis does not talk about business WTP, only consumer WTP. If business WTP or a reduction in business costs is in the analysis there is little information on what kinds of these benefits have been considered or included, or how much of the overall benefit they represent. No mention is made of any gains to government or externalities.[18] If either of these is implicitly included in the consumer WTP there is no information on what kinds of benefits have been considered or their assumed size.

It appears that the consumer WTP measure used is intended to implicitly include all other benefits. Still, the above treatment of other possible benefits suggests that the bulk of benefits included are private benefits to consumers. The comparisons used are suggestive of such a focus. For example, the model used to illustrate the effect of

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[18] Wider social benefits appear to have been dismissed "As for wider social benefits, it is unclear what they consist of, and whether they are indeed greater under the project than under the counterfactual ... Without more precise specification of those benefits, it is not possible to assess whether they have any substance, although some that have been cited in the press seem dubious." (page 27)

speed on the benefits analysed is one where increased download speed is valued as it frees up time for work. This assumption is used to make assumptions about the likely consumer response to higher speeds. It appears to be a narrow view of what consumers might value about broadband. It is entirely possible that users place value on upload speeds or total download allowed. It is also possible that consumers do not think of speed primarily as a download versus work trade-off, but as extra speed permitting qualitatively different applications. A second comparison that is suggestive of an emphasis on private value is the comparison of initial assumed WTP with current market outcomes (page 17). When people actually pay for broadband they are not paying for a slice of all broadband benefits, such as those that might result in lower costs for business, they are only paying for those that accrue to them privately.

Allen Consulting Group & Dandolo Partners (2006)

The primary focus of this report is on Telstra's earlier FTTN plans and on an alternative broadband plan. The report does not estimate economy wide or sectoral benefits of higher speed broadband. It does perform a basic calculation of current consumer surplus and future consumer surplus under FTTN with competition.

Consumer surplus has the usual definition as the difference between consumer willingness to pay and price. The Allen Consulting Group & Dandolo Partners (ACG & DP) current consumer surplus calculation does not rely on any actual demand curve. Instead it is derived by assumptions. ACG & DP assumes that:

- A reasonable benchmark price for broadband is $50 per month.
- Demand is zero at prices greater than twice the benchmark i.e. demand is zero at prices greater than $100 per month.
- Consumer surplus is then calculated assuming price elasticity of demand of 1 or 2.
- Consumer surplus is then converted to net present values assuming the surplus occurs in perpetuity, using a discount rate of 5%.

The increase in consumer surplus in going to a competitive high speed network (FTTN) is calculated by assuming:

- Broadband subscribers double in number, giving Australia the same broadband penetration as Canada. These extra consumers are assumed to be attracted by a series of underlying benefits from improved broadband speeds.

- Prices do not increase.

Under this scenario ACG & DP calculate that moving from then current broadband to higher speed broadband will give an additional $17 billion to $23 billion in consumer surplus, in NPV terms.

From the point of view of cost benefit analysis it is important to recognise two things:

- This assessment of benefits is focused entirely on consumers and does not include any costs of actually increasing broadband speed.
- This measure of consumer surplus is highly dependent on the particular assumptions used about consumer demand. The use of contingent valuation and/or choice modelling methods could be a source of improved estimates of the parameters of demand for higher speed broadband.

Access Economics (2010a) (Telehealth)

This paper is a high level assessment of telehealth. As such it is an example of the type of thinking that could go into the valuation of telehealth programs dependent on the NBN. It gives some indication of an approach to the valuing the benefits of telehealth, mostly by building on overseas studies. The benefits looked at are:

1. Tele-medicine for remote consultations.
2. Remote home-based monitoring of chronic disease patients and the aged.
3. Remote training of medical professionals.

The report specifically excludes any benefits from personalised electronic health records. It also found insufficient data to estimate the benefits of remote training of medical workers. While discussing some of the costs of the technology needed, the report essentially excludes discussion of the exact broadband technology and costs required. In particular it specifically excludes the cost of high speed broadband itself. Where benefits are discussed it is rarely clear which of these benefits are contingent on the NBN and which could be achieved using other technology.

Access Economics suggest that a full model of the costs and benefits of telehealth, could ultimately build upon two US studies.

1. For assessing teleconsultation, using Center for Information Technology Leadership (2007) as a model as it is the only national scale model they

unearthed in a literature search. This national scale model was itself built up from smaller scale results.

2. For aged care / remote monitoring, building upon Darkins (2008), to draw on the experience in this area of the US Department of Veteran Affairs.

As Access Economics say:

> "Essentially under this approach parameters, such as the numbers of hospitalisations, patient and physician visits and unnecessary procedures avoided would be sourced from international studies. However costs, including such hospitalisations, patient and physician visits and unnecessary procedures, would be sourced from Australia, to the maximum extent feasible." (page 15).

Without performing a full modelling exercise based on the above, Access Economics provides a preliminary valuation of the benefits. A simple population scaling of the Center for Information Technology Leadership (2007) benefits for teleconsulting gives a figure of $296M per year. For remote monitoring Access Economics assume that half of the $0.9B benefit claimed for "patient self management" from a Booz (2010) study occurs. Addition of these two figures gives around $750M annually.

This $750M annually incorporates the direct health expenditure and patient time saving. Access Economics go on to suggest that other benefits such as reduced cost of absenteeism, welfare and taxes (among other things) can be considered to give a benefit figure of $2.25B. This is three times the direct benefit assessment of $750M.[19] Then by incorporating the value of a statistical life year as a measure of the reduction in health harm, they arrive at a figure of total gross benefits in excess of $4.5B. Access Economics conclude by giving a preliminary range of $2B to $4B annually.

This is clearly an extrapolation of an incompletely modelled set of benefits. One can argue about the base figures and about the extrapolation used. We do not do that here. There are difficulties in analysing this type of program.[20] It is hard to assess the

[19] It is not clear if the three times multiple is how Access actually calculated the $2.25B figure. It is also not clear if the absenteeism benefits are guaranteed to be clear of double counting with respect to patient time savings appearing in the base $750M figure.

[20] Access Economics mentions that Davalos et al. (2009) reviewed over 600 articles on the cost and effectiveness of telemedicine, finding that fewer than 4% gave a legitimate economic evaluation.

benefits claims made. They appear to be mostly gross benefits (page 20) and as such may not have netted off all existing telehealth benefits. Although the report mentions that high speed broadband is a major constraint to the widespread adoption of telehealth in Australia, it is not clear what broadband technology is required to achieve the various benefits considered.

This Access Economics report gives a flavour for one approach to telehealth assessments. The Access study highlights some of the difficulties in assessing the level of benefits from a program such as the potential scarcity of applicable previous experience, issues in extrapolating from other studies and at least the potential for double counting.

Access Economics (2010b) (Telework)

This is a high level report by Access Economics attempting to calculate benefits from increased teleworking. Due to data restrictions on current teleworking patterns it calculates benefits relative to a baseline of no teleworking.

Here we do not analyse the Access Economics approach in great detail. Instead four general comments are made:

1. It can be hard to analyse incremental benefits, even if they are what the analyst is truly interested in. Here Access Economics analyses benefits relative to the situation where there is no current teleworking, due to data limitations.
2. This particular set of benefits could easily be subject to double counting if it was incorporated in cost benefit analysis of the NBN. For example some of these benefits are essentially private in nature – the savings in time and fuel due to reduced travel for example. It is quite possible that all or a large proportion of this value would also be incorporated in other estimates of household willingness to pay for broadband. Broadband users likely place an implicit value on the potential for broadband to reduce their costs, depending on their probability of increased teleworking in future. Some broadband users may have quite explicitly considered the potential for teleworking and its

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Instead the majority of studies conducted a simple cost analysis, with no linking of costs to program outcomes.

associated benefits in their assessment of their personal willingness to pay for higher speed broadband options.

3. The establishment of the NBN is unlikely to be sufficient for all of these benefits to take place. Other obstacles, such as workplace resistance for one, may remain. To include all of the benefits from teleworking in any NBN cost benefit analysis probably also needs to consider assessing a probability of achieving different levels of teleworking penetration and/or needs to consider the complementary costs likely to be needed in order to obtain the benefits of particular levels of teleworking.

5 The Access Economics report makes use of time savings calculations and increase in workforce participation. These two areas are prone to issues in calculation. Access Economics values the time saved commuting at the minimum wage rate. Increases in workforce participation tend to have large economic effects. Great care is needed to ensure that assumptions about increase in workforce participation are defensible. It is important to either only ascribe any increase in participation to teleworking directly (that is where the absence of teleworking is the only obstacle for someone to increase their workforce participation) or to include all other complementary costs that may be incurred to allow the increase in teleworking.

AT Kearney (2009) (Digital inclusion)

This report was focused on the benefits from an initiative aimed at decreasing the digital divide. The project was aimed at decreasing the disadvantage from poor access to ICT and internet. The program involved providing access to computer hardware, software, affordable internet and user support for residents of public housing in Atherton Gardens Estate in Fitzroy, Victoria. So the benefit analysis is not so much relevant for the broader NBN as it is reflective of the type of program involving complementary investments that may be needed to maximise the benefits of the NBN in disadvantaged areas. Any inclusion of the kind of benefits this type of program can generate also needs to include the cost of complementary investments needed to realise those benefits.

The specific methods used to value the benefits are not given in great detail in the report. AT Kearney identified and valued benefits in the following areas:

- Employment and education, through additional skills and access to new jobs – this appears to have been valued at least in part by the weighted average change in wages. This does not appear to take into account whether the improvement may have been part of a more widespread increase in wages, either via economic growth or via inflation.
- Enhanced communication – estimated by the reduction in communication costs. The reduction in telephone costs arising from substitution to internet based communication appears to have been a clear benefit. However if the program feature of discounted internet access was included as a benefit then in any CBA the cost of that discount would also need to be included.
- Greater transactional efficiencies, by using online tools and access. Direct access to services such as banking and government agencies saves time and money but it is not clear how these were valued.
- Improvements to the health and wellbeing of residents – unclear how the value of this was estimated.

The point this project reinforces is that the realisation of some of the benefits from the NBN, particularly in the areas of reducing disadvantage, is likely to need significant complementary investments in computer hardware, software and user support.

Access Economics (2009a)

This paper examined productivity impacts for various FTTN scenarios. Computable general equilibrium (CGE) modelling was used using AE-RGEM (Access Economics' Regional General Equilibrium Model). Productivity change by industry is initially estimated primarily from other study estimates of individual industry sector productivity gains from moving to simple broadband (ACIL Tasman 2004; Crandall 2007). These initial productivity estimates were then adjusted based on possible applications of "high speed broadband" in the industry, ICT intensity of the industry and the potential for high speed broadband (HSBB) to directly displace production in the sector e.g. for the Cultural and recreational Services sector the displacement of some video applications by internet delivered video applications was considered.

A key conceptual question is the degree to which industry level productivity impacts from moving from no broadband to simple broadband are good predictors of industry level productivity impacts from moving from simple broadband to high speed broadband (either to FTTN as in Access Economics (2009a) or, more extremely, to FTTH under the NBN). Access Economics have endeavoured to adjust for at least some factors that would affect the expected productivity:

> "Determining the productivity gains from HSBB is further complicated by the fact that HSBB is typically a next step beyond broadband, rather than moving from no internet to internet. As a result, the benefits of many basic internet functions, such as text-based emailing and basic internet banking, should realistically be incorporated into a reference case, rather than counted as benefits of HSBB. Instead the benefits of HSBB are focused around functions which are unavailable at lower speeds, including videoconferencing and many e-learning capabilities." (page 15).

As per other CGE modelling, this study faces the issue that the industry undergoing a direct shock is a key input to almost every other industry. Communications and transport tend to enter every industry as inputs. It is possible that the direct effects of increased speed in these industries may be linear. However there is a particular danger of nonlinear or threshold effects in changes to communications technologies that can be difficult to accurately predict and model in a CGE model.

Ultimately outputs from the CGE model are primarily expressed in terms of GDP and NPV of GDP. Without considerable adjustment GDP is more a measure of activity than a measure of welfare, an issue if one wishes to look at the value of the benefits for a cost benefit analysis.

Access Economics (2009b)

This report considers the economic impacts of intelligent or smart technologies for a number of sectors including electricity, transport, health, water in irrigation systems and high speed broadband. Each sector has its own analysis of the impacts associated with that sector. Access Economics here measure the economic impacts of high speed broadband based on a FTTN arrangement detailed in their earlier report (Access Economics 2009a). The primary results they report are based on Access Economics own computable general equilibrium model and for each of the 5 sector scenarios they simulate the impact of the initial capital outlay and the estimated direct impacts on productivity in the particular sector. They report the CGE results in terms of GDP and

NPV of GDP. These results are understandably sensitive to assumptions about discount rates and the degree to which the economy is near full employment.

This approach has some deficiencies from a CBA point of view.[21] Without considerable adjustment GDP is more a measure of activity than a measure of welfare, an issue if one wishes to look at the value of the benefits for a cost benefit analysis. This means that strictly this analysis is not really presenting a cost benefit analysis – it is instead primarily an assessment of the impact on economic activity rather than on economic welfare.

7 Valuing broadband benefits – stated preference approaches

The following sections on contingent valuation and discrete choice experiments detail some stated preference methods often used where market prices are unavailable, methods that may be adapted to the NBN. Under the contingent valuation method, survey respondents are asked to directly state preferences hypothetically for a resource, good or service. In this case respondents would be asked questions about how much they would be willing to pay for a particular broadband offering, assuming such an offering was to be made available. Under the choice experiment approach survey respondents are asked to choose between options containing a monetary element. Willingness to pay for various attribute of the choices is then estimated from the responses. For example respondents may be asked to choose between two broadband offers, each with different prices, download speeds, upload speeds and download limits. Their collective responses can be analysed econometrically to estimate willingness to pay for changes in these attributes.

These stated preference techniques rely on asking people hypothetical questions. Others (Pearce & Ozdemiroglu et al. 2002) draw a parallel with market research interviews. This is a plausible analogy given we are talking about prospective broadband availability. The key difference is that market research may be more designed for eventual pricing decisions whereas a social CBA will have social welfare

[21] This is not intended as a criticism of the Access Economics approach – their brief appears to have been to determine GDP effects, not to perform a high level cost benefit analysis.

rather than price at the forefront. The aim is to use those responses to estimate collective willingness to pay for particular benefits.

The need for incremental valuations of benefits can also point towards these methods as they can be used to get an idea of how much more people are willing to pay for changes in the broadband offer – changes in private WTP. They also potentially allow for different values for the benefits in going from dialup to basic broadband versus going from basic broadband to high speed broadband.

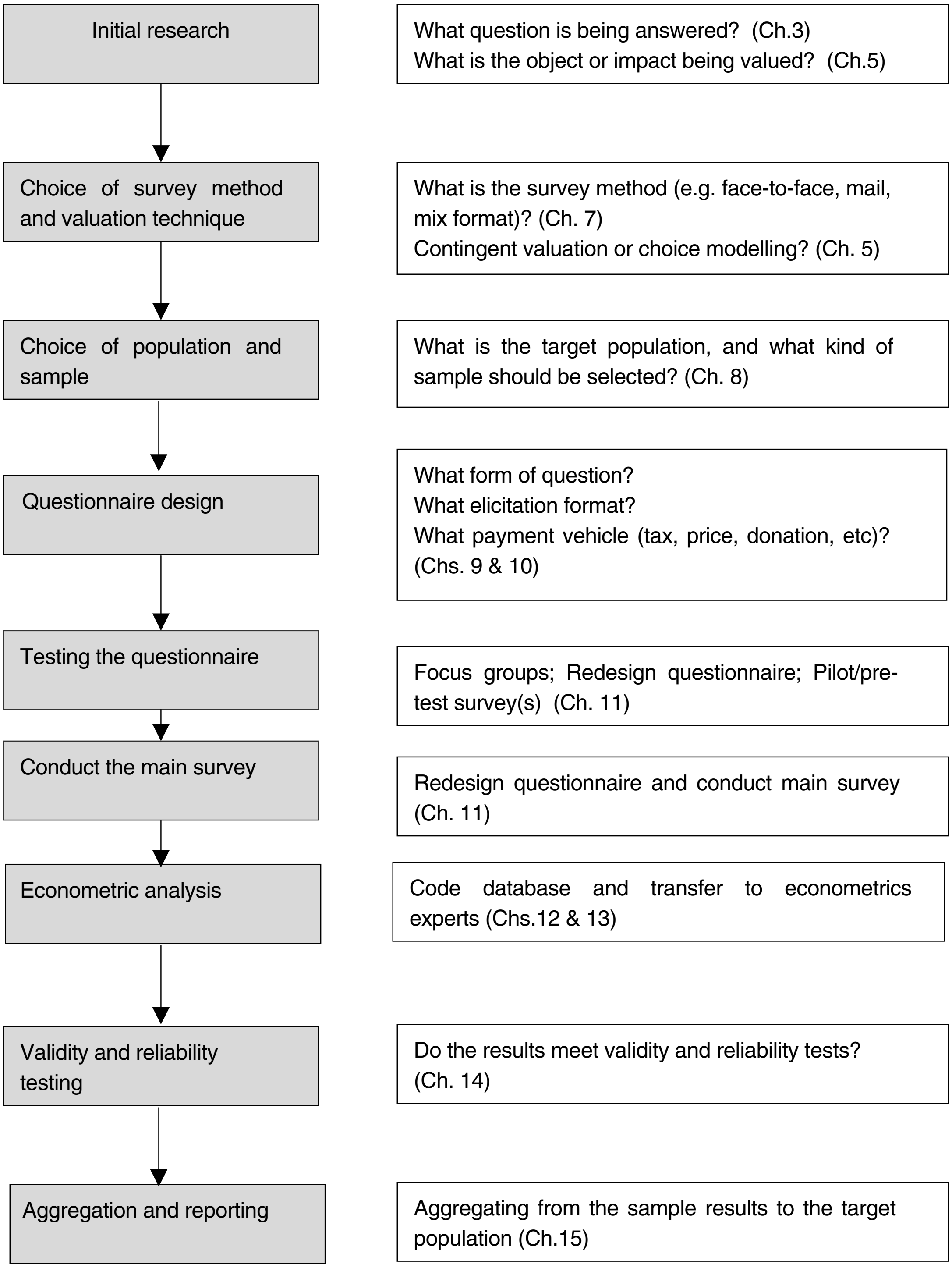
Figure 8 is a typical work plan for a standard stated preference study, adapted from Pearce & Ozdemiroglu et al. (2002). Both contingent valuation and choice experiments can follow this structure, albeit with many potential iterations. However the question design and data analysis stages will differ significantly between contingent valuation and choice experiments. We discuss some of the stages common to both stated preference methods in the contingent valuation section.

Pre-testing of questions can allow refinements and improvements to the scenario to aid in respondent understanding. Usually the application of either contingent valuation or choice experiments is somewhat iterative. As suggested by Pearce and Ozdemiroglu et al. (2002):

> "Piloting questionnaires, revising questions and repeating this sequence is crucially important to ensure that questions and the responses they elicit are as good as possible. Unsound questions or problematic responses may well undermine the credibility of the whole venture — or may allow others to do so once the results are published." (Introduction, paragraph 20).

This kind of iteration is particularly useful in refining what information to provide respondents. There is real skill in the delivery of information about a hypothetical situation. Even with provided information people may have trouble valuing a good until they have an opportunity to actually use it. One option to address this is to increase exposure to the future broadband scenario. Admittedly it is hard to duplicate the experience of using applications and services in the household under future day to day conditions. This is both because it is difficult to provide the experience of high speed broadband in the household without actually installing high speed broadband and because some of the applications and services may not exist yet in a household setting e.g. HD videoconferencing. Exposing people to some aspects of future broadband via Internet kiosks with the higher speed might improve some assessments so that people have a feel for how things they currently do could be done faster. Video on demand and IPTV could similarly be demonstrated / simulated to show what will be possible.

Figure 8 Stages in a stated preference study



Source: Pearce & Ozdemiroglu et al. (2002), page 28.

A further part of the provision of information is that many end users may not know well the specifications of their current broadband. A possibility is for broadband to be sold with a kind of standardised label that clearly specifies what is actually provided in a particular bundle.[22] As well as helping improve the type of survey discussed here (as customers may on average have a better understanding of their own current broadband plan and greater understanding of broadband in general) it should also assist in improving the ability of consumers to make informed decisions about broadband.

7.1 Contingent valuation

Contingent valuation was originally developed as a mechanism for valuing non-marketed benefits, particularly for environmental and ecological values. However it has since been applied in a wider array of settings where markets for the good or service are missing. Of interest here, it has found applications in assessing hypothetical products or services, including hypothetical communications services or products.

Several of these contingent valuation papers are specifically about estimating future demand for communication services, albeit services that may already have a foothold in the market or in other markets. In the NBN context the potential for this methodology is reflected by the fact that in general the "NBN experience" is not currently available. In rural and regional areas without basic broadband there is no basic broadband marketed and priced. In metropolitan areas the full fibre experience is similarly not generally available and priced for households - there is essentially no marketed consumer level broadband experience with the speeds of fibre, the upload potential and the ubiquity that are features of the planned NBN.

7.1.1 What is contingent valuation?

The contingent valuation method asks survey respondents to imagine a market exists for a particular defined resource, good or service and, to state their valuation as if a market for the particular resource, good or service existed. That is the valuation is contingent upon the hypothetical market.

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[22] See http://arstechnica.com/tech-policy/news/2009/10/does-broadband-needs-its-own-government-nutrition-label.ars for one example of a standardised label of information about a broadband service.

This method has particularly been applied to environmental areas where amenity is rarely priced in a market e.g. preserving natural resources, species, water quality, scenic views. It can also be applied to other hypothetical markets, such as a future market for NBN. Application of this method can be tricky. Several design considerations are apparent from the literature and the application to the NBN would require careful design, implementation and interpretation.

7.1.2 What does contingent valuation involve?

As a survey based method, contingent valuation involves selecting a suitable sample and survey instrument. The nature of the survey also requires constructing:

1. Hypothetical scenarios for the resource, good or service.
2. Questions about valuation, typically to draw out information about the respondent's willingness to pay for benefits flowing from the resource, good or service.
3. Information about the characteristics of respondents, allowing analysis of the sample characteristics and allowing assessments of the validity of the WTP results.

This method relies on stated preferences. This is different from more common economic techniques which tend to rely on revealed preferences, particularly on observing actual behaviour in markets. This reliance on hypothetical valuations is probably the primary source of concerns over the method.

Perhaps as a result of these concerns there is extensive information available to foster the design, implementation and interpretation of these surveys, resulting in fairly sophisticated approaches in these areas.[23] We won't go through all of these issues in detail.[24] Instead we give an overview of key elements of the method and highlight some of the considerations for applying the methodology to assessing NBN benefits.

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[23] See for example Bateman et al. (2002); Bjornstad & Kahn (1996); Cummings, Brookshire & Schulze (1986); Mitchell & Carson (1989).

[24] In particular we will not delve into the extensive literature debating and assessing contingent valuation's validity (does it measure what it claims to measure) or reliability (do repeated applications of the method give the same measure of value).

7.1.3 Elements of contingent valuation

7.1.3.1 Survey method (instrument)

The choice of survey instrument between in-person interview, telephone interview, mailed out questionnaire or internet questionnaire is usually made with reference to costs and consideration of the potential for introducing biases. For the NBN using internet questionnaires would appear to introduce a bias as it is likely to over-represent those with better current broadband access. Telephone interviews may introduce a bias if those who currently have higher speed broadband are also more likely to have stopped using landlines, and so are more likely to be underrepresented.[25]

In person, phone and internet instruments allow a greater degree of interactivity. This can readily allow different questions to be asked dependent on previous answers. Some ways of specifying valuation questions require this ability as discussed later. However, in person and phone interviews are likely to be more expensive, for a given sample size.

7.1.3.2 Population & sample selection

The population is the target group of people the analyst would like to cover. The target population here consists of those people who receive the benefit. The likely starting point when valuing private benefits to households is to use a population of the set of households whose broadband availability will change as a result of the NBN. These are the households affected by the project.

Surveying an entire population is usually too expensive and so probability sampling of a subset of the population is usually preferred. Standard procedures can be used to estimate the sample size needed, say for a certain degree of precision or maximum likely error.[26] A smaller desired error requires a larger sample size.

For the NBN application key questions in sample selection will be the distribution of respondents across different geographical locations and the distribution of respondents across different current broadband usage and/or access. It is likely to be

[25] Careful design to include both fixed line numbers and mobile numbers in the sample could decrease this concern somewhat.
[26] See for example Mazzocchi (2008); Mitchell & Carson (1989).

critical here to consider that different sectors of the community are starting from different levels of existing broadband and will end up at different levels of broadband following the NBN. For example some country areas are going from satellite to wireless while some metropolitan areas are going from cable and ADSL2 to fibre. The relevant survey questions for these groups may well differ.

7.1.3.3 Questionnaire design - Developing a scenario

Developing the scenario in the NBN context is particularly important here where respondents are unlikely to have personal experience of the benefits of Australia's planned NBN. Given this, information needs to be provided about key aspects of the future NBN, to make the scenario both plausible and more tangible to respondents. This could include information about forecast speeds and services, duration of the offer, and descriptions of what is currently available.

To determine the value placed on different increments of broadband (say different speeds, or the availability of different services) requires a series of willingness to pay questions, at suitable increments of speed and service. Digestible information about the scale used, say by converting speeds into download times, needs to be provided. If the respondent is unable to distinguish between different speeds then there is the potential for the responses to be overly based on people simply saying "anything better than now is worth x". If this is considered likely to be a major issue then the alternative approach of choice experiments introduced later may be preferable.

The potential for strategic bias can also affect the scenario development. If an individual believes that the survey will be particularly influential in shaping policy then they may choose to misrepresent their true preferences. Respondents in favour of an NBN may give exaggeratedly high willingness to pay valuations and vice versa, if they thought that what they were saying might influence the probability of an NBN being built. Analogously, if people believe it will be built no matter what then people who intend to be heavy users of the NBN may understate their willingness to pay in an attempt to decrease future price levels.

It is difficult to eliminate this kind of strategic bias completely from some survey designs. This is discussed further later. In survey designs susceptible to strategic bias, a strictly academic study might be able to plausibly claim that responses will not directly influence policy. However in such designs it would not be plausible to eliminate strategic bias from respondents without deception if the results were in fact to be used in cost benefit analysis or pricing decisions. If strategic bias is a key concern then contingent valuation survey design methods that reduce or eliminate its potential should be considered. The use of choice experiments discussed in the following section may also reduce this issue.

7.1.3.4 Questionnaire design - Valuation questions

In the NBN context the baseline contingent valuation question is:

> "What is the maximum amount you would be willing to pay for x?"

Where x is a specified broadband bundle and/or broadband service.

A number of different formats of question are possible:

1. Open-ended question

This is the example given above. It is deceptively simple in form. Its biggest issue is respondents may encounter difficulties in responding, as they may be unused to thinking about the value of the item in question, may be unfamiliar with thinking about their maximum willingness to pay or may find open-ended questions more difficult cognitively.

2. Question with a menu of responses

Here a set of possible responses is given such as \$0-\$20 per month, \$20-\$40, \$40-\$60, >\$60, etc. with respondents choosing one. Its chief advantage is that it is relatively easy for respondents. It has two principal potential disadvantages:

- It uses intervals rather than precise values, complicating the obtainment of precise overall values. The surveyor needs to choose the intervals. There is a trade-off between the fineness of the intervals ensuring a variety of responses and increasing complexity of the question. There is also the possibility that different respondent groups have very differing values, necessitating a wide range of options. The differences between different income groups for example may be so large that it is difficult to assign intervals that are suitable for all respondents.
- It may be subject to starting point bias – the order in which options are offered may affect responses, with greater tendencies to go for the first offered

alternative. Randomising the order of the menu items can partly offset this. However this does decrease the ease of answering for the respondent.

3. Iterative bids

Two common forms of iterative bid questions are:

(i) Multiple yes/no questions

First the respondent is asked if they would be willing to pay x, where x is a starting point chosen by the surveyor. If the response is yes then they are asked if they would be willing to pay y, where y is greater than x. If the initial response is no then they are asked if they would be willing to pay some value less than x. Each response of yes leads to a further question asking if they would be willing to pay at a higher price, each response of no leads to a further question as to willingness to pay at a lower price. This continues until the string of yes responses is broken by a no, or a string of no responses is broken by a yes or by asking if WTP is zero.

The highest price with a yes response is the maximum WTP used. If no WTP question gets a yes response then WTP is assumed to be zero.

The biggest issue with this methodology is that a large number of questions may be needed, particularly if the range of possible WTP values is large and/or a relatively specific response is desired. There remains potential for starting point bias and strategic bias.

(ii) Full bidding game (3 yes/no responses)

This method is best explained by example, using a typical set of rules designed to help converge towards a respondent's maximum WTP. The questioner first determines a maximum WTP they will ask about (this might be obtained via pre-testing, or previous open ended questioning). Say the assumed maximum WTP is \$150. The questioner then asks a starting bid question at \$50. If the response to a bid question is yes then \$50 is added to the bid and the respondent is asked again. If the answer to any bid question is no, then the new bid is adjusted halfway (\$25) back to the last accepted bid and asked again. See Appendix A for a full example and interpretation of responses. This is done for a total of 3 yes/no questions. Other starting points and increase/decrease rules are possible.

The key advantages of this method are the ease of response and bearing some similarity to a market. It also restricts strategic bias.

The disadvantages are:

- The potential for starting point bias.
- Anchoring effects for those responding with an initial yes – they may be reluctant to move away from an initial position.
- It is important to get the range right, as WTP responses are effectively capped by the maximum WTP allowed by the game rules.
- If the range is very large then the gradations allowed by 3 questions are not very fine.

4. Dichotomous choice questions

Under the dichotomous choice approach each respondent is asked a single WTP question and asked to respond yes or no.[27] The WTP figure used for each question is randomly selected from a suitably wide range of values. The number of YES responses for each price asked can be converted into a function showing what proportion of individuals are willing to pay different prices.

This method is relatively easy for respondents, avoids strategic bias and avoids starting point bias. Its disadvantages are twofold. First it requires a <u>much</u> larger sample size to generate overall WTP estimates, at a given variance level. Second it requires a much more technically complex regression procedure to isolate the WTP.

Adding follow up questions can extend this approach. The double-bound approach adds a single follow-up question. If the respondent initially answers YES, then the dollar amount is increased and they are asked again. A second response of YES gives a higher minimum WTP; a second response of NO allows the WTP to be bound. An analogous approach is used if the initial response is NO. The multiple-bounded approach is similar to the double-bound approach except that follow up questions continue to be asked as long as the respondents continue to continually say YES or continually say NO. This is like the iterative bidding approach, except with a random starting point. Double-bound and multiple-bound approaches lead to a more precise

[27] This approach is also known as the referendum question approach.

WTP estimate for the same number of respondents. However they re-introduce the potential for starting point bias and strategic bias.

In addition to valuation questions, questions about current behaviour and demographics are often asked. These responses can be useful for explaining and understanding the results, and for assessing if or how the sample differs in important ways from the population.

In particular, there is potential to include additional questions related to actual payments currently made. Responses here can sometimes be used to screen out unrealistic choices. For example, if a respondent said their willingness to pay for high speed broadband was less than what they currently actually pay for low speed broadband, one could consider the exclusion of this observation. If a consumer actually pays a price for a product, then their willingness to pay for that product is assumed to be at least equal to the price paid, and may be greater. So if a consumer actually pays x for a product then their WTP for that product is assumed to be at least x. We assume, other things being equal, that consumers prefer faster broadband to slower broadband. Therefore if a consumer pays a price x for low speed broadband, the consumer's WTP for high speed broadband would be expected to be greater than or equal to x. Survey responses that contradict this could be excluded, or at the very least prompt further questioning. Further questions might include asking why the respondent continues to pay for low speed broadband at the current price if their WTP is less than the current price. It may turn out, for example, that this situation is due to the respondent having a higher WTP when they entered into the broadband contract versus their current WTP, and the contract may be costly to break or renegotiate.

Figure 9 summarises the valuation questions.

Figure 9 Summary of contingent valuation question types

Valuation question	Typical Number of Responses	Strategic Bias	Starting point bias vs Hard to respond	Response Precision	Complexity of statistical analysis
Open-ended question	1	Major	Hard to respond	Precise value	Some
Menu question	1	Major	Some of both	Value range	Some
Iterative Bids – multiple yes/no	Chosen by researcher, usually ≥3	Major	Starting point bias	Approximate value	Some
Iterative Bids – full bidding game	Chosen by researcher, usually ≥3	Limited	Starting point bias	Approximate value	Some
Dichotomous choice	1	Limited	Neither	Approximate value	High; larger sample also needed.

7.1.3.5 Econometric analysis

Contingent valuation survey results can be used several ways. Frequently the goal is to obtain some estimate of the total willingness to pay. Assuming that the sample is representative of the population of interest, simple means, medians or frequency distributions can be used to produce estimates of the population's aggregate willingness to pay. The choice of sample measure can be informed by the distribution of the responses.

Where the sample differs in important ways from the population then multivariate estimation of a valuation function might be pursued. This effectively relates the sample respondents' WTP to characteristics of the respondents. In a high speed broadband example, household income, age, education and occupation might be characteristics expected to influence WTP. Where this data is collected during the contingent valuation survey it may be possible to construct a multiple regression analysis to estimate how WTP varies with each of the characteristics.

An example assuming a linear function follows. A general equation for a linear valuation is:

$$WTP = \beta_0 + \beta_1 C_1 + \beta_2 C_2 + \cdots + \beta_n C_n$$

Where C_i is respondent characteristic i. Regression analysis based on the sample can give estimates for $\beta_0, \beta_1, \beta_2, \ldots, \beta_n$. These estimates can then be applied to the population's characteristics to estimate the population's mean WTP.

Of course this is a simplification of the potential complexities of this approach. Skill and judgement are required to select a functional form for analysis and the subsequent regression analysis can be subject to a range of statistical issues such as multicollinearity, data accuracy, omitted variable biases etc.

The valuation approach requires a different approach when the contingent valuation has taken the referendum approach. This is because under the referendum approach the respondent has given a yes/no response to a randomly determined price. In this case the WTP is modelled as a dummy variable only able to take the values 0 (for a NO response) or 1 (for a YES response). As such it is not continuous and so alternative techniques are used, such as estimation using probit or logit functions.

7.1.3.6 Validity tests

Validity is often assessed with respect to existing theory. Initial validity tests tend to rely on how the WTP responses vary with respondent characteristics. For example, for many (most?) goods and services average WTP could be expected to increase as household income increases. While occasional inconsistencies may not be too alarming, complete reversals relative to theoretical expectations raise questions of validity.[28]

A more involved testing of validity could encompass estimating the valuation function mentioned previously. The size, sign and statistical significance of the coefficients associated with various characteristics influencing WTP can be examined

[28] Consistent and widespread empirical outcomes can in turn cast doubts on the strength of theory.

for congruence with theoretical expectations. Again, occasional inconsistencies may not be too alarming, while major inconsistencies are more problematic.

Checking the similarity of the sample to the population as a whole is part of the validity checking process. Here these sample characteristics have an additional benefit. They are potentially useful to future price setters of the services of an NBN. Knowledge of the demographic and other characteristics of the sample can inform the pricing of the services.

7.1.4 Applications of contingent valuation in communications

Despite the relative novelty of broadband and wireless internet, there are examples in the literature applying contingent valuation to these technologies. In the United States, Rappoport, Taylor & Alleman (2004) published an empirical analysis that used contingent valuation to estimate willingness to pay for access to wireless internet on a handheld device. They based their regression on a survey of households who were asked for their maximum willingness to pay for wireless internet access on a monthly basis.

Other communications technologies have also been studied using contingent valuation. Byun, Bae & Kim (2006) published a contingent valuation study estimating willingness to pay for digital multimedia broadcasting. In the US, Rappoport, Taylor & Alleman (2006) examined WTP for access to Voice over Internet Protocol. Contingent valuation was used specifically for pre-test-market evaluation of cable television in Korea by Yoo (2002).

7.2 Choice experiments

7.2.1 What are choice experiments?

Choice experiments are a stated preference technique. Survey respondents are presented with alternatives and asked to choose between them. Choice experiments can be used to analyse stated preferences to estimate WTP for different increments of attributes.

7.2.2 How do choice experiments work?

Choice experiments assume that a good can be defined by its attributes and by the levels of those attributes. So different attributes or attribute levels make for a different good. A choice experiment focuses on the value of changes in the attributes. To be able to estimate a monetary value for changes in the attributes, one of the attributes of the good must be a monetary item – a cost.

In a choice experiment respondents are asked to choose between two options; or often to choose between two options and the status quo. Each option is composed of a number of attributes, including a monetary cost.

Usually respondents are asked to consider a series of such choices, with each new choice scenario having its own set of options to choose between, with different combinations of attribute levels. Typically there might be 6-12 such choice questions asked of the respondents. Valuation is based on all of the choices made and the monetary trade-off implied by the choices.

Using the choices of the respondents, the probability of making a choice is modelled as a function of the attributes, including cost. This usually involves developing a random utility model. Within this, utility is often modelled as a simple linear combination of costs and attributes. More complex depictions of utility are also possible.

7.2.3 Elements of choice experiments

The elements of survey method, population and sample selection, scenario development and validity testing are largely similar to that for contingent valuation and are not discussed further here.

7.2.3.1 Selecting attributes

A set of relevant attributes must be selected. Often this decision is informed by literature reviews, focus groups or prior iterations of surveys. A monetary item needs to be included to allow the estimation of WTP. As an example, a recent US choice experiment study of consumer broadband (Rosston, Savage & Waldman 2010) included the following:

- Cost – monetary cost.
- Speed – they combined download and upload speed as a single descriptive characteristic.
- Reliability – frequency of disruption.

- Mobile laptop- ability to use the broadband service to connect to a laptop while out of the home.
- Movie rental – able to download and watch HD content.
- Priority – able to designate some downloads as high priority.
- Telehealth – able to interact with health specialists via internet.
- Videophone – able to make free video calls via the broadband service.

In the Australian NBN context a wide range of similar attributes are possible. It might be desired to separate upload and download speeds for example. It also may be desirable to add an attribute to try and capture any incremental WTP for having the whole country with ubiquitous broadband.

7.2.3.2 Selecting attribute levels

Considerations in selecting the levels of the attributes for an NBN based choice experiment exercise include:

- What is realistic under the NBN.
- The levels should generally span the range over which respondents have preferences (within the limits of realistic possibilities under the NBN).
- Normally ensuring a range of levels about existing levels would be considered in order for the estimation to provide estimates about both gains and losses in an attribute. This is probably less relevant for an NBN exercise as all attributes are expected to improve.

The analyst should consider the possibility of developing and using multiple sets of choice experiments, with different sets of choices and levels being offered depending on the respondents' current broadband access. This is because the relevant incremental WTP for many areas may be moving from no or basic broadband to fast broadband while others are moving from basic or fast broadband to very fast broadband. While it may be possible to craft a single choice experiment to uncover information on all types of broadband change it may be that the different broadband changes require separate choice experiments. This could be explored in early iterations of the design.

Values can be informed by earlier contingent valuation or other survey work.

7.2.3.3 Experimental design

The survey would ultimately ask about a variety of attributes with a variety of different levels. Combining these into a relatively small number of scenarios, while maintaining the expected usefulness of the resulting estimation, requires careful application of statistical design theory. References here for issues particular to choice experiments include Louverie, Hensher & Swait (2000) and Hensher, Rose & Greene (2005).

In many cases respondents will be asked to choose between two options and then asked to choose between their selected option and the status quo. It is also possible for the respondent to be asked to choose from 3 or more alternatives (one of which may be the status quo).

Discussion of the survey method (instrument), population and sample selection is similar to that for contingent valuation (see section 7.1.3.1 and 7.1.3.2).

7.2.3.4 Econometric analysis

To analyse the responses from choice experiments and obtain estimates of WTP for changes in attributes requires an econometric model. The random utility model is the usual foundation. It relies on random utility theory, which at its core is based on an assumption that a rational chooser will choose an option from a set of options that gives them the greatest expected utility. In choice experiments that utility depends on the levels of the attributes, including the cost attribute.

This framework leads to the use of an indirect utility function consisting of variables (attributes) contributing to utility plus an error (or random component, hence random utility model) representing the difference between true utility and modelled utility.

Now the hypothetical utility of option i, U^i is not observed. However choices between A and B are observed. So for example, one chooses option A over option B if:

$U^A > U^B$

Now the model sets this utility as a (usually linear) function of the selected variables (attributes) and a random error component. This means if one chooses A over B, and using a short set of potential attributes to illustrate:

$$\beta_1 Cost^A + \beta_2 Speed^A + \beta_3 HDVideo^A + \varepsilon^A > \beta_1 Cost^B + \beta_2 Speed^B + \beta_3 HDVideo^B + \varepsilon^B$$

where $Cost$, $Speed$ and $HDVideo$ are a monetary cost variable, a download speed variable (which may be continuous or discrete) and a dummy variable for if the service has sufficient upload and download speed to enable high definition video. ε is a random error.

Then the probability of choosing A over B is given by:

$$Prob(choose\ A) = Prob(\beta_1 Cost^A + \beta_2 Speed^A + \beta_3 HDVideo^A + \varepsilon^A > \beta_1 Cost^B + \beta_2 Speed^B + \beta_3 HDVideo^B + \varepsilon^B)$$

$$Prob(choose\ A) = Prob(\varepsilon^B - \varepsilon^A < \beta_1(Cost^A - Cost^B) + \beta_2(Speed^A - Speed^B) + \beta_3(HDVideo^A - HDVideo^B))$$

To obtain an explicit representation of this probability an analyst needs to make assumptions about the distribution of the error terms. Different assumptions about the probability distribution of the random error elements lead to different distributions for the probability of choosing A over B. One common assumption is that the error terms are independent and identical with an extreme value distribution (Gumbel distribution). This leads to a logistic distribution for the probability of choosing a particular option i.e. a conditional logit model. Where there are only two options this means a binary logit model, where there are three or more options this leads to a multinomial logit model.[29]

Assuming a normal distribution for the random error elements leads to a probit distribution for the probability of choosing a particular option. Two options suggest a binary probit, three or more options suggest a multinomial probit. Binary logit,

[29] These standard logit models imply that choices made are independent of irrelevant alternatives. That is the relative probability of two options being selected are not affected by the inclusion or exclusion of other alternatives. This follows from the independence of the Gumbel error terms. Relaxing this requirement leads to the use of more complex methodologies. See Louverie et al. (2000) and Hensher et al. (2005).

multinomial logit and binary probit can be estimated using maximum likelihood techniques. Multinomial probit requires simulated maximum likelihood techniques.

The results can be used to assess welfare changes in two steps. First is assessing how respondents' utility would change with changes in the level of an attribute. These do not have a ready interpretation. So the second step is to convert this utility change into monetary terms. The specific calculation of marginal WTP for a 1 unit change in an attribute is a typical goal:

$$MWTP = -\frac{\beta_j}{\beta_1}$$

Where β_j is the coefficient on the attribute being varied and β_1 is the coefficient on cost. For some simple specifications the coefficients will have associated confidence intervals.

Choice experiments such as these permit the analyst to estimate the marginal WTP for a change in the level of any attribute modelled or combination of attributes. This contrasts with the contingent valuation approach which really only gives an estimate of WTP or marginal WTP for a single modelled change in scenario.

An alternative to developing different choice sets for rural versus metropolitan respondents is to interact some of the variables with household demographics.

7.2.4 Applications of choice experiments to telecommunications

Choice experiments and other choice modelling have featured in the literature on estimating demand for broadband, internet services and telecommunications more generally. A list of some relevant papers is provided in Appendix C. An early Australian example is Madden & Simpson (1997), where the authors used a choice experiment to estimate the effect of installation and rental price on the likelihood of subscription to "fibre-optic cable". They are almost certainly referring to the Hybrid Fibre Coaxial (HFC) cable installed in parts of metropolitan Australia around that time, a cable that combines optical fibre and coaxial cable. While this paper is of limited direct usefulness for determining WTP for very fast broadband it does indicate the long history these methods have, in a broadband context.

More recently, revealed preference and stated preference papers using choice experiments have examined the move to very fast broadband in Japan (Ida &

Horiguchi, 2008; Ida & Kuroda, 2006; Ida & Sato, 2006). Choice experiments have also been applied to analyse WTP in the US for moving from fast to very fast broadband, among other things (Rosston, Savage & Waldman, 2010; Savage & Waldman 2005).

The US papers appear particularly informative for any analyst considering a similar WTP study for Australia's NBN, with estimates of WTP for changes in speed, reliability and other broadband attributes. Of particular interest are the US estimates for shifts in speed. Savage & Waldman (2005) use 2002 survey results to estimate a WTP of $11.37 per month for changing speeds between SLOW (dialup speed) and FAST (fast download, slow upload) or changing speeds between FAST (fast download, slow upload) and VERYFAST (very fast downloads, very fast uploads). Their estimation set up does not distinguish WTP between these changes.

Rosston, Savage & Waldman (2010) later report December 2009-January 2010 survey results showing a much higher WTP for moving from SLOW (similar to dialup) broadband to FAST (much faster downloads and uploads) of $45 per month. They also report a WTP of $48 per month for moving from SLOW to VERYFAST (blazing fast downloads and uploads), implying a WTP of only $3 per month to move from FAST to VERYFAST. Interestingly they find that rural WTP for faster connection is about $3 per month higher than urban WTP. More broadly they find that valuations for speed increase with online experience and with exposure to different speeds:

> "An interesting finding from our results is that valuations for Internet service increase substantially with experience. The implication is that, if targeted correctly, private or public programs that educate households about the benefits from broadband (e.g., digital literacy training), expose households to the broadband experience (e.g., public access) or directly support the initial take-up of broadband (e.g., discounted service and/or hookup fees) have potential to increase overall penetration in the United States." (page 5).

This has potential implications for Australia's NBN. It implies that a series of supporting programs may be quite valuable for enhancing the benefits of the NBN from a social welfare point of view. "Providing the pipes" alone is unlikely to maximise the benefit of faster broadband.

Statistically significant WTP estimates were also found for the ability to interact with health specialists on line ($4 per month), to make and receive video phone calls ($5 per month) and to download HD movies and TV shows ($3 per month). A large number of possible broadband plans can have estimated WTP calculated based on these results. They highlight a range of plans from a basic plan at $59 per month to a premium plus plan at $98 per month.

An interesting working paper by Greenstein & McDevitt (2010) estimates the historical increase in consumer surplus for broadband over dialup. It uses adoption information together with Savage & Waldman (2004) estimates of WTP for particular attributes of broadband over dialup, such as speed, reliability and being always on. These are used in a simulation to estimate consumer surplus, a component of total social welfare, for broadband over dialup for the US for each year between 1999 and 2006. The somewhat novel feature of this work is that they appear to have paid careful attention to considering value with respect to a well-maintained dialup counterfactual.

7.3 Discussion

Contingent valuation is perhaps a more straightforward method for analysing value of a good as a whole while choice experiments is more suited to valuing the individual attributes for a good. In choosing either for a broadband WTP study, careful thought about just what information is sought can help in choosing between these methods. A contingent valuation study will require many different valuation scenarios to be developed in order to obtain valuations for each level of each attribute. Choice experiments are a more natural alternative here and where there is a desire to obtain estimates of the marginal value of changes in the attributes.

Choice experiments have some further potential advantages over contingent valuation. One is the avoidance of hypothetical bias. Hypothetical bias is an apparent tendency in contingent valuation studies to overestimate real willingness to pay values (Blumenschein, Johannesson, Blomquist, Liljas, & O'Conor, 1997; Cummings, Elliott, Harrison, & Murphy, 1997; Cummings, Harrison & Rutström, 1995). Though the strength and existence of this potential effect is disputed (Haab, Huang, & Whitehead, 1999; Smith, 1999; Smith & Mansfield, 1998) its potential appears plausible, at least partly because of the potential for the ceteris paribus condition to not hold between actual and hypothetical scenarios (Whitehead & Blomquist 2006). These authors develop an example where respondents in the hypothetical scenario expect greater income in the future and 'the future' is when the hypothetical scenario will occur. In this case responses are based on a future with less binding income constraints, and so WTP is overstated relative to the current situation. Choice experiments should not be as prone to this as the ceteris paribus assumption should more easily hold in the selection between two choices. That is, if respondents place the choice in 'the future' they are doing so for both choices.

Choice experiments also reduce the scope for strategic bias as WTP is neither open ended or directly asked. Because the monetary value is "hidden"[30] and not directly asked it may not be clear to respondents who wish to act strategically which way they should choose. This potential to eliminate strategic bias may be crucial if it was to be used in any social CBA of the NBN in Australia. This is because the politicisation of the proposed NBN may lead some people to exaggerate their WTP (in either direction). Some respondents may profess stronger support or opposition to the NBN on political grounds (or political association) than they would have if they were basing their WTP purely on the basis of their expected private benefits of the NBN.

The flip side of this advantage is that it may be hard for respondents to make consistent choices under choice experiments. This is a key factor in recommendations to keep the number of options and attributes low for each option presented. The phenomena of "non-trading" - always preferring the status quo over alternative options – is sometimes linked with respondent fatigue.

A second flip side to these advantages is that choice experiments typically need to assume that the attributes sum to the whole to obtain an overall valuation. This is a potential issue where there are important valuable attributes that are not included in the study. In some cases this issue has led to the use of ad hoc methods to re-scale valuations (Bateman et al. 2002).

Choice experiments permit a richer set of information about the drivers of WTP for attributes of broadband than contingent valuation.

[30] The monetary value is hidden in the sense that a respondent may not be able to simply say which option is dearer or cheaper as the options will generally vary on other dimensions.

7.4 Conclusion

Estimating private benefits of broadband value is challenging. WTP is a relevant construct for social CBA and there are some methodological possibilities to elicit estimates of consumer WTP. As well as being a relevant construct for social CBA, these methods may be preferable due to the limitations of market price information for broadband that does not exist yet in Australia.

These methodologies for estimating WTP are not straightforward in application. They require specialist survey and statistical expertise. They cannot perfectly allow for the fact that users may not appreciate the benefits of higher speed broadband until they have experienced it. This is especially the case for applications that are not available at the consumer level yet – while opportunities to experience faster download speeds may be possible now, the experience of doing so under the fully developed array of services that the NBN may bring is not easy to replicate now. Still the possibility of developing a program for people to experience some aspects of the broadband experience under the NBN may enhance their valuation of the benefits. Together with the likelihood of network effects this suggests that there is a place for informing people of the benefits of higher speed broadband and providing them with opportunities to experience the higher speeds and/or pilots of future applications.

8 Valuing broadband benefits – hedonic approaches

Sometimes an estimate of value for a non-marketed item can be inferred from prices in another market. Revealed preferences in other markets can provide some information about preferences for higher speed broadband. Two hedonic regression approaches are introduced that use this idea.

Hedonic pricing is a regression-based methodology. It is suited for applications where the price of a good is driven by a set of attributes of the product. It is a revealed price method, because the prices used in the regression are generally market prices for the good.

We look at two possible hedonic pricing avenues for assessing the benefits of broadband. The first considers the effect of broadband on property prices. The second considers the effect of broadband attributes on broadband pricing.

8.1 *Hedonic pricing – property valuation*

The property value approach infers WTP for a property attribute from observed behaviour – revealed preferences – in the property market. The method treats property as an asset with a bundle of uses and features. The property value is considered as a discounted present value of future net benefits from uses of the property. So features of the property that affect the net benefits of owning and using the property affect the property value.

Traditionally this method has a number of uses:

1. To assist in valuation of a property that does not have a current market price.
2. To assess changes in the overall property market correcting for distortions causes by the features of stock that happens to sell.
3. To estimate the value of individual features of property, including features that are not necessarily separately marketable.

We will focus on the third mentioned of these. Still we note that the first two items indicate that some of the data required to perform this type of analysis may be available in the hands of property valuers or of property market researchers such as Rismark International.

In effect here we are suggesting the idea that hedonic pricing of property can at least conceptually be used to estimate a discounted present value of the net benefits of different levels of installed broadband.

We will explain the generic method then highlight the real challenges that would be faced in any attempt to apply this to valuing different broadband benefits in general, and benefits of implementing the NBN in particular.

8.1.1 Hedonic pricing approach

The basic assumption here is that property values reflect individual valuations of particular property aspects. One of those property aspects could be the type of installed or available broadband e.g. cable, ADSL, fibre, satellite; or a key feature or features of the broadband service e.g. maximum speed.

Many factors affect house prices, not just broadband availability. For example, Joye (2010) reports RP Data and Rismark International have developed a regression based hedonic price model for housing values over time that controls for different aspects of each individual property:

- Location.
- Property type.
- Exact land size.
- Number of bedrooms.
- Number of bathrooms.
- Pool if applicable.
- Car spaces if applicable.
- View if applicable.
- Waterfront if applicable.

Any attempt to isolate the value of a particular broadband installation on a property's value would need to control for such factors, in order to isolate the impact of broadband from other impacts.

Typically this is done by estimating a hedonic price function using multiple regression analysis. This gives several regression coefficients that measure each housing characteristic's independent effect on property values.

The exact functional form is selected by the analyst. A linear function is the simplest and implies that as a specific property characteristic changes, then the property value changes in a linear proportion (holding all other variables constant). Another common approach for property value studies is to use a log-linear model:

$$LnP = \beta_0 + \beta_1 LnC_1 + \beta_2 LnC_2 + \cdots + \beta_n LnC_n$$

where Ln is the natural logarithm, P is the property price, C_i is property characteristic i. In this particular model the coefficients β_i are interpreted as the percentage change in property price associated with a percentage change in characteristic C_i.

8.1.2 Difficult practical issues

The prospect of obtaining estimates of broadband benefits via property price hedonic regression appears highly challenging at a practical level. Several issues are apparent in data collection, functional form selection, econometric estimation and interpretation.

8.1.2.1 Data requirements

This method clearly relies on extensive data collection. Prices for both property sales and for the relevant characteristics of sold properties need to be captured. Even more crucially, relevant information on the broadband associated with each property sold is required. It is not clear that anyone has systematically recorded the type of broadband associated with properties sold in Australia, let alone more detailed information such as the maximum or average speed of broadband.

If this potential dearth of data is a reality then hedonic regression using past prices is likely to be impossible.

Even if data on broadband is available there may still be an issue with insufficient variation in the data. In particular there may not be enough variation in broadband that is independent of location, another key determinant of property prices. A key part of the NBN is the move to fibre in metropolitan areas. Suppose an analyst wished to use hedonic regression to try and estimate the value of fibre over ADSL. This would require a sufficiently large number of property sales across a variety of locations that actually feature fibre to the premises. Without this it would be difficult to isolate the impact of the value of fibre from the value of the location. It is not clear that there are a sufficient number of premises with fibre, particularly across different locations, to allow the hedonic regression to estimate the value of fibre.

In rural and regional areas (and maybe some metropolitan areas) there may be some variation in access to broadband that could be used to identify the incremental value in going from one broadband type to another, say between having access to ADSL or not, or between ADSL 2 and ADSL. This may be able to provide some information on property price differences due to different broadband access. However this may still be stymied by the relatively lower number of sales in these regions and difficulties in establishing exactly what broadband is available in each property.

8.1.2.2 Selecting the functional form

A critical step in property price hedonic regression is establishing the functional form of the regression. Each variable in the regression can enter the regression in potentially different ways. As a hypothetical example, it may be that each extra bedroom has less effect on the property price than the previous bedroom. If so, this could be recognised in the structure of the regression.

Selecting the functional form for hedonic regression of property is a key step in the analysis. Property valuers may choose to keep their functional form secret for commercial reasons. For example Rismark International (2007) appears to only publish a very high level regression function for their Australian property hedonic pricing. The key transformations of the underlying variables are not detailed.

Even if the functional form for the property hedonic regression is well informed, the introduction of broadband requires further thought about functional form. For example, is the best representation of the effect of broadband on property prices the simple availability of a particular type of broadband e.g. cable, ADSL, ADLS 2, fibre? Or is maximum achievable speed better? Or perhaps maximum average speed is better? Other possibilities for characterising broadband are a possible. Furthermore each characterisation can then enter the regression in a different way. For example it may be that average speed is not important in a linear way but instead it is important when it exceeds various thresholds (such as a threshold that readily allows video on demand downloads).

Interestingly stated preference methods such as contingent valuation and choice modelling may provide information to help resolve some of these difficulties in establishing the functional form for broadband itself in the property hedonic regression. Failing that other surveys or careful thinking by the analyst are required to inform the functional form choice.

8.1.2.3 Other econometric issues

The hedonic price regression is subject to the same issues as most econometric work. This requires that care be taken to consider data accuracy, specification errors, multicollinearity, statistical significance, model fit, multicollinearity and functional form etc.

8.1.2.4 Interpretation issues

The interpretation of results from a hedonic regression of property prices is important. Depending on the functional form the coefficients need to be carefully interpreted to make statements about the effect of broadband on property value. For example, depending on functional form, the coefficient could be associated with the incremental value of a 100 Mbit/s maximum speed via cable over ADSL. If so it would be important to be careful to realise that this does not necessarily reflect the incremental value placed on a 100 Mbit/s maximum speed delivered via NBN fibre. There are several reasons for this.

One reason is that 100Mbit/s maximum speed via cable is not the same on other dimensions as 100Mbit/s maximum speed via NBN fibre. NBN fibre is expected to have higher upload speeds and be less affected by congestion than cable. This is probably a severe current limitation with using this methodology specifically for valuing fibre benefits for the NBN – few properties are expected to currently have the type of broadband access that will available under NBN fibre.

A second reason is that some of the future benefits of fibre may depend on services that will be more prevalent only when a significant portion of the population has fibre e.g. some video on demand services may require a critical mass of fibre customers before they take off. Now it is possible that the value for higher speeds derived via hedonic regression could include a component representing a probability of increased net benefits of everyone being connected. Still it is quite likely that property sales to date may have underestimated the probability of widespread fibre to the premises, given it has only moved closer to reality relatively recently.

The hedonic price property approach can give an estimate of the present value of net benefits. It only includes an estimate of the value of broadband to the homeowner. Accordingly it does not include any benefits of broadband to others such as any cost savings to government from programs dependent on the NBN, such as particular healthcare cost savings. The method will only capture people's valuation of broadband so if people aren't aware of the linkages between the broadband attribute and benefits to them or their property, then the value may not be reflected in home prices.

8.1.3 Conclusion

Using property pricing hedonic regression to derive value estimates for broadband is an intriguing conceptual possibility. However it does not seem likely that the data requirements can be met at this stage.

Having said that the rollout of the NBN could provide an interesting experiment in whether or not broadband availability affects property prices. With the right dataset and careful consideration of functional form it may be possible to estimate how much value is added to property prices by the NBN. The data and analytical challenges remain formidable.

8.2 Hedonic pricing - broadband pricing as a function of attributes

One option for using hedonic pricing in the NBN context would be to look at the pricing of broadband packages and use this together with information about those packages to examine how the elements of the packages are valued.

Using data on existing broadband plans an analyst could set up a regression model to determine the effect of various elements of a broadband plan on price. Assuming a linear model for expositional simplicity, one could imagine a model like:

$$P = \alpha_0 + \alpha_1 Downloadspeed + \alpha_2 Uploadspeed + \alpha_3 Downloadlimit$$

Many other variables are at least possible and should be considered. The ones shown here are simply the most obvious. The exact measure for download speed could use maximum speed or average speed. Similarly upload speed could use maximum speed or average speed.

As in the hedonic property pricing of the previous section, data requirements and specifying the functional form could be challenging.

The key extra concern would be that this analysis would be limited to plans that actually exist. Now current plans are unlikely to encompass the type of offerings available on NBN fibre for example.[31] This is an issue because to estimate the quality adjusted price for future NBN fibre we would be reliant on the coefficients resulting from hedonic regression using current plans. That effectively means assuming the functional form of the regression based on current plans can be extended to out of sample examples of broadband such as the NBN fibre.

In the example above this would mean assuming that the way features of broadband currently determine price will extend to determining price of NBN fibre. It is not clear how defensible this is and is a key weakness of this approach.

[31] It is also unknown if wireless, satellite or ADSL plans currently available in metropolitan areas are indicative of the kind of plans that will be made available in rural and regional areas after the NBN upgrade in those regions.

It may be possible to ameliorate this weakness somewhat. The ability to do so would depend on the strength of the reasoning behind the functional form chosen and on the strength of the reasoning for that chosen functional form extending to the NBN fibre situation. It is possible that stated preference methods could prove informative for selecting the functional form. An analyst might also choose to rely on information about how some applications depend on achieving a threshold download speed in setting the functional form.

Issues in selecting the functional form are highlighted by the paper of Yu & Prud'homme (2010) looking at constructing quality adjusted price indexes for internet service provision in Canada to illustrate the potential for their inclusion in consumer price indexes. As such they test a wide range of functional forms, but do not need to consider the difficult step of applying the results to an out of sample specification, which would be a key issue if similar work was to be used for estimating price levels for NBN fibre.

Greenstein & McDevitt (2010b) have produced an interesting working paper that uses hedonic regression to create quality-adjusted price indexes for broadband in the United States for 2004 to 2009. The primary variables they consider are upstream speed, downstream speed and location. They use these variables in a few different functional forms to obtain separate quality adjusted prices for DSL and cable broadband, in both standalone contracts and bundled contracts. While the results are interesting for considering the price path of broadband in the United States it is not clear if they can be used to predict future price paths or be readily applied at all to a step change to fibre based broadband.

Even if indicative future prices could be confidently obtained from this type of hedonic regression, it would still only represent pricing information not WTP. The information would remain useful for price setting considerations and as a lower bound for WTP.

8.3 Conclusion

The hedonic pricing approaches discussed here have theoretical appeal and economists often instinctively reach for revealed preference information in the form of market based prices. Unfortunately in this case the hedonic regression approaches are unlikely to be adequate for a prospective cost benefit analysis. The data requirements appear likely to be too onerous for these approaches, and even if Australian data was available it is unlikely to have the extent and kind of variation needed for useful results. This is particularly the case for moving to very fast broadband, which is essentially beyond the current Australian household experience.

9 Valuing broadband benefits – other approaches

9.1 Benchmark adjustment

While the preceding sections provide some detailed methods for generating valuations for broadband benefits, they may be difficult to implement. As a result the most common method is probably actually a collection of methods based loosely on the idea of taking benchmarks from other areas and adjusting them for the valuation purpose at hand.[32] The survey of some methods of valuing broadband benefits encountered a wide range of such applications, reflecting their popularity.

Unfortunately it is difficult to assess the usefulness of these methods, except on an individual, case-by-case basis. Vigilance against the potential for double counting and careful analysis of the implied assumptions in the use of any adjusted benchmark is warranted. The previous survey of some methods of valuing broadband benefits also mentions a number of potential issues with some of the particular benchmark adjustments undertaken.

Careful judgement is required to determine whether results from a previous study are transferable to the current study, or what adjustments need to be made to make the previous results useful. More specifically a checklist of potential differences to consider when assessing the validity of the use of an adjusted benchmark to determine WTP or some other measure of value could be developed. Such a list might include:

- Are there differences in the socio-economic characteristics of the relevant populations?
- Is the proposed incremental change in the relevant attributes the same?

[32] As noted earlier, the literature on valuing non-marketed benefits uses the term “benefit transfer” to refer to estimating values for environmental or social tradeoffs by transferring values in some way from existing valuation studies to a target study of interest. Benchmark adjustment appears to be a more general term for a similar concept.

- How does the availability of substitutes compare between the two populations?
- How do other market conditions compare between the two populations?
- Did the original study use valid techniques?
- To what extent do new studies support the original study results?
- Is there a subsample from the original study that might be most applicable to the current study?
- Is there an expected relationship between WTP and various population characteristics that can be used to adjust the previous study results?[33]
- Do the earlier studies contain WTP regressions that might permit the transfer of an entire valuation function or at least inform how WTP varies with population characteristics?

9.2 Computable general equilibrium (CGE) models

9.2.1 What are CGE models?

CGE models are models of the national economy that describe linkages between its sectors. The usual starting points for CGE models are the input-output tables found in national accounts. The input-output tables show how the output from one industry is an input to another. For example one value in an input output table could be the value of iron used in the steelmaking industry. CGE models then link these relationships to equations representing standard assumptions about consumers (maximising utility), businesses (maximising profit) and governments. General equilibrium models (such as the Monash model) are generally set up capture the effects in the production sectors of the economy (Commonwealth of Australia, 2006).

Typically an exogenous shock, such as a relative price change, is then applied to the model. Each of the markets in the model adjusts to a new equilibrium governed by the

[33] For example, in the environmental context a widely used formula is $WTP_j = WTP_i\left(Y_j/Y_i\right)^e$ where Y is income per capita, WTP is willingness to pay and e is the income elasticity of WTP (Bateman et al. 2002)

model parameters.[34] As well as modelling the linkages between industries, restraints such as full employment can also be included.

9.2.2 CBA versus CGE

In practice CGE models are targeted at estimating economic impacts on GDP and employment, but not on full welfare effects. However it is full welfare effects that are the driving consideration in social cost benefit analysis. CGE looks at GDP and employment and as such is more focused on economic activity than on economic value. Disadvantages of GDP as a measure of welfare are well known.[35]

The economic impacts of a project, as assessed by CGE estimates of changes in GDP, are not the same as the value of the benefits in a social cost benefit analysis. CGE focuses on the effects of a project or policy on variables such as GDP or GSP (Gross State Product), employment, etc. The impact on GDP is a measure of the gross change in value of output as a result of a project or policy change. This addition to output normally requires additional inputs, of land, labour and capital, to enable it to be produced. These inputs have a cost, and this cost would normally be deducted from the economic benefits to obtain a measure of net economic gain. Even this approach ignores the social welfare associated with non-marketed consumer benefits, consumer WTP beyond market price (consumer surplus) and externalities that are properly incorporated in social CBA.

Social CBA is a method aimed at estimating the effect on social welfare from a project, where costs and benefits are estimated. They can be used in a variety of ways to inform decisions where the key criterion is the net social welfare value from a project. In contrast CGE models are designed to estimate effects on levels of economic activity such as the value of output produced (GDP) and employment. These are potentially important inputs to a public policy decision. However without extensive adjustment they are not measures of welfare useful for a social cost benefit analysis. Instead they are potentially complementary, by focusing on economic activity levels and effects on different industrial sectors.

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[34] A key set of parameters is the price elasticity of demand for commodities in the model. The responsiveness of demand for a commodity to changes in price for that commodity is a key determinant of trade in that commodity.

[35] For example it only includes market transactions and tends to ignore externalities.

9.2.3 Practical issues with CGE modelling of NBN

There are several probable practical difficulties with CGE modelling of the NBN. CGE are not always set up to readily model the addition of a new sector, or a radical transformation of a sector. An analyst would need to work out the nature of the shocks implied by the NBN, as a project and then as an ongoing effect on input output relationships and on relative price levels for communications. This poses some likely difficulties.

In practice the models may treat communications as a single commodity, purchased both for direct use and to facilitate trade. It is not clear how to translate NBN induced changes in broadband to changes in the input output relationships for communications. Communication networks improve the efficiency of all other industries, so fundamental technological change in communications is likely to affect input output relationships of all other industries.

CGE relies on price elasticities. Price elasticities for a new product may be particularly contentious.[36] We might expect industry level demand to be potentially quite heterogeneous, requiring individual industry consideration of the effect of the NBN on communications price elasticities. Also a substantial part of the NBN project is the provision of faster broadband at the retail consumer level. Deciding on how to incorporate the distribution of demand elasticities in the consumer population may also require some careful thought.

CGE modelling is also potentially sensitive to assumptions about the extent to which the economy is at full employment. There are differing views in the literature on the inclusion of secondary effects, such as the use of unemployed labour resources, in the cost benefit literature. For example the Commonwealth of Australia (2006) appears sceptical about the inclusion of secondary effects, regardless of whether there is full employment or not. This contrasts with Sinden & Thampapillai (1995), for example, who express a view that secondary effects taking advantage of unemployed resources may be included in a social cost benefit analysis. They highlight the difficulty of making the judgement as to whether secondary outcomes exist and suggest a

[36] WTP studies such as those described in the preceding sections are a potential input to estimating price elasticities of demand.

precautionary principle to exclude all secondary benefits and costs without clear evidence of non-competitive markets.

10 Conclusion

Creating in advance the exact experience of a future world under the NBN is impossible. Some applications are demonstrable, such as high definition videoconferencing, IPTV and cloud computing and backups. But many other future applications may be possible, future applications that may not be realised until a critical mass of very fast broadband users exists. To the extent that these future services are valued, current demand for very fast broadband and the demand implied by WTP studies are likely to be conservative estimates of the value of very fast broadband:

> "It is not reasonable to expect today's consumers to demonstrate a willingness to pay for tomorrow's services when they can barely envisage the scope and nature of those services. Ten years ago, they would not have shown a willingness to pay what they currently do for broadband; twenty years ago, they would not have shown a willingness to pay for what they now do on mobiles.
>
> ...
>
> We should remember the experience of current generation broadband. It should be recalled that initially subscribers to broadband used it for just the same services – typically e-mail and web browsing – that they used when they simply had narrowband. The age of sites such as YouTube and flickr had not arrived; still less on-demand television services like the BBC's iPlayer and IPTV. The use of such sites is now growing at a very rapid rate and consumers will demand faster down-load speeds and better quality – all of which will require greater bandwidth." (OfCom Consumer Panel, 2008, page 7).

The combination of very fast broadband being something of an experience good and being a good that likely needs wide adoption for service development to accelerate makes it hard for valuation to include some of the likely future benefits. It means that current demand curves based on actual consumer purchases of higher speed broadband may be less informative of future demand than they would be in other contexts. Estimated willingness to pay via carefully constructed future very fast broadband scenarios using stated preference techniques are likely to be subject to more uncertainty than in other contexts too. They are likely to be conservative estimates due to these difficulties.

Accordingly a social CBA faces some questions that may be impossible to answer analytically. To what extent will services that are yet to be developed ultimately contribute to social welfare? How much value will come from the development of future services and applications for very fast broadband, value like the then unanticipated value that accompanied the historical moves to basic broadband and fast broadband? How likely is the move to very fast broadband to have the same scale of unforeseen applications and benefits that accompanied the shift to basic broadband and fast broadband? What further unforeseen value or services might be released by having an entire population on fast or very fast broadband?

Ultimately an analyst undertaking a social CBA might take a different approach. They might examine the question - given estimated costs and given estimated values for calculable benefits, how much value is needed to come from various difficult to estimate benefits for the project to have net benefits? The answer to this question would still be subject to uncertainty, but even with uncertainty it would be informative to decision makers.

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Appendix A Full bidding game example

Here is an example of a full bidding game. Other game rules are possible.

A full bidding game involves an interviewer posing an initial "bid" for the price of a bundle, and subsequently revising the bid upwards or downwards in the following question based on the response. Suppose a researcher seeks to find the willingness to pay per month of the respondent for a service bundle of high speed broadband and a telephone call service. The researcher limits the survey respondent's interaction to three yes-no questions. Before the survey is carried out, the researcher uses a pre-test (formal or informal) to determine the likely range of WTP values. Suppose in this case that most respondents' values fall within the range of \$0-\$150. The maximum value is divided into three equal intervals, \$50, \$100 and \$150. Every interview session begins with a question at the lowest interval, \$50. During the survey, if the respondent indicates willingness to pay at a given level (i.e. she answers YES) the next question increases the level by \$50. If the respondent is not willing to pay the given fee (i.e. she answers NO) the next question decreases the level halfway back to the most recent accepted level. If the respondent then answers YES, the next question places the level at the midpoint between the two options.

There are four possible outcomes in each interview. These are presented below for illustration.

1. Would you be willing to pay \$50? YES.

Would you be willing to pay \$100? YES.

Would you be willing to pay \$150?

- if YES, maximum WTP recorded as \$150.

- if NO, respondent's valuation recorded as \$100.

2. Would you be willing to pay \$50? YES.

Would you be willing to pay \$100? NO.

Would you be willing to pay \$75?

- if YES, maximum WTP recorded as \$75.

- if NO, respondent's valuation recorded as \$50.

3. Would you be willing to pay $50? NO

Would you be willing to pay $25? YES

Would you be willing to pay $37.5?

- if YES, maximum WTP recorded as $37.5.

- if NO, respondent's valuation recorded as $25.

4. Would you be willing to pay $50? NO

Would you be willing to pay $25? NO

Would you be willing to pay $12.5?

- if YES, maximum WTP recorded as $12.5.

- if NO, respondent's valuation recorded as $0.

This process is best suited to interviews or online surveys that can alter the course of the questions. However it can be carried out using a questionnaire, although respondents may find the iterations repetitive.

Appendix B Selected contingent valuation papers

Source	Product(s)	Country	Timeframe	Features or characteristics
Yoo & Moon (2006)	Portable/wireless internet	Korea	2003	Respondents stated their choices in hypothetical markets for different service qualities at certain prices with their present service as an "outside option".
Rappoport, Alleman & Taylor (2004)	Wireless access to the internet.	USA	2003	Survey respondents were asked about their WTP per month for wireless internet access.
Byun, Bae & Kim (2006)	Digital multimedia broadcasting.	Korea	2003	Survey respondents were asked whether they would be willing to pay several different sums for monthly access to DMB, using the Double-Bounded Dichotomous Choice method. [good DBDC explanations]
Rappoport, Taylor & Alleman (2006)	VoIP	USA	2004	Survey respondents were asked for their maximum WTP per month for the ability to make local and long distance calls via the internet if they had internet, or if not, their maximum WTP for the service if internet connection cost them $20.
Yoo (2002)	Cable television	Korea	1998	Survey respondents were asked their WTP for cable television in Double Bounded Dichotomous Choice format.

Appendix C Selected choice modelling papers

Source	Product(s)	Country	Timeframe	Features or characteristics
Rosston, Savage & Waldman (2010)	Broadband internet	USA	2009	Online survey respondents were asked several times to choose between hypothetical bundles of broadband access, emphasising different elements such as speed, reliability, portability, cost.
Savage & Waldman (2005)	Broadband internet	USA	2002	Survey respondents were asked questions on availability of internet access options and choice questions on broadband.
Savage & Waldman (2004)	Internet access	USA	2003	Survey respondents given choice experiments with attributes of internet access including speed and being always on.
Greenstein & McDevitt (2010)	Broadband over dialup	USA	NA	Uses adoption information together with Savage and Waldman (2004) estimates of WTP for particular attributes of broadband over dialup, such as speed, reliability and being always on.
Ida & Horiguchi, (2008)	Public services over FTTH.	Japan	2006	Focused on WTP for public services provided by FTTH in rural versus urban areas. Public services included digital broadcasting, IP phone, e-government, tele-working, tele-health, etc.
Ida & Sato (2006)	Broadband services including ADSL, Cable and FTTH.	Japan	2003	Survey respondents were asked to state their choice of service, choosing among ADSL, Cable and FTTH.

Source	Product(s)	Country	Timeframe	Features or characteristics
Kim (2005)	Mobile telecommunications	Korea	2002	Survey respondents, who already subscribed to an International Mobile Technology (IMT-2000) service, were asked to choose between hypothetical bundles of service with different qualities (global roaming, video telephony, etc)
Madden & Simpson (1997)	Broadband internet	Australia	1995	Survey respondents were asked to choose between several services, and asked to choose from different broadband subscription bundles.
Ido & Kuroda (2009)	Mobile telephone services	Japan	2004	Revealed preference with respect to 2G versus 3G, elasticities for email, web and movies on the phone.
Ida & Kuroda (2006)	Dialup, ISDN, ADSL, CaTV and FTTH	Japan	2003	Revealed preference. Survey respondents, who all had access to all five internet alternatives, were asked what type of internet they had chosen as well as demographic details.
Ida & Sakahira (2008)	FTTH	Japan	2005	Revealed preference, exploring determinants of staying and switching between broadband technologies in Japan.
Cardona, Schwarz, Yurtoglu & Zulehner (2009)	DSL, mobile and cable broadband	Austria	2006	Revealed preference. Demand estimation for market definition purposes.