6 Evaluating major infrastructure projects: how robust are our processes?

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Abstract

Australian Government spending on infrastructure projects has increased rapidly in recent years, especially over the course of 2009. In this paper, we examine the processes for project evaluation in the light of the Government's commitment in the 2008–09 Budget to '[infrastructure] decision making based on rigorous cost–benefit analysis to ensure the highest economic and social benefits to the nation over the long term' and to 'transparency at all stages of the decision making process'. We find that, contrary to this commitment, significant projects have been approved either with no cost–benefit analysis or with cost–benefit analysis that is clearly of poor quality. Moreover, despite the commitment to transparency, very little information has been disclosed as to how most projects were evaluated.

To better assess the quality of project evaluation, we examine the largest single project the Australian Government has committed to — the construction of the new National Broadband Network (NBN) — and find that, in present value terms, its costs exceed its benefits by somewhere between $14 billion and $20 billion, depending on the discount rate used. We also find that it is inefficient to proceed with the project if its costs exceed $17 billion, even if the alternative is a world in which the representative consumer cannot obtain service in excess of 20 Mbps

1 We are grateful to Jason Soon for research assistance.

The views expressed in this paper are strictly those of the authors and should not be imputed to any of their clients. This is a shortened version of a longer paper that is available on the web at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1465226.

(megabits per second) and even if demand for high-speed service is rising relatively quickly. This amount of $17 billion is well below current estimates of the costs the NBN will involve, especially if (as the Government has pledged) the NBN is to serve non-metropolitan areas.

In the longer version of this paper we also examine the cost–benefit assessment undertaken for the second largest infrastructure project the Government has committed to, which involves the construction of a rail link in Victoria. We find that lower-cost alternatives to the project were not taken into account in the evaluation, in particular the option of increasing capacity through improved efficiency and better governance of the rail network. Even taking that exclusion on board, we find that the appraisal that was approved by Infrastructure Australia (or, at least, the only version of that appraisal that has been made available) is seriously flawed, including errors of double counting and manifestly incorrect estimates of project benefits. Absent these errors, the project would generate benefits that fall well short of its costs.

We conclude by noting that high-quality project evaluations will not be made if governments do not see value in them. This appears to be the case in Australia, especially with respect to major projects. Nonetheless, we advance a number of proposals for improving the process, including transparency (which is now largely lacking), serious audits and reappraisal of projects at predetermined milestones, and steps to introduce greater rigour into key aspects of the analysis.

'The core of public finance', as Jurgen von Hagen (2006, p. 464) has succinctly put it, 'is that some people spend other people's money'. This separation of spenders and payers gives rise to a wide range of problems of accountability and control (which economists typically analyse under the rubric of 'principal–agent' problems), reflecting divergences of interest between these parties and the inability of voters and taxpayers to costlessly and perfectly discipline the behaviour of those who spend money on their behalf.

There are broadly three sets of control mechanisms that are commonly used to limit these risks: *ex ante* rules that shape taxing and spending powers; budget processes that signal the opportunity cost of public funds and manage resource allocation so as to control, if not prevent, externalities between spending agents (including those associated with common pool problems); and political competition and accountability that, however effectively or ineffectively, discipline 'poor' uses of resources and reward 'good' uses. The role of formal project appraisal within these control mechanisms, and the effectiveness with which it is implemented within the Australian federation, is the central concern of this paper.

The specific focus is on the processes used in the economic evaluation of major infrastructure decisions. Particularly since the election of the Rudd Labor Government in 2007, very significant increases have occurred in public infrastructure outlays. Many of these decisions involve individual projects whose costs exceed a billion dollars; if those projects' costs exceed their benefits, the result is to make future generations poorer. The public stake in proper project evaluation is therefore great and, indeed, has been stressed by the Government itself. Thus, in its 2008–09 Budget, the Government committed to '[infrastructure] decision making based on rigorous cost–benefit analysis to ensure the highest economic and social benefits to the nation over the long term' and to 'transparency at all stages of the decision making process'.[2] However, serious concerns have been expressed about the extent and quality of project evaluation in Australia.

So how robust are our project evaluation processes? In examining this question, we start by setting out the nature and role of cost–benefit analysis, and especially its bearing on efficient resource allocation and on the control of principal–agent problems in government. That discussion highlights just how important cost–benefit analysis is to serious project appraisal, and to helping to control the risks inherent in a situation where very large projects, offering highly concentrated benefits but with very diffuse costs, are being vigorously advocated by powerful private interests.

On that basis, we examine the situation in telecommunications. In essence, neither the Howard Government (1996–2007) nor its successor placed any weight on systematic analysis of the costs and benefits of major telecommunications decisions. The most spectacular recent instance is, of course, the decision to build a 'National Broadband Network' (NBN) with significant taxpayer funding. As the Government has stated that no cost–benefit analysis of this decision has been, or will be, undertaken, we carried out such an assessment. Our results suggest that the incremental benefits of the NBN, when compared to the counterfactual scenarios, do not justify the incremental costs.

Given that evaluation of project decisionmaking in telecommunications, we turn to transport in the longer version of this paper. We outline some major trends in transport cost–benefit analysis in Australia, including those resulting from the creation of the Building Australia Fund and the establishment of Infrastructure Australia as a policy advisory body. To assess the quality of the evaluation processes, we undertake a detailed analysis of the east–west rail project in Victoria. Although that project involves several components, some of which are not now proceeding (or have been deferred), it remains extremely large and has now received very substantial funding from the Commonwealth. However, this is a

2 2008–09 Budget Paper No. 1, (Statement 4, pp. 14–15).

project which, even in its sponsor's cost–benefit analysis, had benefits that were not far above costs. Our examination of that cost–benefit analysis in the longer version of the paper raises a number of concerns, including double-counting of benefits and substantial difficulties with the approach the cost–benefit analysis adopts to the calculation of the project's 'wider economic impacts' (essentially, pecuniary externalities associated with the project).

6.1 The nature and role of cost–benefit analysis

In essence, cost–benefit analysis is a technique for evaluating collective decisions that hinges on the comparisons of the costs of a proposal to its benefits, where costs and benefits are valued in monetary terms. Cost–benefit analysis asks whether the sum of the amounts the individuals who comprise the community at issue would be willing to pay for the project to proceed exceeds the costs of that project. Generally, a project enhances wealth — in the sense of the aggregate monetary valuation of the community's resources — if it meets a properly specified cost–benefit test.

Cost–benefit analysis can be viewed from four complementary perspectives.

First, cost–benefit analysis is related to (though not identical with) the basic equi-marginal condition for overall efficiency in resource allocation. Thus, given a cardinally measurable objective function and perfect knowledge of the effect on welfare of any decision, it is a condition of an optimal set of decisions that the marginal dollar of public expenditure has a benefit equal to that of the marginal dollar of private expenditure (thus assuring that the overall level of public expenditure is optimal) and that the benefit of a marginal dollar of public expenditure is equalised across programs, projects and project elements. Because cost–benefit analysis aggregates willingness to pay across agents with different marginal valuations of income, it is not a perfect measure of underlying utility (and hence cannot be treated as an ideal social welfare function); nonetheless, taking that important caveat as given, one would at least question whether a set of public decisions was optimal if it did not maximise the aggregate benefits obtainable for given aggregate costs or minimise the aggregate costs required to obtain a given aggregate benefit, in each case measured using cost–benefit analysis.

Second, set against the backdrop of a given portfolio of projects, cost–benefit analysis can be used to evaluate whether one or more public projects should be added to or removed from that portfolio. In other words, cost–benefit analysis is a tool that can be used to assess whether wealth (the difference between the aggregate valuation of outcomes and the cost of obtaining those outcomes) would be increased by the decision to, say, proceed with a particular project, compared to the relevant alternatives (which may involve doing nothing, deferring or otherwise varying the project, or proceeding with an alternative project).

Third, cost–benefit analysis is an instrument that the principals in public sector governance can use to improve the decisions taken by their agents, and to enhance their supervision of those agents (see, for example, Adler and Posner 2006, Posner 2001 and Spence and Cross 2000). As a result, the requirement to carefully assess and report the costs and benefits of decisions can improve the quality of decision-making and reduce the information asymmetry between principals and agents. In doing so, it can:

- help reduce the risk of 'capture', in which the agent's decisions, rather than reflecting the interests of the principal, come to be determined either by the agenda of self-interested third parties or by the agent's own interests and aspirations
- help correct 'policy bias', which is a situation in which those working in an agency have policy commitments that differ from (and may undermine) those of the public
- help overcome 'shirking', in which agents do not exercise as much diligence in taking decisions as would be warranted
- help disclose and correct the cognitive biases that affect decisionmaking
- increase consistency in decisionmaking, both by standardising the information base on which decisions are taken and by highlighting anomalies, such as differences between project appraisals in the valuation of common elements
- improve performance auditing and accountability by providing a standardised *ex ante* statement of key expected values for costs and benefits.

Ultimately, all of these effects mean that cost–benefit analysis is never merely an analytical tool; rather, as Aaron Wildavsky (1966) emphasised many years ago, it is inevitably an instrument in shaping bureaucratic structure and process, both within each public sector body and between that body, the other elements of the public sector with which it interacts, and the wider political system.

Fourth and last, cost–benefit analysis can be an anchoring device that reduces undesirable policy instability.

6.2 Telecommunications

We start by explaining the relevant context and then examine recent decisions in the light of cost–benefit analysis.

Context and background

Ergas (2008a) sets out the background to recent telecommunications decisions. Two trends dominated the period leading up to the 2007 change in government.

First, an impasse developed in relations between Telstra and the Australian Government over the issue of upgrading the Australian telecommunications network to higher broadband speeds.

Second, the Australian Government engaged in a wide range of spending programs (with appropriations totalling close to $4 billion, in 2008 prices) aimed at promoting service upgrading, usually in regional areas, and implemented an ever broader and more draconian range of quality of service regulations.

None of these spending initiatives or quality of service regulations were ever subjected to proper cost–benefit analysis (or if such analysis was undertaken, it was never disclosed). However, an analysis by one of the authors found that in 1999 the total benefits associated with addressing claimed service quality problems (including in terms of consumer gains and network-related cost savings) were between $644 million and $713 million in present value terms over the length of the project life. These benefits were outweighed by the costs which (again in present value terms) were estimated at $1387 million over the project life (Ergas and Hardin 1999).

The lack of attention to systematic evaluation of the costs and benefits of policy initiatives has continued under the Rudd Government. The Minister for Broadband, Communications and the Digital Economy, Senator Stephen Conroy, when asked by the opposition whether a cost–benefit study of the proposed expenditure had been carried out, said (according to a report in the *Communications Day* of 13 May 2009), that there was 'no need' for such a study, as 'Labor's commitment to build a high speed broadband network has been clear … A range of studies have been carried out all over the world that have investigated the economic impact of broadband.' (Bartholomeusz 2009)

Since then, one study, by Professor Joshua Gans (2009), has been submitted as evidence to a Senate inquiry into the NBN. Although its author notes that the calculations are essentially back of the envelope, the submission suggests that the social benefits of the NBN will exceed the costs. However, these calculations are seriously flawed. These deficiencies are summarised in Appendix A of the longer version of this paper. Even more seriously, however, Professor Gans's submission uses the wrong test for assessing whether a project is worth while: it compares total costs and benefits, when the correct test is whether the incremental gains from the project (relative to network capabilities in the base case) exceed the associated incremental costs.

Before turning to examine the project's costs and benefits, it is useful to undertake a wider consideration of the relevant decision. In particular, it is uncontroversial that sensible policy evaluation requires a specification of the problem to be addressed and of the policy options for addressing it. As a result, it is reasonable to ask what precise problem the NBN is intended to resolve, and what other means might have been used to resolve it.

The Government's primary concerns appear to be with the availability of broadband access and its price. However, the data on availability that the Government has cited actually refers to take-up of broadband services, and hence might be more indicative of the demand for broadband than of its supply. This is all the more probable given that broadband availability appears to greatly exceed demand, with some 80 per cent of PSTN lines being connected to ADSL2+ enabled exchanges and close to 50 per cent of copper lines being short enough deliver very high speeds. Moreover, competing hybrid fibre-coaxial networks (which currently deliver up to 30 Mbps but which can, at relatively low cost, be upgraded to much higher speeds) either pass or run very close to some 60 per cent of premises.[3] Despite all of this, high-speed fixed services account for a relatively small share of total broadband services.[4] It is therefore not implausible that penetration levels simply reflect

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3 Low incremental costs for hybrid fibre-coaxial upgrade are discussed in the Soria and Hernández-Gil paper (2009), as well as in the Telstra documents (2008a, 2008b and 2008c). It is worth noting that, according to the *Communications Day* of 31 July 2009, Telstra will upgrade its hybrid fibre-coaxial network in New Zealand to 100 Mbpss for NZ$10 million. The cost of deploying the proposed FTTP network in those coverage areas is likely to be at least 10 to 20 times greater.

4 According to Telstra's most recent annual results (released on 13 August 2009), Telstra's wireless broadband subscriptions doubled over the year to reach over 1 million (this figure includes data card subscribers only; it does not include customers with 3G handsets). In contrast, Telstra's high-speed services (20 Mbps plus) had 241,000 high-speed subscribers in June 2009, up from 160,000 the previous year. This represents about 10 per cent of Telstra's broadband customers. See http://www.telstra.com.au/abouttelstra/investor/docs/tls685-fyr2009esults
announcement.pdf.

consumers' low valuations of the incremental benefits of higher speed fixed network access.

A similar picture emerges regarding business access to high-speed broadband. Competing, ubiquitous fibre networks cover all of the capital city central business districts (CBDs). Larger business premises outside the CBDs are almost always on direct fibre optic connections, even in non-metropolitan areas, as are premises such as hospitals and government offices. Smaller businesses have access to business parks, which are almost invariably on fibre access networks, and those smaller businesses that operate in activities where high-speed communications are an important element tend to locate in those business parks (where they can also benefit from other economies of agglomeration). Symmetric high-speed services over copper (such as BDSL) are available in virtually all urban locations and in many regional centres. There is, in short, no evidence of any absence of business access to high-speed broadband networks.[5]

There is also no evidence that suppliers of social services lack access to high-speed services — indeed, the opposite is the case. In other words, availability does not appear to be the constraint the NBN deployment assumes.

Australian broadband prices are in the upper half of OECD comparisons. However, prices in a number of countries are distorted by subsidies, and those subsidies would need to be added back, along with a mark-up to reflect the marginal social cost of funds, for a welfare comparison to be made. Additionally and importantly, there is significant competition in Australian broadband supply and key input prices are regulated. Service supply to CBDs and business parks is intensely competitive, as is the wiring of new residential estates. As for established premises in metropolitan areas, broadband is widely provided by Telstra's competitors using Telstra's Unconditioned Local Loop Service (ULLS), a regulated service that provides third-party access to the copper pair. As is shown in Appendix B of the extended version of this paper. Australian regulated ULLS charges are relatively low in urban areas, while take-up of ULLS has increased very rapidly.

As for non-metropolitan areas, the case that supply is failing to keep up with demand is also weak. Overall, these outcomes, like those above, suggest that the

5 Residential mobility and new household formation rates in Australia are relatively high. As a result, consumers who value high-speed access will tend to move to locations at which access is available and will incur low incremental costs from doing so. We are unaware of any evidence of a residential housing price premium associated with access to high-speed broadband. These elements suggest that latent demand, and welfare losses from lack of access, are likely to be low.

primary obstacles to take-up may lie in low customer demand, which implies low customer valuation of any new network.

This is not to say that there are no issues with respect to investment in, and upgrading of, Australia's telecommunications network — the opposite is true. As argued in Ergas (2008a, 2008b), the current telecommunications-specific access regime vests enormous and unwarranted discretion in the regulator. In this industry, as in others, such discretion creates a risk of time inconsistency; that is, of regulatory decisions which *ex post* expropriate the returns on socially worthwhile investments.[6] To that extent, an option for the Government would have been that of reforming the regulatory arrangements (along lines already adopted in the energy industries) so as to provide greater investor confidence, and then seeing whether socially desirable investment in network upgrading materialised.[7] As for areas where service is commercially unviable, these could have been dealt with at relatively low cost through a voucher scheme, which would have the merit of being technologically and competitively neutral (Ergas and Ralph 2008). There is, however, no evidence, at least in material disclosed to date, that the costs and benefits of those options were assessed relative to the option of simply building a new network.

The economics of the new network

What then can be said about the costs and benefits of the new network? To examine the underlying economics, we have used a cost model developed by Concept Economics.[8] The model describes the rollout of a fibre to the home (FTTH) network with a footprint covering 90 per cent of the Australian population by modelling the construction cost of new infrastructure.

6 Simply put, time inconsistency refers to situations where a policy that is optimal (from the point of view of the policymaker) *ex ante* turns out not to be the optimal policy *ex post*. If the policymaker cannot commit to a policy, it may then find itself wanting to change its policy *ex post* (say, after a regulated firm has made an irreversible investment decision), regardless of what it promised *ex ante*. Such an approach to policy is said to be time-inconsistent (Kyland and Prescott 1977). Specific applications of the concept to regulated industries can be found in the literature (Evans, Levine and Trillas 2008; Guthrie 2006; Levine, Stern and Trillas 2005). Ergas (2009b) provides a test of whether ACCC decisions in telecommunications are time-inconsistent (with the conclusion that they are).

7 Obviously, some care is required in the design of such an option. In particular, if there remains a material threat of the Government expropriating the returns on that investment, for example by subsequently building a network of its own, then socially desirable investment may be deterred. Jullien, Pouyet and Sand-Zantman (2009) systematically discuss the conceptual issues involved.

8 The model was developed by Dr Dieter Schadt, and we are grateful for his assistance in this respect. Obviously, he bears no responsibility for our use of the model's results.

As regards capital costs, we have assumed a weighted average cost of capital (WACC) in which the cost of equity is determined according to the capital asset pricing model. This reflects three considerations. First, this investment substitutes for private sector investment in competing infrastructure. Use of any other cost of capital than that for the private sector alternative will distort resource allocation between the public and the private sector (see, for example, Steiner 1974). Second, the Government has confirmed on a number of occasions that it intends the project to earn a commercial rate of return, suggesting that it values capital devoted to this project at that rate of return. Third, investing in a new broadband network has a high level of systematic risk. As a result, the Arrow–Lind conditions for use of the risk-free rate as the discount factor (which depend on the assumption that the benefits of the investment are independent of variations in overall incomes) do not hold in this instance, and the cost of the project to taxpayers must reflect the project's systematic risk.[9]

The model is designed to allow testing of the sensitivity of the results to a range of variables. Setting these variables to their base case levels (which involves a GPON-gigabit passive optical networking-architecture), we estimate a final retail cost per customer (on a nationally averaged basis) of just over $170 per month. This amount is the cost of the access network plus the cost of backhaul to the service provider's network, and an allocation for usage and other retail costs. It is, in other words, broadly comparable to the charge for a broadband service, minus the cost of any content.

While both the input assumptions and the outcomes are broadly consistent with studies undertaken in other countries (see, for example, Analysys Mason 2008), the cost estimates are sensitive to a range of assumptions, including, with respect to 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. Variations in those parameters lead to a possible range for unit per customer costs of between $125 per month and $225 per month. There is also very significant variation in costs between metropolitan and non-metropolitan areas. Thus, for the most likely estimate of $170 per month, unit costs in metropolitan areas are $133 per month, while those in non-metropolitan areas are just under $380.

9 In a classic article, Arrow and Lind (1970) showed that if a government project is 'small' (in relation to the total wealth of taxpayers) and 'the returns from a given public investment are independent of other components of national income', then the social cost of risk for project flows that accrue to taxpayers tends to zero as the number of taxpayers tends to infinity. The required assumption, in other words, is that the returns from the project are not related to (in the sense of being dependent on) income from other investments in the economy.

Given these sensitivities, we have run a variant which seeks to minimise unit costs, including by assuming that eventually all premises will subscribe to the service. This variant, which also sets initial service quality at relatively low, but perhaps not inappropriate, levels (in terms of the Committed Information Rate used to dimension backhaul) and somewhat reduces the WACC, only slightly reduces unit retail costs in metropolitan areas but could reduce unit retail costs in non-metropolitan areas to around $280 per month. Nonetheless, even these costs are high compared to current charges. They are about double the level of current non-content payments for telephony and broadband service (that is, the sum of the monthly rental and of the non-content component of DSL charges) in metropolitan areas and three or more times those in non-metropolitan areas.[10]

These costs need to be compared to alternatives. The most straightforward counterfactual involves continuation and some upgrading of the current copper-based network alongside progressive upgrading of the hybrid fibre-coaxial, with copper delivering speeds of some 20 Mbps to 40 Mbps and the hybrid fibre-coaxial delivering speeds of 50 Mbps to 100 Mbps. The costs of this scenario could be in the order of one-third those of the NBN in metropolitan and regional areas, up to around 80 per cent of the population. Remaining areas would primarily be served by wireless, at costs that would be around one-half those of the NBN, with speeds of 10 Mbps to 30 Mbps. Regulatory reform that increased investment certainty would make the progressive upgrading that took place in this counterfactual both quicker and more extensive.

Incremental cost-based retail network charges for broadband service per connectable premise under the counterfactual would therefore be in the order of $50–$70 per month in metropolitan areas, rising to around $80–$100 per month in regional areas, with a difference relative to the NBN scenario of around $75 per month in metropolitan areas and of $120 per month in regional areas (noting that the regional areas have less population coverage than is envisaged for the NBN, so that the like-for-like comparison involves assuming a regional cost-based rate in the NBN of around $210). Broadly speaking, the additional outlays (of $75 per month in metropolitan areas and of $120 per month in regional areas) allow speeds to rise to 100 Mbps in one step. However, this benefit is somewhat qualified by the fact that deployment of the new network may take 7 to 10 years (if not longer), but the

[10] They are even higher when compared to the access payments made by the average residential premise, remembering that about 30 per cent of households do not subscribe to any form of broadband service. Relative to those current average monthly payments, they are more than twice the current average monthly payments in metropolitan areas and about four times those in non-metropolitan areas.

prospect of that deployment may prevent the somewhat more limited, but sooner, upgrades that would otherwise have occurred from occurring.

The question then is whether the valuation of the incremental speed associated with the NBN outweighs the incremental costs. While there are some symmetric services (such as very high-quality videoconferencing) that could benefit from higher speeds, the difference in delay and overall service quality between (say) 30 Mbps and 60 Mbps would only rarely be discernible. This is all the more so as once the access network operates at reasonably high speeds; the relevant constraints on service quality are likely to come from performance in the core network (that is, the links between the first point of traffic aggregation and the global Internet), with further increases in access network speeds having little effect. Holding all else constant, it is therefore reasonable to expect the valuation of further reductions in download time to decline as average download times themselves decline (that is, as speeds increase). The median consumer's willingness to pay (WTP), taken as a function of service bit rate, would, in other words, increase more slowly for successive increases in speed.

This can be illustrated using the standard Becker (1965) time-allocation model. Naturally, the incremental benefits are higher for those earning higher wages (that is, who have a higher opportunity cost of time), but, all else being equal, the incremental benefits decline with the square of the speed.[11] For any given set of applications, the valuation of speed will therefore be significantly concave, though the location of the valuation curve will shift over time, as 'bandwidth-hungry' applications develop and as a greater number of consumers attain a utility level from access to broadband that induces them to obtain the service (that is, that exceeds the service's start-up costs). Appendix C of the extended version of this paper details the model.

Incremental willingness to pay and net benefits for the new network

Given these considerations, we have undertaken an assessment of the costs and benefits for the project. As with any such assessment, a substantial number of assumptions need to be made. In this section, we explain the approach we have adopted.

[11] Goolsbee and Klenow (2006) use Becker's framework to compute the consumer benefits of access to the Internet, but they do not examine the welfare effects of greater download speeds.

Computing incremental benefits of a project requires specification of a baseline scenario with which to compare the project scenario. We consider three such scenarios, which entail the following alternative comparisons.

Scenario A

- Baseline: The median consumer initially has speeds of 10 Mbps, which gradually increases to 60 Mbps by year 6, and remains on 60 Mbps.
- Project: The median consumer initially has speeds of 10 Mbps, which gradually increase (but at a slightly slower rate than the baseline) to 60 Mbps by year 9, and then has speeds of 100 Mbps from year 10 onwards.

Scenario B

- Baseline: Same as for scenario A.
- Project: The project is delayed by five years, during which time the median consumer is on the same path as the baseline. The median consumer then goes on to 100 Mbps at a later time than with the project Scenario A — from year 15 onwards.

Scenario C

- Baseline: Same as for scenario B.
- Project: Same as project for scenario B, but the project is targeted at consumers with a relatively high willingness to pay — those consumers in the top quintile. This is, in other words, a targeted version of the project, with the aim of serving only high WTP areas.

These speed adoption paths are plotted in figures 6.1 and 6.2.

Figure 6.1 **Time path of speeds: scenario A**

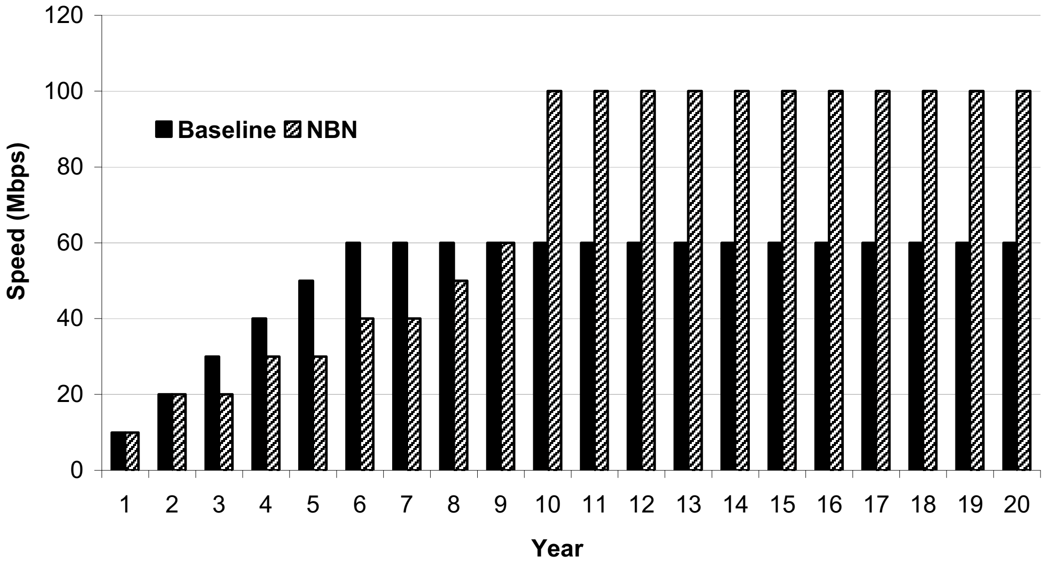
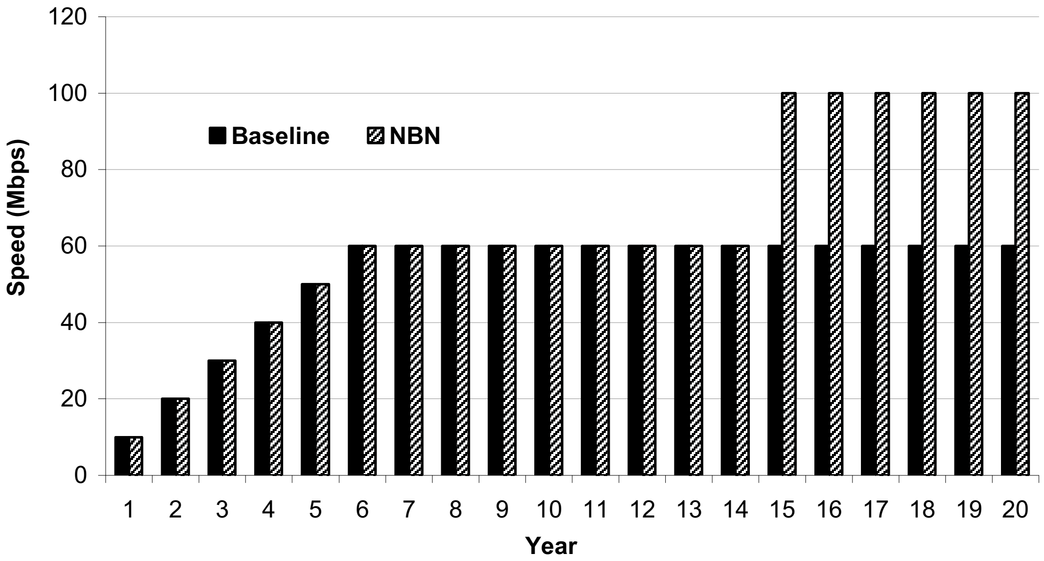


Figure 6.2 **Time path of speeds: scenarios B and C**



For scenario C, we assume the same WTP curves, except that the relevant consumer that is targeted when the project is built has a much higher WTP. By construction, the top 25 per cent of consumers are assumed to have initial valuations exceeding $100, and we take this consumer as the representative consumer that is targeted by the project under scenario C. We also assume that the growth rate of this consumer's WTP is 5 per cent per year (figures 6.3 and 6.4)

Figure 6.3 **Time path of willingness to pay curves: scenarios A and B**

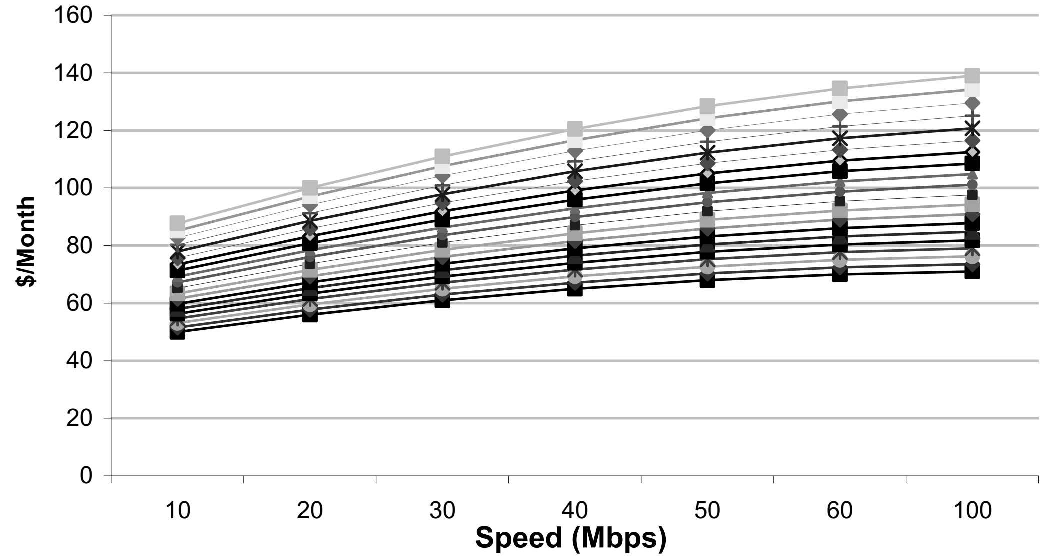
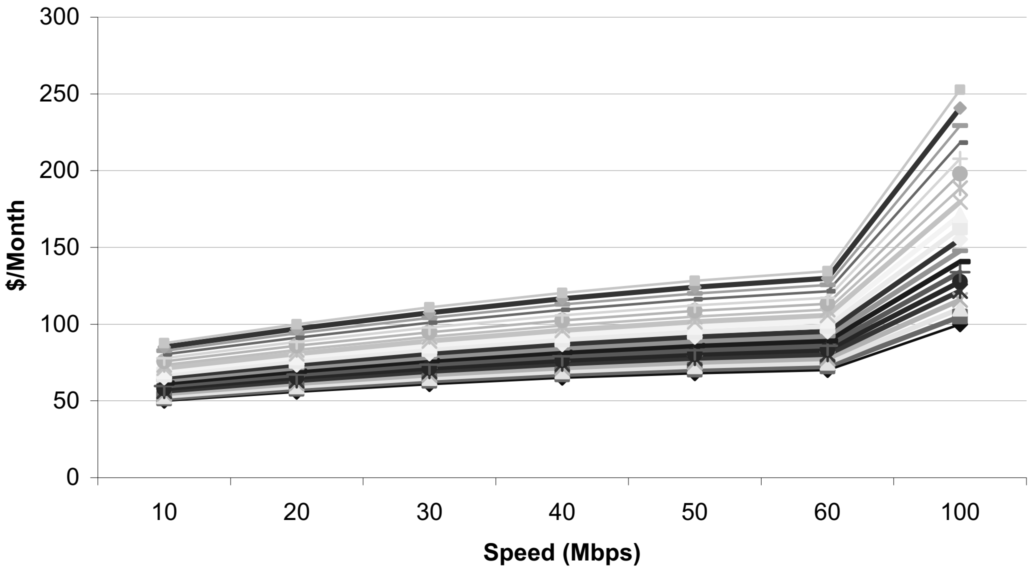


Figure 6.4 **Time path of willingness to pay: scenario C**



The next step is to combine the speed adoption path and the WTP curves to calculate a WTP curve for the baseline and the project under each scenario, and also compute the difference in the path of WTPs under each scenario. This gives us the incremental WTP curve — it is the path of benefits that the representative consumer would receive if the project went ahead, instead of the baseline.

These are plotted in figures 6.5 to 6.7.

Figure 6.5 **Path of willingness to pay under the baseline and the National Broadband Network: scenario A**

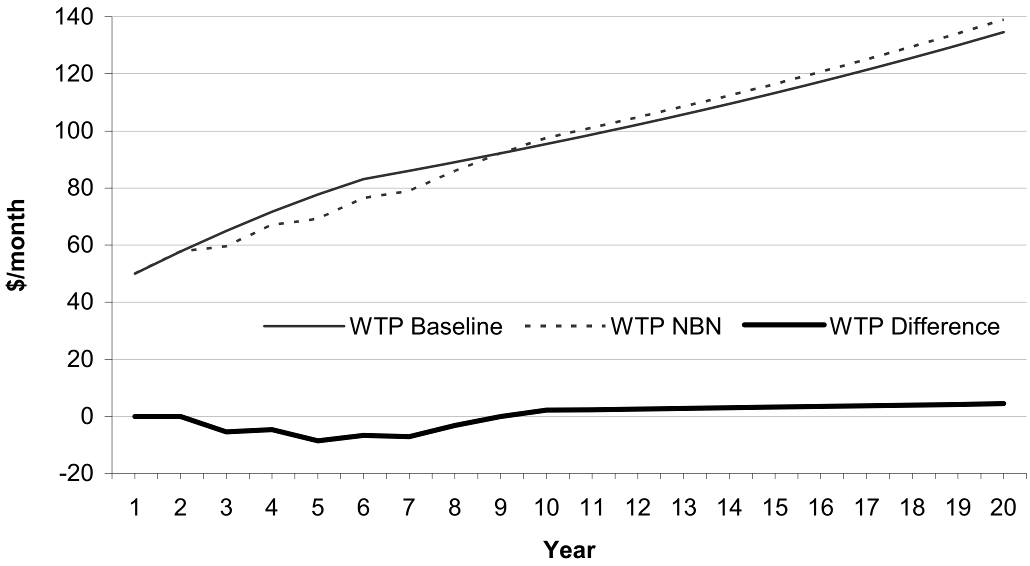


Figure 6.6 **Path of willingness to pay under the baseline and the National Broadband Network: scenario B**

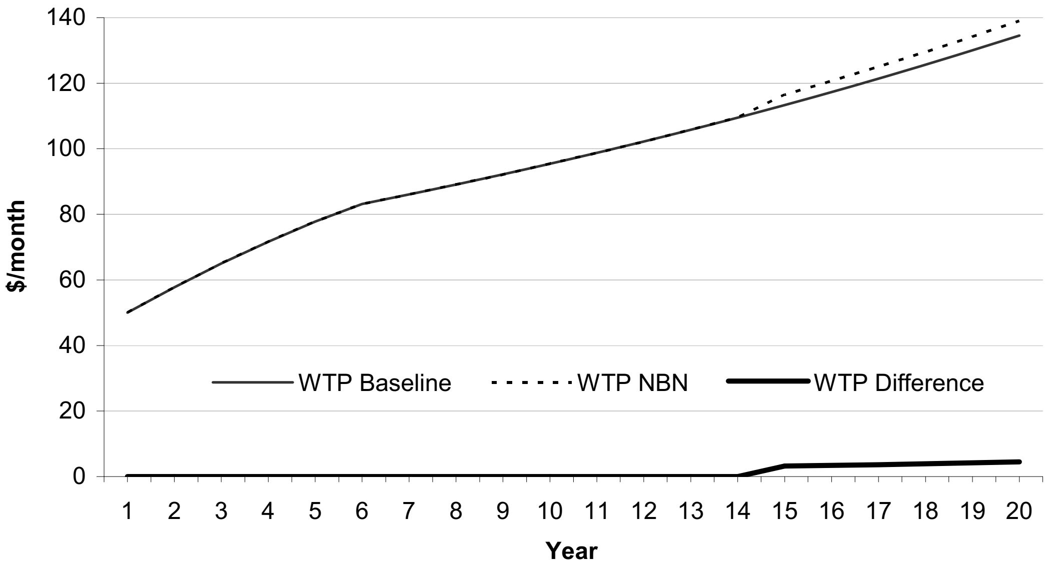
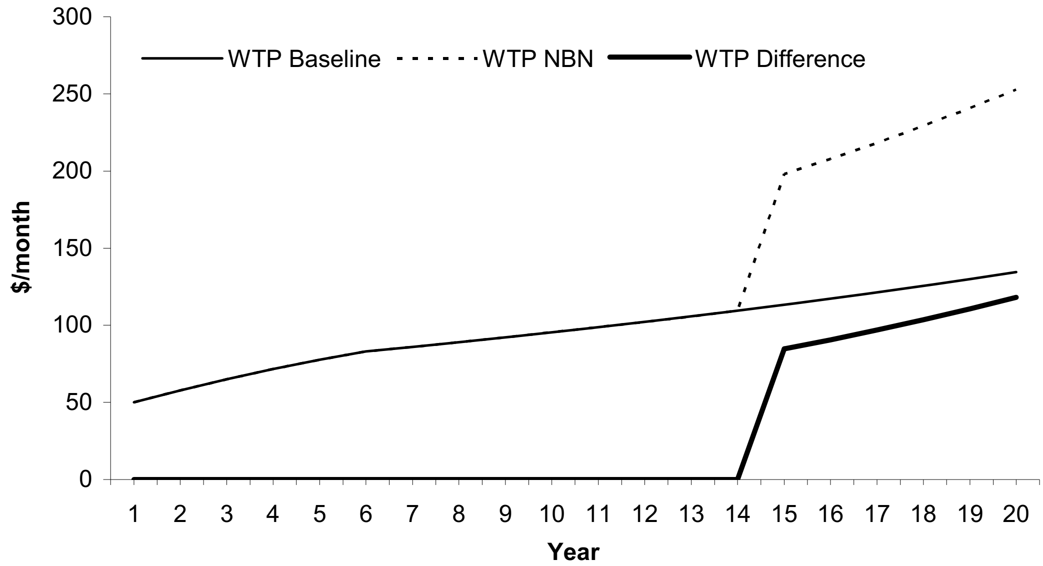


Figure 6.7 **Path of willingness to pay under the baseline and the National Broadband Network: scenario C**



We then compute the present value of the stream of benefits under each scenario, using a range of discount rates. The numbers in the tables are the present value of the consumer's WTP, expressed in dollars per month. Thus, the number in the first row of the first column ($1273) is the present value of the future stream of benefits that the consumer expects to receive.

The tables also compute the 'monthly constant equivalent', which is the constant amount that a consumer with the relevant discount rate would be willing to pay in each and every month over the next 20 years to receive the given stream of benefits. So, for example, under scenario A, a consumer with a 4 per cent discount rate would be willing to pay $0.52 every month (rounded up to $1 in the table) for the next 20 years to not have the NBN, and instead receive the benefits under the baseline.

To arrive at a final assessment of costs and benefits, we subtract the incremental costs computed earlier from these incremental benefits. Note that under scenario A the incremental benefits are negative, and so accounting for the incremental monthly costs that were computed earlier (of around $75 per month in metropolitan areas and of $120 per month in regional areas), the NBN has incremental net benefits that are negative. For all the other scenarios, the incremental benefits of the NBN are far below the incremental costs; indeed, it is difficult to conceive of credible scenarios for the NBN that would make its incremental costs fall below the incremental benefits (that is, result in the project yielding net benefits to Australia).

Indeed, in all of the scenarios, the incremental upgrading path is always the most socially beneficial.

Table 6.1 **Incremental benefits under various scenarios**

		NPV of per month benefits			*Monthly equivalent*		
	Discount rate	*Baseline*	*NBN*	*Increment*	*Baseline*	*NBN*	*Increment*
	%	$	$	$	$	$	$
Scenario A	4	1237	1228	–9	91	90	–1
	8	846	834	–13	86	85	–1
	12	612	599	–13	82	80	–2
Scenario B	4	1237	1249	11	91	92	1
	8	846	852	6	86	87	1
	12	612	615	3	82	82	0
Scenario C	4	1237	1540	303	91	113	22
	8	846	1002	156	86	102	16
	12	612	695	83	82	93	11

NPV = net present value

Sensitivity analysis of willingness to pay paths

To what extent do these results depend on the willingness to pay curves? To examine this question, we have conducted a sensitivity analysis on the WTP assessment, by examining 'enhanced' WTP curves in each of the three scenarios.

The results of the enhanced WTP analysis are very similar to the standard analysis. The ranking of the three scenarios remains unchanged, with the delayed project (scenario B) and the targeted project (scenario C) becoming slightly more attractive from an incremental benefit point of view. The incremental benefits under scenario A actually fall and become more negative under the enhanced WTP setting. In other words, increasing the willingness to pay for higher speed reduces the attractiveness of the NBN option, essentially because it also increases the density of demand in the midspeed tier (and hence increases the relative value of the options that involve incremental development of the access network).

Put slightly differently, the enhanced WTP curves have higher marginal WTP at lower speeds relative to the original analysis. Under the NBN the consumer misses out on those relatively high marginal gains in the early years, even though the consumer eventually receives high absolute benefits. This fact, combined with the logic of discounting, means that scenarios B and C become more attractive, while scenario A becomes less attractive.

Table 6.2 **Incremental benefits under various scenarios: enhanced WTP**

		NPV of per month benefits			*Monthly equivalent*		
	Discount rate	*Baseline*	*NBN*	*Increment*	*Baseline*	*NBN*	*Increment*
	%	$	$	$	$	$	$
Scenario A	4	1608	1609	1	118	118	0
	8	1087	1070	–17	111	109	–2
	12	776	753	–23	104	101	–3
Scenario B	4	1608	1648	41	118	121	3
	8	1087	1108	21	111	113	2
	12	776	787	11	104	105	1
Scenario C	4	1608	1918	310	118	141	23
	8	1087	1247	160	111	127	16
	12	776	861	85	104	115	11

NPV = net present value

Overall, the results are relatively robust because WTP is concave in speed, network coverage and in the rate at which upgrades are deployed, while costs are convex at a discontinuity (the upgrade to FTTP).[12] Moreover, the results reported above tend to understate the consequences of this fundamental feature of the situation, as we consider a median user, while there are substantial numbers of users — especially in non-metropolitan areas — who have low willingness but very high costs to serve.[13] In the counterfactual, the loss incurred on these users is limited by the more limited coverage of the upgrading; in the NBN, these costs are incurred in full and relatively soon.

Comparison of project costs and benefits

To examine the net benefits and costs of the NBN, we examine a scenario (scenario D) that is intentionally conservative as far as service quality is concerned, as it involves speeds under the base case rising to only 20 Mbps, which is less than the hybrid fibre-coaxial networks can currently provide.

12 Costs are, in other words, concave in speed up to 30–60 Mbps and then leap at the discontinuity. Costs are always likely to be convex in the geographical breadth of deployment and in the speed of deployment, while the WTP gains in each of these dimensions are likely to be concave.

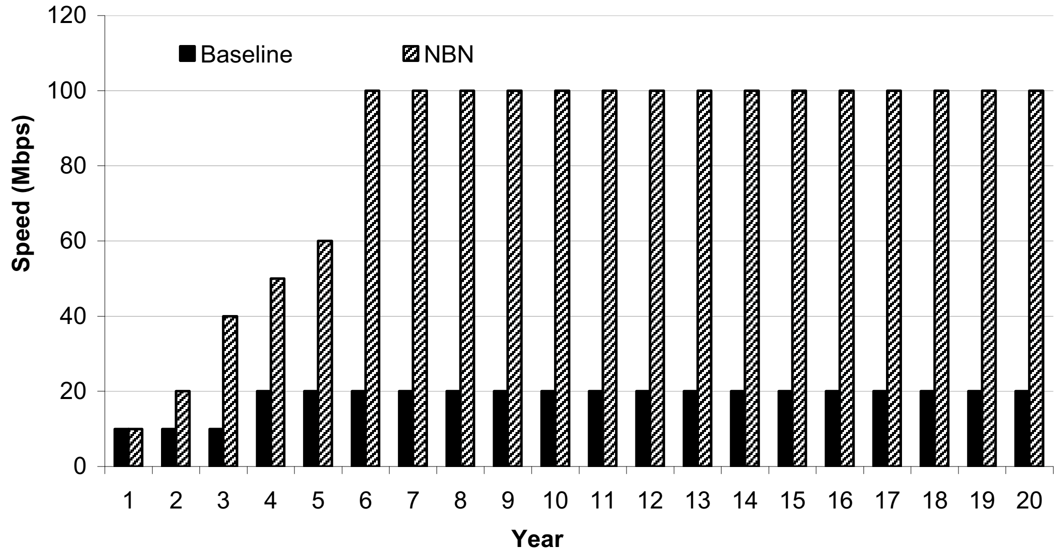
13 This probably reflects the fact that WTP is correlated with human capital endowment, and human capital — especially that associated with 'information' activities — tends to be concentrated in metropolitan areas (see O'Flaherty 2005).

Scenario D

- Baseline: The median consumer initially has speeds of 10 Mbps, which increase to 20 Mbps in the fourth year and remain there.
- Project: The median consumer initially has speeds of 10 Mbps, which gradually increase to 100 Mbps by the sixth year of the NBN project, where they remain.

These speed adoption paths are plotted in figure 6.8.

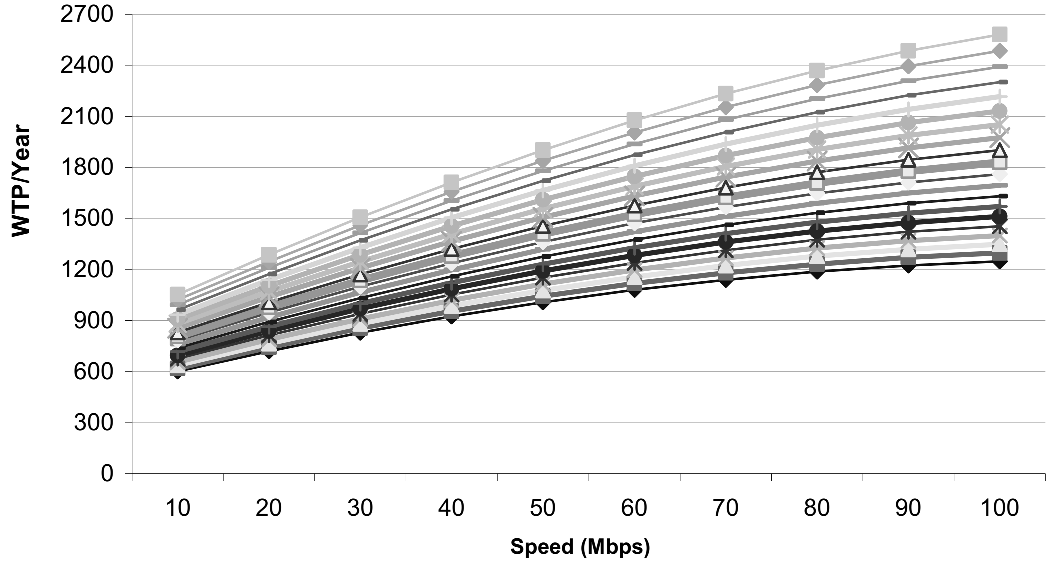
Figure 6.8 **Time path of speeds under scenario D**



For consumer willingness to pay, we assume a monthly WTP of $50 for 10 Mbps, increasing to $104 for 100 Mbps. To estimate aggregate willingness to pay, we assume that all consumers are alike. We also assume an annual growth rate of 3 per cent in WTP at the lowest speed, but assume that the growth rate increases as we move up the WTP curve. Thus, we assume an annual growth of 3 per cent for WTP for 10 Mbps, with the growth rate rising to 3.9 per cent for 100 Mbps. The initial annual WTP curve for scenario D and its growth rate over time is shown in figure 6.9.

Our next step is to combine the speed adoption path and the WTP curves to calculate a WTP curve over time for the baseline and the project, and also compute the difference in the path of WTPs under each scenario. This gives us the incremental WTP curve — it is the path of benefits that the representative consumer would receive if the project went ahead, instead of the baseline. These are plotted in figure 6.10.

Figure 6.9 **Time path of annual willingness to pay curves: scenario D**



Under the scenario D baseline, we assume that retail prices are $30 per month in metropolitan areas, and $50 per month in non-metro areas, which gives a national monthly cost recovery retail price of $32.90 (assuming an 85%–15% split between urban and non-urban areas).

For the NBN, under scenario D, and the assumption of a CIR (Committed Information Rate) of 1 Mbps, the engineering cost model provides estimates of break-even retail prices of $128 per month in metro areas, and $313 in non-metro areas, for a national average cost recovery price of $155 (again assuming a 85–15 per centsplit between metro and non-metro areas).

To compute aggregate costs and benefits, an assumption must be made about the path of demand. Under scenario D, the NBN engineering cost model assumes an S-shaped take-up pattern over time, with 50 per cent of the population taking up the service by year 6 and a saturation rate of 80 per cent. For the baseline case, we assume a slightly more rapid take-up rate, with the same starting percentage as under the NBN but with a final saturation rate of 90 per cent. These two demand profiles are shown in figure 6.11.

Figure 6.10 **Path of annual individual annual WTPs under the baseline and National Broadband Network: scenario D**

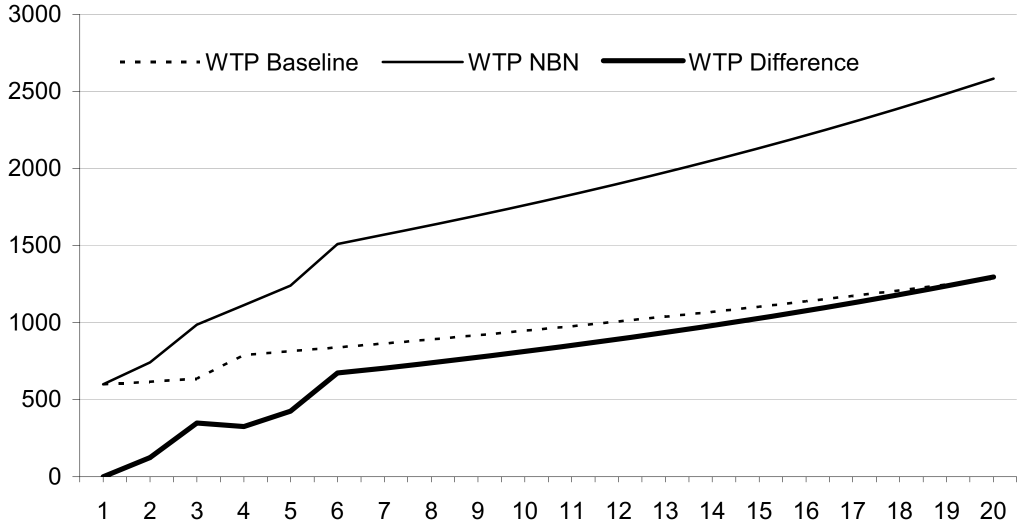
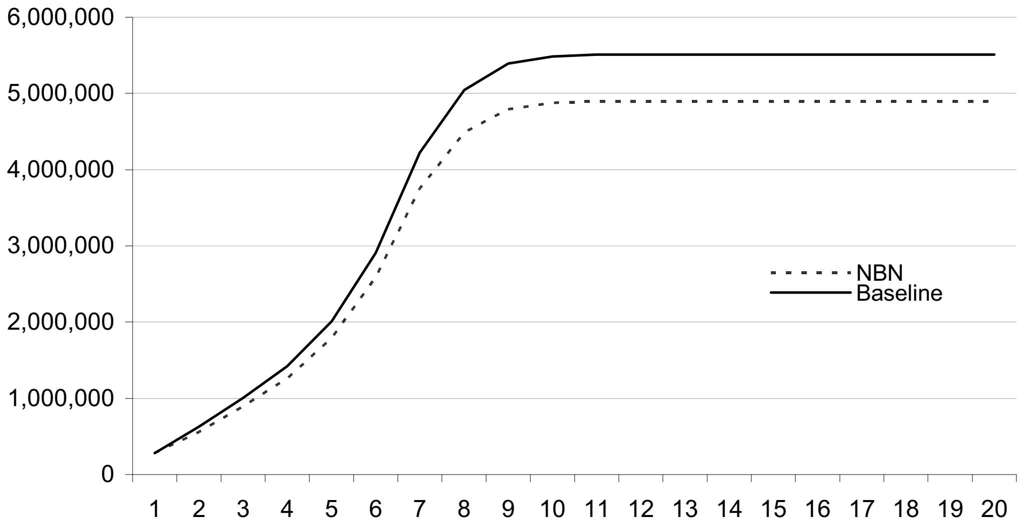


Figure 6.11 **Take-up paths: scenario D**



Finally, we can put all of this together and compute aggregate costs and benefits under the baseline and the NBN, and compute the present value of net incremental benefits of the NBN (table 6.3). The numbers in the table are the estimated present value of the net incremental benefit of the NBN, relative to the baseline. The estimates suggest that undertaking the project will result in a social loss in present value terms of between $13.9 billion and $20.4 billion, depending on the discount rate chosen.

Table 6.3 **Present value of the net incremental benefits of the National Broadband Network: scenario D**

Discount rate	*Present value*
%	$(2009) billion
6	–20.4
7	–19.2
8	–18.1
9	–17.2
10	–16.2
11	–15.4
12	–14.6
13	–13.9

Since we have assumed that the willingness to pay for the NBN far exceeds that for the baseline, it is clear that the key drivers of the NBN's social losses are the large capital and operating costs of the project.

In fact, the central result of our modelling can be expressed in terms of the familiar condition for replacement investment. More specifically, it is economic to replace the existing network with a new network if the net present value of the ***total*** costs of the new network is less than the net present value of the ***incremental*** costs of the existing network, in each case adjusted for relative service quality (which we do through the willingness to pay calculation). It turns out that the NBN would satisfy this condition only if the present value of the additional cost of deploying and operating the NBN, compared to even the 20 Mbps scenario, were no more than $14 billion (evaluated at a discount rate of 13 per cent) to $24.7 billion (evaluated at a discount rate of 6 per cent).

Put slightly differently, assuming a midpoint discount rate of 10 per cent, it is irrational to spend more than $17 billion on the NBN, even if the alternative is a world in which the representative consumer cannot obtain service in excess of 20 Mbps and even if demand for high-speed service is rising relatively quickly. This amount of $17 billion is well below current estimates of the costs the NBN will involve, especially if it is to serve non-metropolitan areas. Alternatively and more realistically, if the base case (that is, the alternative to the NBN) is one in which the representative consumer is assumed to ultimately have access to 40 Mbps (rather than 20 Mbps as above), then it is inefficient to proceed with the NBN if the present value of its incremental costs of deployment and operation, evaluated at a 10 per cent discount rate, exceed $10.6 billion, which is below the lowest bound of the estimates of these costs.[14]

Discussion of the results

It may be thought that these estimates understate the gains from the project because they do not take account of wider economic and social benefits. While it is likely that use of higher speed access lines will allow productivity gains, we would expect those gains to be reflected in consumers' and businesses' willingness to pay for that use. As a result, treating the productive efficiency gains as an added benefit amounts to double counting. 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. Moreover, to the extent such social benefits exist, there must be the question of whether the project is the most efficient means of ensuring their delivery.[15] 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.[16]

Rather, it is our view that the estimates understate the likely project-related social costs. Thus, it seems probable that, evaluated at a rate of return that reflects the risks the project imposes on taxpayers, the project will incur losses.[17] While those losses themselves are a transfer, the distortions associated with financing them through taxation are not, and need to be added to the social costs of the project. In contrast,

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[14] Using 40 Mbps is especially realistic if sorting is allowed to occur — that is, if account is taken of the fact that suppliers will target those customers who place a high value on speed, and that those customers will have incentives to choose locations (for instance, at which to site offices) that offer such access.

[15] If these benefits can be obtained at lower cost under some alternative option, then the cost increase from forgoing the use of that lower cost option (that is, from using the NBN to deliver those benefits, rather than the cheaper alternative) is a net cost to the project and should be treated as such in the analysis.

[16] Claimed wider benefits such as the promotion of tele-medicine seem very difficult to credit. With respect to tele-medicine, it is not clear what residential medical applications require access to residential fibre optics, short of a future being projected in which individuals will have CAT scanners in their homes. As for GPs and medical centres, there is no evidence that network access costs and speeds have any effect on their use of tele-medicine; Paolucci et al. (2009) survey the literature on the effectiveness of tele-medicine and do not find such evidence. Finally, hospitals are generally already connected to high-speed access networks and would be so under the factual and counterfactual alike.

[17] Of course, the project might be profitable were it given a monopoly or regulatory protection from competition (say, through an exemption from the merger laws that allowed it to acquire assets that would otherwise act as an effective competitive constraint). However, were that the case, then the efficiency costs of such a monopoly would need to be brought to account in the cost–benefit analysis.

under the counterfactual, taxpayer outlays would be limited to any vouchers used to subsidise demand by consumers in high-cost areas. Moreover, the prospect of taxpayer financing of the project's losses can lead to moral hazard, as well as to direct political interference in project decisions, diminishing the productive efficiency with which the project is pursued. Our estimates, however, do not gross up financing costs for the difference in the value of private and public income (that is, for the marginal social cost of funds) and assume the project is deployed and operated at least cost.

Additionally, the NBN project, whatever its merits, will create risks to the integrity of the regulatory system. First, the Australian Government will be both the primary investor in a major competitor and the industry policymaker and regulator, creating sovereign risk for private investors and introducing potential distortions to policy and regulatory decisions. Second, the NBN may involve some form of joint venture between entities that would otherwise have the scope to compete on a head to head basis, with the associated dangers of collusion. Third, there will be strong pressures for geographically uniform pricing, which can add distortions not only to resource allocation but also to competition (for example, if restrictions or taxes on bypass are used to protect the flow of cross-subsidies). These costs are not taken into account in our estimates.

At the same time, our estimates of the project benefits do not take account of offsetting equilibrating processes and therefore tend to overstate them. In particular, it is clear that, in the counterfactual, those consumers that place the greatest value on high-speed access will generally have such access, for two reasons: first, suppliers will have incentives to provide it, including through geographically targeted upgrades; and second, over 10 to 15 years , geographical mobility is relatively high, and consumers will sort themselves geographically in a way that, inter alia, reflects the valuations they place on different forms of broadband access. As a result, the population that gains access to very high-speed broadband in the NBN world relative to the counterfactual is likely to be that segment that places the lowest valuation on broadband access. To that extent, our estimates, which do not allow for this sorting process, exaggerate the gains from NBN deployment. This is all the more the case as our counterfactual scenario (scenario D) assumes relatively low speeds would be available should the NBN not proceed.

This overstatement of project gains is accentuated by our approach to estimating net benefits, which compares the willingness to pay for the incremental speed the project provides to the incremental cost of providing that speed. However, whether benefits are realised depends to a significant extent on the entity's future pricing policies. For example, if prices are set at average costs, then some potential utility gains will not be realised (as those consumers who value the project output at more than incremental cost, but less than project average cost, will not consume its services).[18] This is equivalent to the issue that arises when toll roads are built: the cost–benefit analysis for the road link may be undertaken on the basis of potential social gains; however, the tolls may lead to some users whose valuations exceed marginal costs (and hence who are counted towards the cost–benefit analysis's estimate of benefits) not actually using the road, causing realised benefits to fall below assumed levels. Because we do not discount our estimated benefits for this effect of the entity's pricing policies, we probably overstate the likely benefits.[19]

Finally, we have not costed the most natural alternative — which is simply to delay the project and re-examine its economics every few years. This option to delay is likely to have high value, particularly if it is accompanied by regulatory reform that addresses the current disincentives to invest. Such an option would allow any public investment to be more narrowly targeted to areas of genuine and durable market failure and would reduce both the risk of asset stranding and of significant deadweight losses due to the tax financing of project losses.

In short, we believe our estimates overstate the likely gains and understate the likely costs from the NBN.

All that said, the notion of wider productivity benefits from broadband deployment is a popular one, with especially frequent reference being made[20] to an estimate by Access Economics that:

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[18] As noted above, the Australian Government's *National Baseline of School Broadband Connectivity 2008*, shows that while 'the majority of schools in metropolitan locations reported using fibre (51.6 per cent) and most schools in provincial locations also reported using fibre (46.5 per cent)', most schools 'use download speeds of up to 4 megabits per second, which is the lowest download speed range used in the FCS baseline survey. This disparity may be due to affordability of the service or the specific contractual arrangements negotiated, throttling and issues relating to the availability of suitable online curriculum resources and tools.'

[19] Obviously, were perfect lump sum taxes and transfers available, then no such social costs would eventuate. Project charges to users would, in such a world, be set to marginal costs, and any fixed costs would be covered through public transfers. Unfortunately, such perfect lump sum taxes and transfers are not available, and hence it may be efficient to impose break-even constraints (or at least some degree of fixed cost recovery) on public suppliers. The welfare costs of any such constraints then need to be taken into account.

[20] 'Access Economics predicts that a national high-speed broadband network would mean economy-wide productivity growth 1.1 per cent higher after ten years compared to if the network was not built.' Senator the Hon Stephen Conroy, Minister for Broadband, Communications and the Digital Economy, speech to CeBIT Australia 2009 AusInnovate Conference, 12 May 2009. The Minister goes on to say: 'It is worth noting that Access Economics views this as a conservative estimate.' However, as discussed below, the comparison Access Economics makes is to a world in which only dial-up service is available (noting that as of the time of writing, 70 per cent of Australian households subscribe to some form of broadband).

… economy-wide multifactor productivity levels would be around 1.1 per cent higher in an Australian economy with HSBB [high-speed broadband] available everywhere relative to an Australian economy without any HSBB after ten years. That is, the average annual growth rates in productivity would be around 0.1 percentage points a year higher in a complete HSBB world *compared with a situation where only, say, dial-up was available.* (Access Economics 2009, p. 20, emphasis added.)

However, as the Access Economics report plainly states, these productivity gains are relative to an economy in which only dial-up service, or similarly very low-speed access options, would otherwise be available. Moreover, it is also plain from the Access Economics report that the numbers cited are no more than assumptions, albeit ones Access Economics believes to be conservative for the comparison being made.

To take account of these differences, we believe that the Access Economics estimates of productivity gains should be set to one-third to one-half their initial levels, given that 70 per cent of households now have some form of broadband access. Additionally, account needs to be taken of the likely crowding-out effects of the public expenditure. We use a simple macroeconomic model with crowding out (> 0) to assess the likely impacts. The results, set out in table 6.4, are expressed as the present value of the cumulative change in GDP over a twelve year period, discounted to the present at a discount rate of 7 per cent (the rate used by Access Economics) and put in 2009 dollars. Broadly, the results suggest that cumulative GDP declines, despite an assumed increase in productivity.

Table 6.4 shows the present value, in 2009 dollars, of the cumulative 12-year change in GDP due to construction of the NBN, for a range of values of productivity increase and of extent of crowding out of other investment.

Table 6.4 **Present value of the cumulative 12-year change in GDP due to construction of the National Broadband Network**

Increase in productivity level						*Degree of crowding out*
	0.5	*0.6*	*0.7*	*0.8*	*0.9*	*1.0*
0.3	–12	–17.1	–22.2	–27.3	–32.4	–37.5
0.4	–7.6	–12.7	–17.8	–22.9	–28	–33
0.5	–3.2	–8.3	–13.4	–18.5	–21	–23.6

Note: A discount rate of 7 per cent is used, for comparability with the Access Economics (2009) results.

This loss is not directly comparable to that derived from a comparison of incremental project costs and consumer valuations; however, some component of it — that part that reflects distortions due to the burden of taxation — could properly be added to the cost–benefit analysis loss (as that loss is calculated without regard to the difference between the private and public value of income). Unfortunately, this component is not separately identifiable, being simply an element in the assumed crowding-out parameter.

Conclusions on telecommunications

In short, under both the Howard and Rudd governments, important telecommunications decisions have been made without formal, transparent assessment of costs and benefits. Our review — both of the quality of service regulations implemented by the previous government, and of the proposed NBN — suggests such an assessment would conclude that the policies at issue impose costs than exceed the relevant benefits.

6.3 Improving the evaluation process

The case studies set out above and in the long version of this paper suggest that at least some important infrastructure decisions are being taken on the basis of little evidence and in at least some instances, inadequate analysis. This is an obvious concern given the scope poor infrastructure decisions have to reduce capital productivity and hence lower living standards in the longer term. Mounting evidence of inefficiencies in the way our infrastructure is run — with the search for 'ribbon-cutting' opportunities displacing adequate investment in maintenance, causing a rapidly growing maintenance deficit that is well documented in Victoria and New South Wales (NSW Audit Office 2006, Victorian Auditor General 2008) — only adds to the concerns. What then can be done to strengthen the evaluation process?

Ultimately, the quality of evaluation depends on the value governments place upon it. Governments that view project evaluation as merely a nuisance that stands in the way of the decisions they want to take, and that believe they can get away with no evaluation or poor quality evaluation, will, over time, invariably succeed in devaluing the evaluation process. This has, we believe, occurred in Australia in recent years.

In part, this simply reflects a loosening of government budget constraints due, first, to sustained economic growth and, second, to a belief that the global financial crisis meant that high levels of government spending were not only feasible, but also desirable. As the threat of recession loomed, confused reasoning led to a belief that infrastructure investment could legitimately be claimed to be a tool of macroeconomic policy, even though, in an economy with monetary and aggregate fiscal policy instruments, infrastructure investment should play no role in stabilisation policy and cyclical conditions should not affect the timing or extent of infrastructure outlays, other than through their effects on projected demand and on the shadow prices of inputs (effects which, properly analysed, can suggest that infrastructure projects should be deferred, rather than accelerated, during downturns); see, for example, Bureau 1985.[21]

There are, however, also longer term forces at work. These forces reduce the effectiveness of accountability and increase the attractiveness of infrastructure decisions as elements in rent-seeking bargains.

The first is the ever greater blurring of responsibility for infrastructure between the Commonwealth and the States, and the progressive loosening, by the Commonwealth, of budget constraints at a state level. This reduces the electoral accountability of, and electoral pressure on, State Governments, while reducing the opportunity cost that State Governments incur for poor investment decisions. To some extent, the Commonwealth has sought to offset the resulting moral hazard by imposing performance obligations on the States, such as the evaluation requirements built into Auslink. However, much as with foreign aid, these requirements typically bear only a very indirect link to the outcome being sought (which, in this case, is quality decisionmaking) and readily become (at best) 'tick-the-box' constraints that are often easily gamed (as the quality of compliance is rarely monitored, and, when monitored, even more rarely acted upon). Threats of conditionality have little credibility, especially when doing so would impose a significant political cost on the Commonwealth itself. Again, much as with foreign aid (see Azam, Devarajan and O'Connell 1999; Brautigam 2000; Knack 2001; Alesina and Weder 2002; Bardhan 2005; Easterly 2006; Moss, Pettersson and van de Walle 2006; and Janus 2009), the result is a degradation in institutional quality and in ultimate outcomes.

These issues associated with fiscal federalism have become even more complex with the creation of the Building Australia Fund and of Infrastructure Australia. Although there can be merit in coordinated approaches to infrastructure selection, there can be little doubt that the new mechanisms create significant incentive

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21 Bureau develops a non-Walrasian model with an external constraint, a monetary policy instrument and fiscal policy. While no policy instrument should be thrown away, his main result is that macroeconomic considerations should enter into the evaluation of infrastructure investment only to the extent that the consequences of that investment are orthogonal to those of the macroeconomic instruments. As for the impacts of cyclical factors on the cost–benefit analysis, where public assets will compete with private assets (as in the case of the NBN), then the costs of those public assets will rise during recessions, even in the presence of Keynesian unemployment; see, for example, Johansson (1991, pp. 122–3). Additionally, to the extent demand expectations are reduced, this should lead to lower infrastructure investment.

problems. To the extent to which the projects they fund are worth while, that funding may simply displace funding of those projects by the States themselves, but with higher transactions costs and possibly poorer monitoring and other performance incentives in the process.[22] There may, in other words, be incentives for adverse selection, and then for moral hazard in project execution to boot.[23]

The second factor that has contributed to a decline in the quality of project evaluation is the growing involvement of the private sector in the design, construction, financing and operation of major infrastructure projects, both through the contracting out of almost all aspects of project implementation and perhaps especially, through public–private partnerships (PPPs). While these may have merits in terms of productive efficiency, the use of high-powered incentives[24] has complex, and often undesirable, impacts on the quality of public administration (see for example, Estache and Martimort 1999). In particular, because the incentives are high powered (that is, the private party secures substantial gains from reducing costs under the contract), these arrangements increase the returns to rent-seeking and to tainted deals between governments and private sector suppliers. Particularly with PPPs, the effects are then threefold: they concentrate the gains from the project (as some share of these is now captured by the private participant), and, by so doing, increase the payoffs from collusion between the public decisionmaker and the project's private beneficiaries; they allow crucial aspects of the project to be cloaked in commercial commerciality, thus reducing the transactions costs of collusion; and they relax (or, more properly, are widely but incorrectly claimed to relax) the public sector budget constraint. Each of these effects induces a deterioration in the efficiency of decisions and overall outcomes.

Ultimately, PPPs are only as good as the governments that make them; and if governments are intent on poor decisions, these partnerships can not only make

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22 Obviously, if the Commonwealth funding were simply matching grants associated with the pure spillover effects of state infrastructure decisions — that is, a Pigouvian subsidy — the issue of displacement would not arise. Conversely, if the projects are so poor that they would never have been undertaken by the states then there will indeed be a 'flypaper' effect and aggregate infrastructure outlays will rise (on which see, generally, Brennan and Pincus 1990; as per Brennan and Pincus, this is a case where the grant pushes spending to the corner solution).

23 The question of how to design multi-level funding institutions and associated cost–benefit analysis processes so as to deal with these effects has received some attention in the EU, although with few readily implemented results to date; see Florio 2007.

24 The 'power' of an incentive structure is determined by the extent to which the agent to whom that incentive structure applies can secure for itself the gains from cost reductions (or other improvements in performance). Incentives are said to be 'high powered' when the agent secures a large share of the gains (as in a fixed price contract); conversely, they are 'low powered' when the agent's share of any gains is small (as in a cost-reimbursement contract).

those decisions more (privately) profitable but allow them to be locked in through long-term, judicially enforceable, contractual commitments.[25]

A third factor, which is yet to fully play itself out, is the recourse to hypothecated funding sources for long-term infrastructure finance, most notably the Building Australia Fund. While economic theory yields ambiguous results as to the effects of hypothecation on fiscal efficiency[26], it does identify a number of important ways in which earmarking it can reduce the quality of public expenditures.

First, earmarking implies inflexibility in the allocation of revenues among competing uses. If the earmarking is substantive, in the sense of being effectively constraining, social rates of return are unlikely to be equalised at the margin across uses. Tax rates, expenditure levels or more likely both, will be distorted as a consequence.

Second, reserving revenues to a program gives it a monopoly over those revenues, encouraging and potentially perpetuating technical inefficiency in its supply.

Third, earmarking can facilitate rent-seeking by allowing the interest groups that benefit from the hypothecated revenue stream to focus their activities more effectively. Rather than competing against other interest groups for a larger share of general revenues, the relevant groups can limit their efforts to seeking an increase in (or protecting from erosion) the hypothecated fund. At the same time, the political commitment they secure is potentially made more credible by the earmarking, increasing both the 'price' that the interest groups are willing to pay in exchange and the resources they are willing to dissipate in obtaining it. Rent-seeking coalitions therefore become easier to create and sustain, and the aggregate costs to the community from rent-seeking rise, as Kimenyi, Lee and Tollinson (1990) found in their study of the US Highway Trust Fund.

Fourth, these adverse consequences are made all the greater by the risk created by earmarking of fiscal illusion; that is, of the hypothecated revenues not being as visible as other forms of public revenue and expenditure.

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[25] This is similar to the 'Landes–Posner effect', whereby an independent judiciary increases the extent of rent-seeking by making it easier for legislators to lock in tainted deals (Landes and Posner 1975).

[26] For example, earmarking may be a way of increasing the credibility of promises, reducing the inherent incompleteness of the implied contracts between government and the public. As well as any direct benefits arising from greater credibility of commitments, this may allow proponents of programs to signal the quality of the programs, of the proponents or both. Thus, in the model of Brett and Keen (2000), a commitment to dedicate revenues to a particular use, which is of value to the public but would not be of value to a 'poor-quality' politician, can support a separating equilibrium in which politicians signal their quality to the electorate.

All of these factors create risks that the new earmarked funds, though they may increase spending on infrastructure, could reduce the quality of that spending.

Set against these long-term forces, project evaluation is a relatively weak reed, and the effects of changes to evaluation processes alone may well be relatively small. Nonetheless, we would suggest three areas for reform.

The first is **greater transparency**. There is no reason why cost–benefit analyses should not be publicly disclosed as a matter of course. Instead, most cost–benefit analyses are never released, and those that are are often difficult to locate. Governments should also regularly publish, in readily accessed form, the cost–benefit analysis rankings of those projects they have decided to proceed with and those they have considered and rejected (as is done in Finland, for example). Were disclosure of cost–benefit analyses routine, the fact that a cost–benefit analysis had not been conducted on a particular project would become more obvious, as would the relative quality of the cost–benefit analyses that had been carried out.

The second is greatly enhanced **auditing**. Auditing plays an important role in improving the efficiency of principal–agent relations, both by allowing principals to better assess the outcomes of the efforts made by agents and by deterring collusion between agents and third parties (see Mookherjee and Png 1989). The introduction of an independent auditor, whose interests are separate from those of the party being audited, increases the likelihood of poor conduct being detected, including when that conduct takes the form of bias (for instance, associated with 'excess optimism' or with the strategic understatement of costs[27]).

The auditing we believe desirable would take two forms. To begin with, there is substantial merit in having independent reviews of all cost–benefit analyses for 'mega-projects' (say, projects with projected outlays in excess of $500 million). This could be done by an office answerable to Parliament, rather than forming part of the Executive. Such an office could be similar to the Congressional Budget Office in the United States. Were establishing such an institution considered too radical, at the very least adequate specialist resources should be provided to a parliamentary standing committee to engage the kind of forensic analysis required. This is not to cast doubt on the Australian National Audit Office, but rather to suggest that its competence, and standard form of operation, are not especially well suited to this task.

As well as this form of review, there is a pressing need for much more to be done in terms of post-completion review of projects. Although a few useful post-completion

[27] The pervasiveness of these forms of bias in transport assessments is amply documented by Flyvbjerg, Bruzelius and Rothengatter (2003).

reviews of cost–benefit analyses have been undertaken (BTE 2001; BTRE 2007a, 2007b; NSW Audit Office 2006; NSW Auditor General 2005; NSW Treasury 2008; Victorian Auditor General 2009), these are ad hoc, which limits their effectiveness both as instruments of accountability and as a means of learning from experience. The Auslink program mandated post-completion reviews; unfortunately, this requirement has not been rigorously enforced. We believe it should be.

Mandating systematic and transparent post-completion review could have far-reaching consequences. To begin with, it would force Commonwealth and state entities to more properly document and archive material related to the cost–benefit analyses and the cost–benefit analyses themselves. In contrast, as matters currently stand, cost–benefit analyses are typically undertaken before the final form of projects is determined, and then never updated. Additionally, little investment is made in documenting cost–benefit analyses and in ensuring the integrity of the documentation chain. A genuine system of post-completion reviews would require all of those deficiencies to be addressed. At the same time, such reviews could be used both to benchmark jurisdictions and to more effectively learn from mistakes.

In short, we would strongly endorse — and argue more should be done to implement — the conclusion Little and Mirrlees (1994, p. 206) reached in reviewing, after two decades, the impact of their great cost–benefit analysis manual:

> If good project appraisal warrants expenditure, as we argue, so does good appraisal of appraisal.

Third and last, there is a great deal that could be done both to increase the **quality of cost–benefit analyses** and to promote a greater sense of professionalism in the group of people engaged in project evaluation. There are still many complex technical issues to tackle in Australian project evaluation — including the selection of the criterion function (where, unfortunately, the use of Benefit–Cost Ratios is still widespread, despite its well-known deficiencies), the treatment of the marginal social cost of funds (which is usually ignored), the determination of the discount rate (often set in a manner that is somewhat arbitrary), the assessment of changes in service quality and reliability (which is particularly important in public transport, as well as in communications), the appropriateness or otherwise of corrections for ‘optimism bias’ (which, in the authors’ opinion, are likely to be ineffective at best and distorting at worst), the role of ‘wider economic benefits’, and so on. While many of these issues are well traversed in the literature (if not in the practice) of project evaluation, there are other important issues that are relatively under-explored, such as the implementation of cost–benefit analysis in the context of hypothecated funds (where congruence requirements should come into play[28]) or the design of incentive-compatible evaluation schemes for structures such as Infrastructure Australia.

There is consequently considerable potential for cooperative research across jurisdictions, and for using that research, and its dissemination, as an instrument of ongoing training for both practitioners and users of cost–benefit analysis. Moreover, that process could help give greater standing to the 'profession' of project evaluation and help define a community of those involved in project evaluation across different areas of infrastructure policy. There is an important role here for the Bureau of Transport and Regional Economics and also for the Productivity Commission. Thus, the Productivity Commission could, much as it did in regulation review, issue 'information notes' recommending particular approaches to the technical issues analysts face. While we do not believe there is one 'right' approach to all of these issues, and hence would not favour mandatory standardisation across the States, that should not impede the exchange of views and the fostering of comparability of analyses across jurisdictions (so that the effect of different approaches can be identified). Much has been done in this respect by the Australian Transport Council's 2006 *National Guidelines*, but the list of issues identified above highlights the task that remains.

6.4 Conclusions

Infrastructure investment is a cost, not a benefit; a means, not an end. This proposition, which is obvious to economists, is as utterly alien to contemporary Australian politicians as the notion of comparative advantage was to their predecessors.

That matters should be so is by no means a new phenomenon. Thus, in Hancock's magnificent *Australia* (1930), now sadly out of print, the great historian famously said that it was a failing of democracies, and especially of Australian democracy, to constantly confuse ends and means, and to show too much reluctance 'to refuse

[28] When decisions are delegated to agencies, and agencies are instructed to make optimal use of their budgets, the expected growth path of agency budgets on the one hand and of investment opportunities on the other becomes an important factor in determining the optimal pattern of outlays. When an agency regards both its current budget and its current set of investment opportunities as representative of future opportunities — either because these regenerate periodically or because they are linked — it is referred to as having congruent expectations. Agencies should, in defining the choice set for evaluation, choose a set of projects and time horizon that can reasonably be regarded as congruent. Where agencies are budget funded, it is not unreasonable to assume the current budget defines such a set; however, this assumption cannot simply be carried over to an agency whose budget is hypothecated.

favours, to count the costs, to discipline the policies they have launched'. '[The] policies therefore yield diminishing returns, until at last, they may become a positive danger to the national purpose that called them into existence.' Nowhere was this more marked, Hancock noted, than with public involvement in infrastructure ventures such as rail, where Australian government was 'particularly slow to confess it has got into a bad business, for its mere entry … has created vested interests which immediately express themselves in politics … So … it throws good money after bad, and hopes that something will turn up. In this way, losses accumulate in a lump, and the crisis, when it comes, is likely to be prolonged and severe.'

The costs and risks of this approach to infrastructure have also been known for many years. There are surely many echoes in current telecommunications decisions of the tendency, identified by Butlin, Barnard and Pincus (1982, p. 294) in their analysis of the development of the Post-Master General's Department, for Australian public enterprise to provide 'services that were too large, too quickly supplied and too cheap'. That so little should have changed is not encouraging.

Set against that background, how great a contribution can improved project appraisal make to securing better outcomes? Little and Mirrlees (1994, pp. 225–7) develop a simple model of the value of information in which good project appraisal yields benefits that, in expected value terms, are in the order of 10 per cent of project value.[29] For an economy investing over $10 billion per year on its transport and communications infrastructure, 10 per cent of project value would seem like a saving well worth seeking. That said, the Little–Mirrlees model assumes unbiased estimates and a decision-maker who, as a benevolent social planner, maximises social welfare; it is hardly contentious that those assumptions do not hold — if they did, central planning would be a far better system than it has ever proved to be.

To recognise this, however, is not to imply that no value should be placed on good appraisal; on the contrary, it is one of the protections taxpayers deserve to have. Testimonials of commitment to 'evidence-based policy' notwithstanding, shaping an environment in which project appraisal can effectively discharge this task remains as great a challenge as it has ever been.

Overall, our review suggests the following conclusions:

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[29] The Little–Mirrlees formulation yields a value of appraisal that is at least 10 per cent of standard deviation of the errors removed by the appraisal, multiplied by the ratio of that standard deviation to the standard deviation of the errors not removed. This ratio should be about 1, though with competent appraisal it could be much more than that. As a result, a conservative estimate of the value of appraisal is 10 per cent of project value.

- Insufficient attention is paid in the evaluation process to options that would avoid investment, or, more broadly, that would focus on securing greater efficiency from the existing capital stock. Simply put, infrastructure investment appears to be viewed as a benefit, rather than a cost.
- The distortions arising from this undesirable narrowing of the range of options considered are then compounded by evaluations that are too vulnerable to 'fudge factors'. In a Gresham's law of evaluation, bad evaluations (often by consultants) can drive out good, given that they trade at equal values.

In our view, these outcomes are driven by governments that see little real value in major project evaluation. They may see merit in evaluation of essentially routine decisions (such as the decision to place a new roundabout or improve a road surface) or in cost-effectiveness analysis of the options available for meeting pre-determined goals (such as improving bus transit in a congested area) but not in the full analysis of objectives and options (including the option of not spending taxpayers' money). This, we argue, reflects the impact of a perception (initially due to strong economic growth, and then to a belief that the global financial crisis justifies greatly increased outlays) that public funds have a negligible opportunity cost. This perception has been accentuated by the growing blurring of accountability in the Australian federation, which reduces the budget disciplines on the States, and the blurring also of responsibility for financing infrastructure as between the public and private sectors (which, whatever its other merits, increases the return to rent-seeking deals between governments and private infrastructure developers). Together, these trends risk making cost–benefit analysis merely a box to be ticked, rather than an exercise that has real value, not least to government itself.

We are not optimistic that changes to cost–benefit analysis processes alone can counteract these powerful trends. Nonetheless, we think three changes would have merit:

- a requirement for all cost–benefit analyses to be disclosed that would also highlight which projects had not been subjected to economic project evaluation
- far greater and systematic auditing of cost–benefit analyses, both at the stage of the financing decision and post-project completion. In contrast, there is little or no such audit currently, and in many instances, cost–benefit analyses are not even updated, maintained or properly archived after the initial 'go/no go' decision is taken.
- the establishment of a centre of excellence or reference for cost–benefit analysis within the Australian Government, preferably in an independent entity, such as the Productivity Commission.

The Little–Mirrlees rule suggests that the value of proper project appraisal is at least 10 per cent of the value of projects. With Australia spending ever more on infrastructure, these are gains well worth seeking. Whether they can be achieved is obviously an open question.

References

Access Economics 2009, *Impacts of a National High-speed Broadband Network*, March.

Adler, M.D. and Posner, E.A. 2006, *New Foundations of Cost–Benefit Analysis*, Harvard University Press, Cambridge, Mass.; London, England.

Alesina, A. and Weder, B. 2002, 'Do corrupt governments receive less foreign aid?', *American Economic Review*, vol. 92, no. 4, pp. 1126–37.

Analysys Mason for BSG 2008, *The Costs of Deploying Fibre-based Next-generation Broadband Infrastructure*, Final report, 8 September.

Arrow, K.J. and Lind, R.C. 1970, 'Uncertainty and the evaluation of public investment decisions', *American Economic Review*, vol. 60, no. 3, pp. 364–78.

Australian Transport Council 2006, *National guidelines for transport system management in Australia*.

Azam, J.P., Devarajan, S. and O'Connell, S.A. 1999, 'Aid dependence reconsidered', Policy Research Working Paper No. 2144, The World Bank.

Bardhan, P. 2005, *Scarcity, Conflicts, and Cooperation: Essays in the Political and Institutional Economics of Development*, MIT Press, Cambridge, Mass.; London, England.

Bartholomeusz, S. 2009, 'Conroy's stab in the dark', *Business Spectator*, 15 May.

Becker, G.S. 1965, 'A theory of the allocation of time', *The Economic Journal*, vol. 75, no. 299, pp. 493–517.

Brautigam, D. 2000, *Aid Dependence and Government*, Almqvist and Wiksell, Stockholm, Sweden.

Brennan, G. and Pincus, J. 1990, 'An implicit contract theory of intergovernmental grants', *Publius*, vol. 20, no. 4, pp. 129–44.

Brett, C. and Keen, M. 2000, 'Political uncertainty and the earmarking of environmental taxes', *Journal of Public Economics*, vol. 75, no. 3, pp. 315–40.

BTE (Bureau of Transport Economics) 2001, *The Black Spot Program 1996–2002: An Evaluation of the First Three Years*.

BTRE (Bureau of Transport and Regional Economics) 2007a, *Ex-Post Economic Evaluation of National Highway Projects: Case Study 1: Wallaville Bridge*.

—— 2007b, *Ex-Post Economic Evaluation of National Highway Projects: Case Study 2: Northam Bypass*.

Bureau, D. 1985, 'Cohérence entre choix des projets et politique de régulation macroéconomique', *Annales d'Economie et de Statistique*, INSEE, Paris (English version in Champsaur, P. (ed) 1990, *Essays in Honor of Edmond Malinvaud,* vol. 2, *Macroeconomics*, The MIT Press, Cambridge, Mass.).

Butlin, N.G., Barnard, A. and Pincus, J.J. 1982, *Government and Capitalism: Public and Private Choice in Twentieth Century Australia*, George Allen & Unwin, Sydney.

Easterly, W. 2006, *The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good*, Oxford University Press, Oxford.

Ergas, H. 2008a, *Wrong Number: Resolving Australia's Telecommunications Impasse*, Allen & Unwin, Sydney.

—— 2008b, 'Setting access prices: a critique of the ACCC's approach in telecommunications', *Agenda: A Journal of Policy Analysis and Reform*, vol. 15, no. 4, pp. 35–58.

—— 2009a, 'Time consistency in regulatory price setting', *The Review of Network Economics*, vol. 8, no. 2, pp. 153–63.

—— 2009b, 'In defence of cost benefit analysis', *Agenda: A Journal of Policy Analysis and Reform*, vol. 16, no. 3, forthcoming.

—— and Hardin, A. 1999, 'Annuity and levelisation issues in forward looking cost models: the case of telecommunications', Paper presented at the ACCC Depreciation Forum, 30 September.

—— and Ralph, E. 2008, 'A policy framework for a new broadband network', in *Growth 60: Australia's Broadband Future: Four Doors to Greater Competition*, CEDA.

Estache, A. and Martimort, D. 1999, 'Politics, transaction costs, and the design of regulatory institutions', World Bank Policy Research Working Paper no. 2073, http://ssrn.com/abstract=620512

Evans, J., Levine, P. and Trillas, F. 2008, 'Lobbies, delegation and the under-investment problem in regulation', *International Journal of Industrial Organization*, vol. 26, no. 1, pp. 17–40.

Florio, M. 2007, 'Multi-government cost–benefit analysis, shadow prices and incentives', in Florio, M. (ed), *Cost–Benefit Analysis and Incentives in*

Evaluation: the Structure Funds of the European Union, Chelten, UK.; Northampton, Mass, pp. 1–46.

Flyvbjerg, G., Bruzelius, N. and Rothengatter, W. 2003, *Megaprojects and Risk: an Anatomy of Ambition*, Cambridge University Press.

Gans, J. 2009, 'The right policy for telecommunications and broadband', Submission to the Senate Select Committee on the National Broadband Network, 18th June.

Goolsbee, A. and Klenow, P.J. 2006, 'Valuing consumer products by the time spent using them: an application to the internet', *American Economic Review*, vol. 96, no. 2, pp. 108–13.

Guthrie, G. 2006, 'Regulating infrastructure: the impact on risk and investment', *Journal of Economic Literature*, vol. 44, pp. 925–72.

Hancock, W.K. 1930, *Australia*, Ernest Benn, London.

Janus, T. 2009, 'Aid and the soft budget constraint', *Review of Development Economics*, vol. 13, no. 2, pp. 264–75.

Johansson, P-O. 1991, *An Introduction to Modern Welfare Economics*, Cambridge University Press.

Jullien, B., Pouyet, J. and Sand-Zantman, W. 2009, 'Public and private investments in regulated network industries: coordination and competition issues', mimeo.

Kimenyi, M.S., Lee, D. and Tollinson, R.D 1990, Efficient Lobbying and Earmarked Taxes, *Public Finance Review,* Quartery, vol. 18, no. 1, pp. 104-113.

Knack, S. 2001, 'Aid dependence and the quality of governance: cross-country empirical tests', *Southern Economic Journal*, vol. 68, no. 2, pp. 310–29.

Kyland, F. and Prescott, E. 1977, 'Rules rather than discretion: the inconsistency of optimal plans', *Journal of Political Economy*, vol. 85, pp. 473–92.

Landes, W.M. and Posner, R.A. 1975, 'The independent judiciary in an interest-group perspective', *The Journal of Law and Economics,* vol. 18, pp. 875–901.

Levine, P., Stern, J. and Trillas, F. 2005, 'Utility price regulation and time inconsistency: comparisons with monetary policy', *Oxford Economic Papers*, vol. 57, no. 4, pp. 447–78.

Little, I.M.D. and Mirrlees, J.A. 1994, 'The costs and benefits of analysis: project appraisal and planning twenty years on', in Layard, R. and Glaister, S. (eds), *Cost Benefit Analysis*, 2nd edn, Cambridge University Press, Cambridge, England; New York, NY.

Moss, T., Pettersson, G. and van de Walle, N. 2006, ‘An aid-institutions paradox? A review essay on aid dependency and state building in sub-Saharan Africa’, Working Paper no. 74, Centre for Global Development.

Mookherjee, D. and Png, I. 1989, ‘Optimal auditing, insurance, and redistribution’, *The Quarterly Journal of Economics*, vol. 104, no. 2, pp. 399–415.

NSW Audit Office 2006, *Condition of State Roads: Roads and Traffic Authority of NSW*.

NSW Auditor General 2005, *Performance Audit: Liverpool to Parramatta Bus Transitway*.

NSW Treasury 2008, ‘Circular: revised project size/risk thresholds for the submission of business cases and gateway reports’, NSW TC 08/07.

O’Flaherty, B. 2005, *City Economics*, Harvard University Press, Cambridge, Mass; London, England.

Paolucci, F., Ergas, H. Hannan, T. and Aarts, J. 2009, The effectiveness of health informatics, in press.

Posner, E. 2001, ‘Controlling agencies with cost–benefit analysis: a positive political theory perspective’, *University of Chicago Law Review*, vol. 68, p. 1137.

Soria, B. and Hernández-Gil, F. 2009, Exploring potential natural monopoly properties of broadband access networks, Paper presented at the 19th European Regional Conference of the ITS, 20 September.

Spence, D.B. and Cross, F. 2000, ‘A public choice case for the administrative state’, *Georgetown Law Journal*, vol. 89, p. 97.

Steiner, P.O. 1974, ‘Public expenditure budgeting’, in Blinder, A.S., Break, G.F., Netzer, D., Solow, M. and Steiner, P.O. (eds), *The Economics of Public Finance*, The Brookings Institution, Washington D.C, pp. 241–361.

Telstra 2007a, Application to ACCC for exemption from standard access obligations in respect of the Singtel Optus HFC network, 17 December 2007.

—— 2007b, Application to ACCC for exemption from standard access obligations in respect of the SingTel Optus HFC Network, Schedule A, 17 December 2007.

—— 2007c, Application to ACCC for exemption from standard access obligations in respect of the SingTel Optus HFC Network, 17 December 2007, Schedule A, Annexure 2, Expert report of Michael G. Harris: Use of HFC to deliver broadband services, 12 December 2007.

Vanderbilt, T. 2008, *Traffic*, Allen Lane, London.

Victorian Auditor General 2008, *Maintaining the State's Regional Arterial Road Network,* Government Printer, Melbourne.

—— 2009, *Buy-back of the Regional Intrastate Rail Network*, Government Printer, Melbourne.

Von Hagen, J. 2006, 'Political economy of fiscal institutions', in Weingast, B.R. and Wittman, D.A. (eds), *Oxford Handbook of Political Economy*, Oxford University Press, N.Y, ch. 26.

Wildavsky, A. 1966, 'The political economy of efficiency: cost–benefit analysis systems analysis, and program budgeting', *Public Administration Review*, vol. 26, no. 4, pp. 292–310.