

Arthur Grimes

# INFRASTRUCTURE

## New Findings for New Zealand

### Research programme

Infrastructure is a crucial input into economic production, and provision of infrastructure is a key avenue through which government may materially raise economic productivity. Recognising the importance of infrastructure investment, the Foundation for Research, Science and Technology granted Motu and its research partners a four-year research grant to examine the impacts that infrastructure investments have on New Zealand's economic development.<sup>1</sup> The programme has resulted in a range of empirical research studies that examine the impacts of specific and general infrastructure investments in this country. It has also resulted in contributions addressing theoretical and funding aspects related to infrastructure investment.

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This article summarises the aims of the programme and its key empirical findings, relating these findings to prior theoretical and empirical work. A companion article in this issue ('Planning new infrastructure: some issues') examines some of the theoretical and funding issues raised by the programme.

At the time the programme was devised, it had become widely recognised that the quality of New Zealand's infrastructure had fallen behind that of many other developed countries. The 2004 OECD report on New Zealand raised significant questions about the quality of land transport, electricity and telecommunications infrastructure. The World Economic Forum *Global Competitiveness Report* ranked New Zealand 20th of 29 developed countries for overall infrastructure quality.

As a New World country, infrastructure had to be built largely from scratch from the early 19th century onwards. Without modern economic tools, strategic judgements were made about which investments to undertake. The infrastructure investments of Julius Vogel in the 1870s stand out as transforming the New Zealand economy. Factories and mines mushroomed around the railways, and

whole provinces and industries opened up for production (Grimes, 2009b). Since then, productive infrastructure (including roads, rail, bridges and telecommunications) and social infrastructure (including schools, hospitals, community facilities) have further transformed our economy and our society.

Prior to the current programme, there had been little evaluative work examining

have too much, just enough, or too little infrastructure investment? How large are the costs to productivity and to broader well-being of having the wrong amount, or the wrong type, of infrastructure? Is inadequate infrastructure placing a material constraint on New Zealand's economic and social development? What would be the pay-offs to relieving those constraints?

infrastructure (Grimes, Ren and Stevens, 2009; Grimes, 2010b; Howell and Grimes, 2010); water infrastructure (Grimes and Aitken, 2008); social infrastructure (Roskrige et al., 2010); primary processing infrastructure (Grimes and Young, 2009); impacts of legal (planning) constraints on infrastructure outcomes (Grimes and Liang, 2009); infrastructure impacts on national and city productivity (Maré, 2008; Maré and Graham, 2009); and effects of local authority infrastructure investments on economic outcomes (Cochrane et al., 2010). Analyses of funding mechanisms (Coleman and Grimes, 2010a and 2010b) and theoretical issues involved in *ex ante* assessments of infrastructure (Grimes, 2009a, 2010a) have addressed additional conceptual issues.

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the benefits (relative to the costs) of investing in many of these infrastructure projects. The research programme aimed to conduct a range of evaluations in order to help answer questions such as: Do we

The programme has included analyses of: transport infrastructure (Grimes, 2007; Grimes and Liang, 2010; Grimes and Young, 2010a; Fabling, Grimes and Sanderson, 2010); telecommunications

### Importance of infrastructure

New infrastructure is normally designed to increase the productivity of firms and/or increase amenity values for people who make use of the facility. The investment may relieve an existing bottleneck (e.g. a



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new road may reduce traffic congestion) or may create new opportunities (e.g. a fibre broadband connection may open up the possibility for international electronic marketing). As discussed in the companion article, the latter may create increasing returns to scale opportunities that lead to enhanced benefits. However, even the former type of investment may lead to increasing returns, especially if co-ordinated with other investments servicing the same community.

In either case, if the investment has a localised effect it will raise land values in the affected locality, since firms and/or households will be prepared to bid more to locate in that area. In such circumstances, the change in land value consequent on a new infrastructure investment can be taken as a measure of the net present discounted value created by that investment (Roback, 1982; Haughwout, 2002). The insight that changes in land values reflect value creation has been used in a number of the studies in the programme.

Other forms of infrastructure have more widespread impacts that are not confined to a defined local area. Investment in telecommunications technology that enhances broadband access is one such form of investment. To measure these benefits, one can examine impacts on individual firm productivity to assess the productive benefits arising for firms. The benefits of social investments may be examined by recourse to survey data on individuals; we utilise these approaches in some of our studies.

#### **Empirical findings: specifics**

##### *Transport*

The programme examined three specific transport investments and provided background information about transport issues in general (Grimes, 2007). The three specific investments related to Auckland: the Northern Motorway extension from Albany to Silverdale (Orewa), the upgrade of Auckland's Western Line passenger rail service, and the opening of Port of Tauranga's inland port at Southdown.

The Northern Motorway research (Grimes and Liang, 2010) utilised the change in land value methodology, comparing relative changes in land values

according to their degree of proximity to the newly-opened motorway exits. *Ex ante* cost-benefit ratios for the motorway extension were favourable, with benefit-cost ratios of around 5. The difficulty that such *ex ante* analyses face is that they may not adequately capture the full range of benefits that a major new investment offers, especially where options for as yet unknown activities are created (see

'Planning new infrastructure: some issues', *infra*). By providing motorway access from the heart of Auckland to the Whangaparoa Peninsula, new work, leisure and residential opportunities were greatly expanded.

While there were major cost overruns on the project, we find that there were also extra benefits relative to what were expected *ex ante*. Population and employment growth, especially around the Peninsula and around Warkworth, were very strong. More generally, areas within 3 kilometres of new exits experienced strong rises in population and employment. Land values rose considerably (relative to comparable land elsewhere in Auckland) in areas closely adjacent to the new motorway exits, with this effect tailing off to zero at around 7 kilometres from an exit. These responses are as one would expect to observe if the new infrastructure were highly valued.

Our assessment of the benefits was such that the benefit-cost ratio of the extensions was estimated to be at least 6, and possibly as high as 20, even after the considerable cost overruns were accounted for. The high ratios imply that initial analyses of benefits were conservative.

Similarly, we find benefits from upgrading the Western Line passenger rail service to Waitakere City (Grimes and Young, 2010a). We find that the price of houses near existing Waitakere City stations rose in the order of 6% to

8% at the time of the announcement of Auckland's rail upgrades; properties near the urban redevelopment at New Lynn rose by up to 10%. The upgrades will substantially improve the frequency of Western Line services and improve amenity values associated with the New Lynn town centre.

The third transport project that we have examined concerns freight: the

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opening of Port of Tauranga's inland port (Metroport) in Auckland at Southdown (Fabling, Grimes and Sanderson, 2010). This new port facility opened up the opportunity for Auckland (and Northland) firms to ship their goods to a port in the southern part of Auckland rather than all the way to Tauranga, in addition to the option of using Port of Auckland (which subsequently also opened an inland port, in Wiri). The analysis shows considerable uptake of the new port by existing export firms, particularly by larger firms and those exporting lower value-to-weight cargoes (e.g. commodities). Many existing exporters chose to add Metroport to Port of Auckland (rather than switching ports entirely), so increasing their shipping options (i.e. increasing the frequency of ships that they can access for their exports).

##### *Telecommunications*

New Zealand firms and households can access the internet through a number of means: dial-up, copper wire-based broadband (ADSL), mobile broadband and multiple forms of cable/fibre. Current policy is to substantially upgrade the fibre offering across the country so that the bulk of consumers can gain access via a fast fibre connection. Because this is a new technology, it is difficult to measure the benefits that may flow from such an upgrade; by contrast, the (large) costs are apparent.

The infrastructure research programme attempted to provide new information to address the benefit side of the equation by examining differential effects of internet access on individual firm performance (Grimes, Ren and Stevens, 2009). This research was enabled through access to Statistics New Zealand's prototype Longitudinal Business Database (LBD), and particularly to the 2006 Business Operations Survey (BOS), a Statistics New Zealand survey of approximately 6,000 firms. The research provided descriptive statistics of how firms with different types of internet access utilised the internet for their business operations, and estimated the impact on firm performance arising from a switch to broadband from dial-up access, or a switch to

because: (a) recent adoption of cable/fibre means that productivity benefits had not yet materially affected firm performance for many firms; (b) fast broadband may have benefited only a small subset of firms in 2006, so did not materially influence the overall results; (c) the data did not allow for a clear delineation in speeds between differing measures of broadband type; or (d) there may in fact be little or no effect of switching from one type of broadband to another, at least for most firms. The study could not differentiate between these explanations.

Discussion of the implications of these results (see Grimes, 2010b; Howell and Grimes, 2010) notes that major investments in 'new technology' projects such as a fibre roll-out must consider

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fast (cable/fibre) broadband from slow broadband (ADSL/mobile).

The descriptive statistics showed that firms with cable/fibre connections made much greater use of the internet for business purposes than firms with other forms of broadband. These latter firms in turn made greater use of the internet than those with only dial-up (or no internet access at all). Firms with cable/fibre were especially over-represented amongst firms that had a web page, purchased goods and services on the internet, sold goods and services on the internet, had high ratios of international sales as a proportion of internet sales, had high tourism-related sales, and entered new export markets.

The research identified that firms with broadband had higher productivity than firms without broadband, after controlling for observable differences across firms. However, it could not find an additional impact of cable/fibre relative to other forms of broadband access on firm productivity. This latter result may be

the factors that are likely to lead to large benefits accruing to firms. The ability to access the internet at a reasonable speed through adoption of ADSL without tying up a firm's phone line (as with dial-up) may have a much greater effect on productivity for many firms than the marginal benefit of sending through the same information at a faster pace using a fibre connection. However, for some types of firm that are reliant on very heavy data traffic and high customer expectations, the move to fibre may open up major opportunities (e.g. for international sales). Currently, only a minority of firms may be in this latter group, but the portion of firms comprising that group in future may rise. The creation of an 'option' (potentially for firms that have yet to be created) through judicious investment is therefore relevant. The unknown, at this stage, is just how large the pay-off will be from investing in this option and whether the benefit exceeds the cost.

### Water

Plentiful water is one of New Zealand's greatest resources, but in some parts of the country it is already over-allocated; Canterbury is the most seriously affected region in this regard. Irrigation and water storage can considerably increase the water available to productive enterprises, but existing water allocation mechanisms (water rights) are based largely on a 'first-applied, first-allocated' basis. It is difficult, under current legal arrangements, to trade a water right with other parties who may have a greater use value for that water.

In order to ascertain whether there are gains from trade to be had from better use of water in Canterbury, the programme included a study on the value of water consents to farms in the Mackenzie district of South Canterbury (Grimes and Aitken, 2008). It found that water was more highly valued on farms that were flatter and on more poorly draining soils than on other farms (possibly because the water is retained for longer on those properties). Farms that are situated close to town derive especially strong benefits from irrigation, since these units are most likely to have potential water-intensive land uses such as dairying and cropping that require access to processing facilities and/or urban labour pools. Accordingly, farms with irrigation are, on average, located closer to town than farms with no irrigation.

The study found that reasonable variations in the size of water right and in farm characteristics can give an estimated premium of at least 50% for irrigated properties relative to similar unirrigated properties. Thus, there can be high net returns to irrigation in a drought-prone region such as the Mackenzie district. Farms that have a water right are more valuable than similar farms without water rights. However, the full value of water is not being realised, since returns differ significantly according to farm characteristics, and differing valuations of water cannot be fully capitalised upon where restrictions on water trading exist. This result is indicative of a more general issue for infrastructure policy: poor pricing of infrastructure can lead to

severely sub-optimal allocations and to poor investment choices.

#### *Local social and economic infrastructure*

Local authorities make considerable investments in both productive assets (e.g. roads, ports) and amenities (e.g. social infrastructures such as community facilities, parks, etc). Similarly, private firms invest in facilities, some of which have similar properties to public infrastructure; primary processing plants that are locationally fixed and available for use by many local firms (farmers and/or foresters) are an example of the latter. A number of studies in the programme examined impacts of such investments.

Investments in amenities are undertaken by local authorities in order to improve social outcomes for the local population. One council objective may be a desire to facilitate a high degree of participation in community activities by local community members. By encouraging such participation – for example, through providing community facilities that complement private endeavours – councils may raise the community's 'social capital' and assist community solutions to existing community challenges.

One study in the programme (Roskrugge et al., 2010) examined such issues, modelling the impact of local government community facility expenditure on individuals' participation in community activities. The study found a complex impact of such expenditures. Greater funding was found to increase the number of community activities that active participants were involved in, consistent with building community social capital. However, a free-rider effect was also found to operate: increased funding reduced the likelihood that an individual participated in community activities. Thus, the greater effort of some individuals appears to have enabled others not to participate and instead enjoy the fruits of others' exertions. These results have a more general corollary: the effect of a particular investment may extend beyond the immediately measured impacts to indirect, but nonetheless substantial, effects that may

be complementary or contrary to the impacts of the immediate effects.

A study of the productive impacts of local government infrastructure expenditures (Cochrane et al., 2010) similarly found effects extending from local government investment choices. After controlling for induced infrastructure expenditures arising from factors such as past population growth, the study found that new infrastructure expenditure had positive growth effects on the local community. In particular, there was support for the 'build it and they will come' notion: new infrastructure expenditure (over and above what was required to service past and expected growth) leads to an influx of extra population to a community, and may also raise incomes and land values as people and firms bid to establish themselves in the growth area. These findings are in keeping with the insights of the Roback and Haughwout models cited earlier.

Private investment in rural processing infrastructure is similarly found to have considerable impacts on community outcomes (Grimes and Young, 2009). The study examined impacts of two surprise meatworks closures: Patea (1982) and Whakatū (1986). Patea and Whakatū represent contrasts, one rural and one peri-urban (Hastings). Consistent with the findings on local infrastructure investments, the closures resulted in substantial immediate losses of employment in each community; however, the longer-term impacts differed considerably between the two cases. The loss of employment in Patea was permanent given the lack of other opportunities in the surrounding area. By contrast, the losses in Whakatū were temporary, as new employment opportunities arose both in the broader urban area and within Whakatū as new firms replaced the former meatworks.

Perhaps the most important insight of the study was that such (dis)investments may also have an impact on the age structure of the population. This was especially seen in the case of Patea, which saw a shift to a much older population structure following the closure, as young workers and families left, while older people moved in to the vacated houses.

Thus, infrastructure (dis)investment may affect not only population size but also population structure. A corollary is that investment in productive infrastructure and amenities that appeal to the young may be used as a mechanism to attract a younger population to a local area.

The 'agglomeration' relationship between infrastructure impacts and urban status (implied by the primary processing study) is emphasised in two analyses of firm productivity and employment density (Maré, 2008; Maré and Graham, 2009). Large urban areas tend to have greater infrastructure requirements and greater employment density than smaller areas. The former study finds an agglomeration elasticity of around 0.05 (i.e. a 10% increase in employment density (employees/km<sup>2</sup>) results in a 0.5% increase in firms' labour productivity);<sup>2</sup> the intensity of this relationship is similar to that obtained in North American and European studies. The importance of this result is that, if the effect is causal, facilitation of higher density (e.g. through improved transport networks) can result in higher productivity and hence higher incomes.

The second study (Maré and Graham, 2009) provides further detail on the nature of this agglomeration elasticity. By industry, agglomeration benefits are lowest for agriculture, forestry and fishing and highest for the finance and insurance industry, with wholesale trade, retail trade and health and community services also having high elasticities. The latter four industries are most commonly found in major centres, emphasising the importance of infrastructure investments that facilitate increased employment density in larger cities. However, the study finds that there may be decreasing returns to agglomeration, since the higher density cities (Auckland, Wellington, Christchurch) have lower agglomeration elasticities than less dense areas, albeit still in the vicinity of 0.05–0.06.

#### **Empirical findings: commonalities**

The analyses summarised above indicate the importance of infrastructure investments for raising productivity and amenity values at local and national levels. In some cases, the nature of the benefits

that flow from the projects are easy to identify (e.g. improved local passenger transport options). However, in other cases benefits may be diffuse and/or difficult to pinpoint *ex ante*. One factor which causes difficulties in evaluating benefits *ex ante*, especially of large-scale projects, is judging the nature of eventual benefits and the recipients to whom they may accrue.

For some infrastructure projects – e.g. a rural road straightening – the recipients of the project may be definable. But for others – e.g. investment in fibre-optic cable or a major new motorway linking two cities – the investment benefits are

partly in the nature of the purchase of an option for future development, where the size and recipients of the potential options pay-off are unknown. Two of Vogel's major investments – in telegraph and rail – were of this nature; both had an immediate surge in usage with a further lift in usage 30 years later (see Grimes, 2009b). The nature and size of Vogel's investments effectively purchased an option that enabled these subsequent developments to occur. Investments in fibre and/or investments in major transport networks may today have similar properties. The companion article examines some considerations

that must be taken into account when considering such matters. In keeping with that article, the studies cited here provide prima facie evidence to support a strategic, network-oriented approach to infrastructure investment that goes well beyond a project-by-project analysis of specific investment proposals.

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2 This is the central estimate of three estimates provided in Maré (2008).