Arthur Grimes

PLANNING NEW INFRASTRUCTURE
Some Issues

Empirical themes

Infrastructure investments are mostly long-lived, service multiple (current and future) users, and interact with other public infrastructures and private investments. Empirical examples cited in the companion article in this issue, 'Infrastucture: new findings for New Zealand', include long-lived road, rail and port investments, telecommunications networks (fibre), water infrastructure and local social amenities. Much of this infrastructure is provided by central or local government, but some is also provided by public (state-owned enterprises) and private commercial enterprises.

The presence of positive agglomeration elasticities found in New Zealand and elsewhere (see Maré, 2008; Maré and Graham, 2009) indicates that increasing returns to scale may be present in relation to some infrastructure investments. The possibility of such increasing returns needs to be accounted for in *ex ante* assessments of the benefits flowing from new infrastructure investments. Increasing returns mean that many infrastructure investments do not stand alone: analysis requires a network approach rather than a specific project analysis.

The empirical work outlined in the companion article also points to the importance of considering the options role performed by certain infrastructure investments. The importance of network thinking and the consideration of options complicate the use of traditional cost-benefit analysis (CBA) tools. Other complications also arise in relation to CBA, especially in determining the weightings given to current versus future benefits and to different types of benefit (especially consumption versus production benefits). This article indicates some of the issues that have surfaced as a consequence of the findings of the empirical studies. A fuller examination of these conceptual issues is provided in Grimes (2010a).[1]

Cost-benefit analysis

CBA is the standard tool used in New Zealand and elsewhere as a basis for decisions regarding infrastructure investments. It makes explicit the nature, size and timing of a project's costs and benefits, covering both tangible and intangible items, and includes consideration of wider economic benefits (e.g. agglomeration externalities).

As with any such tool, the analyst using CBA must adopt a range of assumptions. CBA is most useful when these assumptions apply equally to a range of alternatives, so that the outcome of a decision is invariant to the particular

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assumptions made. For instance, it can be used with confidence when making comparisons between alternative projects designed to produce similar benefits (e.g. two roading choices designed to meet a similar need).

The scope of a cost-benefit analysis must be appropriate for the issue at hand. If a project has synergies with other prospective investments, a project-specific CBA will provide an inadequate estimate of benefits if the interactions with other synergistic projects (i.e. the full network) are not taken into account. In many circumstances – for instance, upgrading a roading network – a network CBA is therefore required instead of a project-specific CBA. (The latter may nevertheless still be useful where there are multiple ways of building a particular stretch of road within the network, provided the full network CBA is also undertaken.) The article by John Boshier in this issue and discussion in Grimes (2010a) deal with this issue in more depth.

Options and uncertainty

Investment is frequently undertaken under conditions of uncertainty with respect to many factors, including future demand, construction costs, future input costs, rival investments, complementary investments and the potential for new technologies. In some cases the uncertainty may relate to the investor's own future actions, but in most cases it will relate to the actions of others. For long-lived investments, the uncertainties relate to actions of agents who may not be alive or active at the time the initial investment is considered.

Investments in general-purpose technologies are especially beset with such uncertainties. At the time telegraph cables were first erected in New Zealand in the 19th century (under Julius Vogel's infrastructure investment programme), no one could foresee that movies would one day be downloaded to an individual's home from any point on the globe through such cables.

These uncertainties may have a considerable impact on infrastructure investment. A classic result from the literature on 'investment under uncertainty' is that investments may face a high hurdle rate if information about future conditions unfolds over time (Dixit and Pindyck, 1994). The reason for this is that a project that today has a benefit-cost ratio (BCR) exceeding one (based on current information) may have a BCR next period (or later) that is less than one (based on updated information). By waiting for further information to unfold, the risk of investing in a poorly performing project can be lessened. A conventional CBA that ignores uncertainty and learning therefore provides an insufficient basis for making investment decisions under conditions of uncertainty.

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The logic of delaying investments (or raising the hurdle rate) under conditions of uncertainty may be reversed where a project forms part of a sequence of potential projects in which future ones can only be undertaken if the initial investment is itself undertaken. If information about returns to future projects is forthcoming only after the initial project is completed, the initial investment creates a valuable option for potential investment in subsequent projects. For instance, consider an investment in fibre for broadband. The fibre itself constitutes the initial investment; subsequent projects relate to a range of private sector investment choices by firms that may wish to utilise the new technology. At the time of the initial (fibre) decision, the future returns to the private sector's investments are uncertain; the expected net returns (given current information) of the fibre investment plus future private investments may even be negative (i.e. a BCR of less than one). However, as shown in Grimes (2010a), it may still be worthwhile investing in fibre because, unless the initial fibre investment is undertaken, there may be no possibility that the future firm-specific investments can be undertaken. Those future investments will be undertaken if they are privately optimal for those firms, but these decisions will only be revealed in the future and will be conditional on the fibre already being in place. The initial public investment therefore creates the option for subsequent investment opportunities and hence for increased national income, and may be worthwhile even though no private sector participant would embark on the initial investment programme.[2]

The key to this result is that investment in the initial project creates an option to reap high returns through prospective future investments, with no obligation to invest in those projects where circumstances indicate that returns will instead be low. The potential for such options means that analysis for a project may, on occasions, need to incorporate a list of prospective (but uncertain) opportunities that may arise due to the completion of the project. Furthermore, the analysis must be undertaken at a national scale, rather than relating solely to the returns to the initial investor.

A corollary of the options approach is that disinvestment decisions must account for future opportunities that may be lost if existing infrastructure were scrapped. This insight is particularly relevant where large sunk costs are involved (rail freight lines are one such example).

Options analysis means that a BCR greater than one (within a conventional CBA) is neither a necessary nor a sufficient condition to make investment decisions under conditions of uncertainty and learning. Some projects with a BCR greater than one optimally should be delayed, whereas other projects with a BCR of less than one optimally should proceed. Analyses that use certainty-equivalent methods in the presence of uncertainty and learning are therefore flawed.

Discount rate

One of the most important decisions that must be taken when conducting a CBA, or using any other method to determine the net benefit of an infrastructure project, is how to trade off future against current net benefits. In order to arrive at a BCR or a net present value (NPV) figure, the trade-off between present and future net benefits is normally made through choice of an explicit discount rate. As implied by the multiplicity of discount rates used for infrastructure projects internationally, there is no single 'correct' discount rate that covers all project types.

Nevertheless, some guidance can be given. Where returns from a project are monetary and can be reinvested in another project that in turn gives the same explicit rate of return (with the same risk profile) as the project under consideration, and where the project could be undertaken equally by another agent, a cost of capital (incorporating a market-derived risk premium) constitutes an appropriate discount rate for the project.

Even here, the choice of risk premium is far from trivial, and circumstances exist where a negative risk premium may be appropriate at a national level. Consider, for instance, an irrigation scheme, which has its highest pay-offs during times of drought. Empirical work demonstrates a causal link from drought to GDP decline in New Zealand (Buckle et al., 2007). If government is averse to negative shocks to national income, there is a case for government to support an irrigation scheme through provision of funds at a discount rate that reflects a negative price for risk. In other words, because the scheme can mitigate adverse national income fluctuations, it has a negative 'consumption beta' and this makes it worthy of access to funds at a less than risk-free rate. If government is not concerned with fluctuations in national income, this result no longer holds and a market rate of return reflecting purely private risk is appropriate.

The issue of appropriate discount rate becomes even more difficult to determine where the benefit stream of a project in part comprises intangible consumption benefits, such as social benefits that cannot be monetised. In this case, the discount rate reflects the decision maker's subjective trade-off between people across time (i.e. between generations). Consider, for instance, a government faced with the choice of investing in two projects. The first is a one-off purchase of 1,000 hip operations today for elderly people in need of the operation (and who otherwise could not afford one). Assume that this incurs a one-off cost of $10 million which is lost to the government once the operations have been completed. The second project invests $10 million in a toll-road that yields a 7.5% compound real rate of return over 25 years (and where the returns can be reinvested at 7.5% real). The New Zealand government's current discount rate used for roading projects is 8% real; thus, it would reject the toll-road proposal as having a BCR of less than one.

What does this rejection mean? Investment of $10 million for 25 years at 7.5% real would result in a capital sum of $61 million at that time. Assuming hip operations cost the same in real terms then as now, a government in 25 years time could conduct six times as many hip operations as now if it invested in the toll-road instead of purchasing hip operations today. Use of an 8% real discount rate says that we would prefer to conduct 1,000 hip operations today rather than invest that sum and have 6,000 hip operations in 25 years time. In other words, faced with consuming today or setting aside these funds to make the next generation six times as wealthy, the official choice in New Zealand is to consume today.

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Furthermore, current roading projects are generally not undertaken unless their BCR is considerably greater than one (using an 8% real discount rate). The effective trade-off between current consumption and wealth of the next generation is therefore effectively much greater than the ratio of 6 implied by the discount rate choice. Seen in the light of these official policies, New Zealand's high rate of consumption out of income and low growth rate is understandable.

The nature of investments

New Zealand is an open economy with free migration internally and across the Tasman. In these circumstances, New Zealand needs to be considered as one region within a broader economy. A recent analysis for US states (Moretti, 2010) demonstrates that increased demand for a region's tradable goods raises employment in that industry and also raises demand for employees in non-tradable industries, thus inducing net inward migration. If labour is not perfectly mobile across regions, the result is a rise in incomes across the regional economy. A similar result holds for an increase in tradable sector productivity that arises from an improvement in infrastructure (Grimes, 2009a, 2010a). The productivity improvement to firms in the tradable sector translates into income increases across the economy as returns to local resources are bid up in order to increase output in the more productive tradable sector. The effect is to relocate resources both within and between countries.

These results are important for interpreting the agglomeration findings in the Motu infrastructure programme (Maré, 2008; Maré and Graham, 2009). Rather than seeing a productivity-enhancing infrastructure investment in Auckland as potentially taking resources away from the rest of New Zealand, it should instead be interpreted as boosting the return to factors of production in New Zealand. The resulting higher incomes attract additional resources (including labour) to this country and/or reduce the

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net outflow of labour and other resources to Australia.

Strategic and funding implications

The empirical work summarised in the companion article and the conceptual issues discussed in this one together suggest that a more strategic approach to infrastructure investment could be pursued in New Zealand than has been the case in recent decades. A national infrastructure strategy may concentrate on prioritising projects that: (i) service the internationally traded productive sector; (ii) exhibit network complementarities; and/or (iii) create opportunities for subsequent value-enhancing investments that take advantage of the initial investment project.

These considerations, which are largely absent from conventional CBA evaluation, may be combined with use of a lower discount rate in order to prioritise projects that boost the productive base of the New Zealand economy for future generations.

Where projects are national in scale and have positive net pay-offs (after inclusion of network and other externalities and option values), they can be financed through debt, since the stream of benefits is available to service that debt. Where the effects are predominantly localised (for instance, with a motorway extension or new social amenities) another funding avenue is possible. Theory, and the empirical work cited here, shows that beneficial infrastructure investments with localised benefits result in an uplift in land values. This value uplift accrues to property owners who have not necessarily risked their own capital to undertake the infrastructure investment. The value uplift affords a base on which to raise revenue through targeted local authority rates (land taxes). Historically, similar mechanisms have been used to fund railway development in the United States and in New Zealand, and are used today in the United States through TIF (tax increment financing) funded projects (Coleman and Grimes, 2010a, 2010b). Further consideration of this approach, possibly in place of development contributions and financial contributions (under the Local Government Act and Resource Management Act respectively), is warranted in New Zealand.

Whichever funding mechanisms are used, there is a need in New Zealand to extend current approaches to infrastructure planning so as to incorporate some of the analytical extensions to cost-benefit analysis introduced by modern economic approaches. Incorporation of network externalities and option values, plus reconsideration of discount rates (especially in respect of differing types of benefits), are specific extensions to consider. The land value-based funding mechanisms then provide a funding option to finance further productive infrastructure investments, especially at the local level.

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2 Against this option must be weighed the option of delaying investment in a fibre network. This option may have value if cheaper fast broadband options (e.g. improved mobile technology) were potentially to become available in a relatively short timeframe, so enabling savings on the large costs of investing in a ubiquitous fibre network.

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THE COSTS OF CRIME
Toward Fiscal Responsibility

A one day forum on Monday 21 February 2011
Government Buildings lecture theatre one, Pipitea Campus, Victoria University of Wellington

The Costs of Crime: Toward Fiscal Responsibility forum will provide information on the fiscal and others costs of the impact of crime and policy measures to respond to it and generate discussion on cost-effective ways of responding to crime and repairing the harm caused by it. The primary focus will be on public expenditure but costs to non-governmental organizations will also be considered where relevant and possible.

Speakers include:

- Audrey Sonerson and Paul O'Connell, New Zealand Treasury
- Kim Workman, Rethinking Crime and Punishment
- Professor Tony Ward, School of Psychology, Victoria University
- Dr Gabrielle Maxwell, Institute of Policy Studies, Victoria University
- Heather Henare and Kiri Hannifin, Women's Refuge
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