



## **The Role of Infrastructure In Developing New Zealand's Economy**

**Arthur Grimes\***

(Motu Economic & Public Policy Research; & University of Waikato)

[arthur.grimes@motu.org.nz](mailto:arthur.grimes@motu.org.nz)

Paper presented to Institute of Policy Studies Spring 2008 Lecture Series:  
*New Zealand: Future Maker or Future Taker?*  
Wellington, 16 September 2008

### **Abstract**

The concept of an 'infrastructure deficit' is commonly referred to within New Zealand. A claim that there is a deficit implies that there exists knowledge that the optimal stock is greater than is currently the case (at least for certain types of infrastructure) and hence that new investment would yield positive net benefits. Yet little work has been conducted in New Zealand to evaluate the impacts of new infrastructure investments or to analyse whether returns to recent investments have been positive. This paper provides an overview of the impacts of some major nineteenth century infrastructure programmes and reports on current work analysing the returns to some more recent infrastructure investments. The main aim of the paper is to draw lessons about the role of infrastructure in developing New Zealand's economy and to understand factors that may currently inhibit the full benefits of these investments being realised.

---

\* The research contributing to this paper has been funded by grant MOTU0601 from the Foundation for Research, Science and Technology (programme on *Infrastructure*). Thanks are extended to FRST for making this research possible. However, the author is solely responsible for the views expressed.

*“New Zealand has both the legacy of a developed country with the associated infrastructure, and the reality of being a small player, with a limited resource base. There is a risk that, rather than being ‘future maker’, New Zealand will be consigned to being a ‘future taker’ and thus constrained to paths that it would not have consciously chosen.”<sup>1</sup>*

## **1. Introduction**

The Institute of Policy Studies description (in the quotation above) concerning issues facing New Zealand’s future places infrastructure at centre stage. In order to look towards the future, it is imperative that we understand the past. We can see the past; it must therefore be ahead of us. We walk backwards into the future hoping that some reflections from the past may illuminate our tentative, stumbling path. In this paper, I draw on research conducted within Motu that analyses the impacts of major infrastructure developments to help illuminate the role of infrastructure in developing New Zealand’s economy.

The historical perspectives cover two separate time horizons. First, we use data from the turn of the 20<sup>th</sup> century relating to the impacts of two major 19<sup>th</sup> century infrastructure investments – railways and the electric telegraph. Second, we turn to the early 21<sup>st</sup> century, examining the state of play in New Zealand’s current infrastructure. Recent research is drawn upon to analyse specific infrastructure investments in motorways and irrigation, and how their impacts are affected by regulations. Lessons are drawn from each of these examples, and it is the reflections from these lessons that we hope yield some luminescence to provide guidance for future paths.

## **2. Vogel’s breadth**

In 1870, New Zealand’s Colonial Treasurer, Julius Vogel, promoted a broad scheme to advance New Zealand’s development. The scheme, designed to encourage secondary industry and to promote immigration, was centred upon a budgeted £10 million scheme of major public infrastructure investments. Investments through the 1870s included

---

<sup>1</sup> Quotation sourced from Institute of Policy Studies description of the Spring 2008 Lecture Series.

construction of over 1,000 miles (1,600 kilometres) of railway lines, 4,000 miles (6,400 kilometres) of electric telegraph wires, an undersea telephone cable to Australia, and the establishment of a regular shipping service to San Francisco (McMillan, 1968).<sup>2</sup>

One result of this investment programme was the opening of whole new provinces to national and international trade. Taranaki, for instance, now had an outlet for its dairy produce following the construction of rail, roads and bridges. By the turn of the twentieth century, formerly isolated Taranaki had 97 dairy factories plus a freezing works (the latter still under construction).<sup>3</sup> The large number of dairy factories indicates two features of the then extant infrastructure. First, inter-regional transport links now made dairying worthwhile in Taranaki, since the produce could be transported to other locations (domestically and internationally) for sale. Second, intra-regional transport links were poor, making it worthwhile to invest in multiple plants to ensure that milk did not spoil prior to processing. Improved transport links in the past century now mean that the Hawera plant can process milk not just from across Taranaki but from multiple North Island regions.

Some technologies take a considerable time to build and even longer time to achieve full market penetration and use. This is particularly true of general purpose technologies (GPTs) such as electricity (Lipsey and Carlaw, xx). These technologies (and the infrastructures that support them) are characterised by multiple subsequent uses of the underlying technology, with those subsequent uses potentially only being invented decades or even centuries later. An example is computing, which utilises the electricity network.

Long adoption periods may also occur for technologies that replace earlier technological modes that have sunk costs attached to them and/or which require some learning to utilise fully (Kehoe & xx, xx). Kehoe & xx use the example of the electric engine replacing steam engines in the United States (check xx). Start-up firms, with no sunk costs in terms

---

<sup>2</sup> The investments eventually cost £20 million, double the budgeted amount.

<sup>3</sup> This information, and that in the remainder of this section is sourced from the New Zealand Official Yearbook, 1903.

of equipment utilising the old technology, adopt the new technology immediately. However existing firms may only replace their initial production technologies once the former technology is sufficiently depreciated and/or once the entrepreneur has mastered the new technology (or employed new staff who can do likewise).

The Kehoe & xx approach is consistent with the adoption of the electric telegraph and the railway in New Zealand. Figure 1 graphs the length of electric telegraph cable available in New Zealand from its advent in the country in 1866 until 1902. Construction of the telegraph network was undertaken almost continuously throughout the period. As a network industry, its usefulness increases as the number of people able to access the network increases. In large part, beyond 1875 the extra construction was required just to keep up with population growth. Figure 2 demonstrates that line miles per (pakeha) person was almost constant beyond that date. The pakeha population more than doubled between 1875 and 1902, from 376,000 to 808,000, in keeping with the Vogel strategy of increased population serviced by improved infrastructure.

Population trends, however, do not fully explain the uptake of the new technology. Figure 3 graphs the number of telegraph messages sent per person over the period. As posited by Kehoe & xx, the number of messages per person grew steadily over the its first 12 years of availability, and then plateaued for the next 15 years. In the final 10 years of the period, the number of messages per person again rose steadily to be almost double the level of a decade before.

A forecaster in 1866 would have had little ability to judge the extent of use of the new infrastructure over subsequent years given the lack of precedent for it. A forecaster in 1896, having seen 15 years of constant messages per person may confidently have forecast a stable outlook for that variable over the coming decade, but in fact would have been mistaken almost by a factor of two within ten years.

Use of rail shows similar trends. Figure 4, graphing the length of available track shows an initial burst between 1873 and 1877 (Vogel's 1,000 miles) and then steady increase

thereafter throughout the period. As with the case of the electric telegraph, the number of track miles per person remained almost constant beyond 1877 as both track miles and population increased (Figure 5). Receipts per person (Figure 6) rose rapidly from 1873 through to 1878 and then plateaued for 20 years (explicable only in part by depressed conditions for part of that period). Over the final six years, receipts again began to increase quite sharply. Again, planners at the initial phase and towards the end of this period would have had great difficulty in predicting subsequent usage of the rail infrastructure.

### **3. Importance and Quality of Infrastructure**

If predicting use of infrastructure is difficult, so too is understanding the contributions that specific infrastructure investments make to national economic development. It is now generally acknowledged that ensuring provision of appropriate infrastructure is a key government role in order to raise economic productivity (Bassanini et al, 2001; Nijkamp & Poot, 2004). Aschauer (1989) found large positive productivity impacts of infrastructure investment in the United States, although the magnitude of these effects have since been questioned (Gramlich, 1994; de la Fuente, 2000). More recent cross-country evidence has re-established a case that infrastructure expenditures can have material positive productivity impacts (Bassanini et al, 2001). In addition, recent assessments of individual infrastructure projects (e.g. new rapid transit lines) indicate that benefits to the community's broader wellbeing may be large in specific cases (Gibbons and Machin, 2005; McMillen and McDonald, 2004).

New Zealand's public infrastructure expenditure in the 1990s and early 2000s was low by international standards. Average government expenditure on 'Economic Affairs' (including infrastructure investment) was 2.8% of GDP in New Zealand over the five years to 2001, compared with an (unweighted) OECD average expenditure of 4.4% of GDP (Grimes, 2003). Sanderson (2004) found that New Zealand's rate of "other construction" (that includes infrastructure investment) is "low" relative to nine developed

comparator countries.<sup>4</sup> She documented a material decline in central government gross fixed capital formation (i.e. public sector investment) after the mid-1980s that may, at least in part, be associated with this low rate of other construction. The OECD (2004), in its annual survey of the country, considered New Zealand's infrastructure inadequate in several respects (land transport, electricity, telecommunications). The 2004 infrastructure stock-take conducted by PricewaterhouseCoopers (PWC, 2004) assessed the quality of New Zealand's energy, water, transport and telecommunications infrastructure in terms of contributing to or representing a barrier to achieving economic growth and sustainable development objectives. It noted that while many infrastructure deficiencies have localised effects (e.g. road congestion) these effects can have national implications. It particularly identified deficiencies with respect to:

- Land transport, particularly roads in Auckland and deferred rail maintenance;
- Water and wastewater;
- Security of potable water supply in drought-prone areas;
- Water supply and wastewater treatment in smaller communities with large tourism-driven seasonal fluctuations in population;
- Competing demands for agricultural and commercial/industrial water supply;
- Fuel for future electricity generation and certainty of supply in dry periods.

Several indicators of the current quality of New Zealand's infrastructure have recently been published in *Economic Development Indicators 2007 (EDI; MED et al, 2007)*. Figure 7 reproduces Fig 4.15 from that publication (in turn sourced from the World Economic Forum Global Competitiveness Report, WEF-GCR) comparing the perceived overall infrastructure quality in New Zealand with the OECD and with 11 chosen comparator countries. New Zealand is actually ranked 34<sup>th</sup> in the world on this measure, well below most other developed countries.

---

<sup>4</sup> By contrast, against the same countries (Australia, Canada, Denmark, Finland, Ireland, Netherlands, Norway, Sweden, UK), New Zealand's investment is "high" in the categories of machinery and transport equipment, and is "moderate to high" for residential construction. New Zealand is "low" in ICT and other products (including software).

One reason that infrastructure stocks may be poor is that overall investment within the country is comparatively low. Figure 8 (reproducing EDI Fig 3.1) indicates that this is not the case. New Zealand's ratio of fixed investment to GDP over 2001-2006 was almost identical to the OECD average, and this was also the case for the 1995-2000 period. However the composition of investment may be skewed away from infrastructure investments. Figures 9 and 10 (reproducing EDI Fig 3.5 and 3.4 respectively) address this issue. New Zealand's housing investment as a percentage of GDP has been approximately equal to the OECD median since 1994, and was well below the median between 1970 and 1993. Thus there is no indication that excessive housing investment has crowded out infrastructure investment. By contrast, New Zealand's plant and machinery investment has been well above the OECD median for almost the entire 1970-2005 period. It has also consistently exceeded equivalent measures in the United States and Australia, contrary to popular myth.

The remaining investment categories (including infrastructure) must therefore be well below the OECD median. While EDI contains no cross-country comparisons for other investment categories, we can infer some of the history from Figure 11 (EDI Fig 3.3) that graphs private and government investment as a percentage of GDP. Much of the latter category relates to various types of infrastructure investments (including social infrastructure such as schools and hospitals as well as transport, energy and water infrastructure). Private investment ratios have remained between 11% and 14% for most of the period. By contrast, the government investment ratio averaged approximately 8% from 1971-1986, but thereafter has averaged approximately 4%, a halving in the government investment rate relative to GDP.

While New Zealand's infrastructure stock and investment rate appear low by international standards, this does not automatically imply that they are "too low". For infrastructure investment to be justified, the extra expenditure must have a positive net return, either by raising productivity or by raising amenity values for the public - in each case by more than the full costs of the investment. Until recently, and unlike the United States, very little work has been conducted in New Zealand to assess whether our aggregate

infrastructure expenditures are appropriate by this standard. Nor has there been significant work evaluating whether particular infrastructure expenditures have been warranted.

#### **4. Measuring Infrastructure Effectiveness**

How can the effectiveness of an infrastructure investment be measured? Cost-benefit analyses are used often to measure the effectiveness of an investment ex ante (e.g. in order to rank prospective land transport projects); and sometimes have been conducted ex post to evaluate the effectiveness of a completed project (e.g. Sinclair Knight Mertz, xx). Cost-benefit analysis requires a large number of assumptions to be made to measure the net benefits, even where the costs are reasonably well identified. This makes their use highly speculative, and they may be particularly prone to error where significant externalities exist. For instance, agglomeration benefits within cities (if they exist) are unlikely to be well identified within a traditional cost-benefit analysis.

An alternative approach, suitable especially for projects that have principally local or regional effects, is to examine the impact of a new investment on land values in the affected areas. This technique uses the insight of Ricardo (1817) that the value of land reflects the rents that can be earned from that land. If new infrastructure raises the productivity of firms that can operate from a certain locality and/or raises the amenity values for people residing in that locality, rents will rise to capture the value of the extra productivity and amenities. Thus the value of the land will rise and that rise in values equals the productivity and amenity benefits attributable to the new infrastructure. Negative externalities (disamenities) will be reflected in a fall in the price of the land. Use of techniques based on this insight is now common in evaluating infrastructure benefits in the United Kingdom (e.g. evaluation of the Crossrail project in London) and the United States (e.g. xx, xx).

As an illustration of the technique, consider the advent of a new rail station within an area, as shown in Figure 12. The area serviced by the new station is shown in the ellipse along with individual blocks of properties (the rectangles). We may expect that areas

closest to the new station will experience the greatest rise in property values as people bid to locate near the station for commuting purposes. Land values will rise in blocks 1 to 5, with a decreasing increment in values as distance from the station increases. Some disamenity value may be experienced by people living alongside the track; thus prices in block 6 may actually fall. The total benefit of the new station is given by the sum of all changes in property values (including the negative changes). Total benefits can then be compared with total costs (suitably discounted to take account of time differences) to form an ex post benefit:cost ratio.

The technique has the advantage that the evaluator does not have to be able to isolate or quantify all sources of potential benefit (or disamenity) arising from the new investment. This is important since it beggars belief that any individual could contemplate the myriad uses of many new infrastructure projects. For instance, could a planner in 1870 have imagined that Taranaki would soon have 97 dairy factories arising from the rail investment? Could a planner today contemplate what new industries will arise in Warkworth as a result of the Northern Motorway extension to Puhoi? Can an energy planner today anticipate the nature of industries that may use new transmission capacity across Cook Strait over the next two decades?

The difficulty in predicting responses to infrastructure make typical B:C analysis, with its concentration on estimates of expected benefits and costs, an incomplete approach for use in ex ante planning. Modern investment theory is based on the real option approach concerning investment under uncertainty (Dixit & Pindyck, 1994). An investor has the option to invest which may be exercised over a range of time periods. Normally, application of this approach encourages a conservative approach to investment (i.e. effectively a high discount rate) since the investor finds out more about payoffs to the investment if it is delayed.

With the case of infrastructure, however, I conjecture that the opposite may be the case. The investor may not know what opportunities will arise for other investors as a result of investing in the new infrastructure. Even other agents may not know the resulting flow of

new opportunities until well after the infrastructure is built since new opportunities may arise randomly over time. In this case, the infrastructure investment is in the nature of a multi-stage investment programme, with the feature that the infrastructure investor is not the same agent as the investor in subsequent stages. For instance, a public or private agency may build a new highway, but other – potentially start-up firms not yet in existence – undertake the subsequent investment decisions. In this situation, it is difficult for the infrastructure investor to fully internalise the full value that arises as a result of the initial infrastructure investment.

One method, for a localised investment, would be for the infrastructure investor to obtain initial ownership of all land expected to be serviced by the infrastructure, since the value of the infrastructure for subsequent investments will be capitalised into the value of the land. However, this is an unlikely ownership scenario for most major local infrastructure investments, and is completely out of the question for national-scale investments such as providing fibre for broadband across the country. Effectively, there is a missing market (since future start-up firms cannot contract to pay the infrastructure provider prior to the investment). In this case there may be a role for public financing of the initial infrastructure. Indeed local authorities meet this issue head-on by financing local infrastructure investments and charging development levies on newly serviced land. In addition, they levy rates on local land (or capital) values so partially capturing the benefits from the infrastructure that is impounded in the land price. At the national scale, there is much less recourse made of such financing alternatives, suggesting that current approaches to identifying who should pay for new national-scale infrastructure could still be improved.

## **5. Modern Examples**

The impacts of historical examples of major infrastructure benefits (such as the Vogel programme) are reasonably easy to discern with hindsight. More difficult is the task of evaluating whether more recent infrastructure investments are worthwhile. The current FRST-funded Motu programme chooses a number of modern examples to evaluate

whether certain recent infrastructure choices are in the public interest. Brief results are summarized here; readers are referred to the full papers in each case for more detail.

### *5.1 Roading Infrastructure - Auckland's Northern Motorway*

Major roading projects in New Zealand are prioritised subject to a standard benefit: cost analysis. Between the mid-1990s and 20xx, Auckland's Northern Motorway was extended in a number of stages from near Albany to Silverdale/Orewa. Figure 13 provides a map of the affected area. The Northern Motorway currently runs from the Harbour Bridge (between "Auckland" and "North Shore") to Silverdale and Orewa; prior to the extensions referred to here, it ran to just south of the junction with Highway 18. The major extension (referred to as APLURT A) had an ex ante B:C of xx. While costs ran significantly over the ex ante budget (costs, excluding land, amounted to xx compared with the budgeted xx) an ex post evaluation still considered that the project was worthwhile, with a B:C of xx (Sinclair Knight Mertz, xx). That analysis, in keeping with the ex ante analysis, sought to attribute benefits by way of xx...

We have revisited the benefits side of the equation using changes in land values (after controlling for a large range of other factors, including possible diminution in values in areas previously well serviced by the motorway) to assess the productivity plus amenity benefits of the extensions. In addition, we have analysed the changes in population, employment and incomes in a spatial context relative to the new motorway exits (Grimes and Liang, 2008). We can compare the revealed benefits with the actual costs to arrive at a revised B:C calculation.

The analysis shows that between 1991 and 2006 population and employment rose rapidly both near the newly opened motorway exits and in the area surrounding Warkworth, slightly to the north of the new northernmost exit at Orewa. Specifically, using Statistics New Zealand meshblock boundaries (which approximate city blocks in urban areas with larger areas, but smaller populations, in rural settings) the study found that population and employment grew by xx% and xx% respectively in areas within three kilometres of a new exit. This growth compared with Auckland region-wide growth for the same

variables of xx% and xx%. Areas that were more distant from the nearest new exit also grew (by xx% and xx% respectively) but the rate of growth tailed off as distance to the exit increased.<sup>5</sup>

Land values within three kilometres of new exits rose xx, while those in xx xx. These compared with rises in land values elsewhere on the North Shore of xx. The land value outcomes and the trends in employment and population growth rates are consistent with a productivity and amenity boost to the newly serviced areas arising from the motorway extension (noting that the amenity boost may partly be in the form of improved accessibility to work opportunities).

Total costs of the projects, after discounting the costs of the projects forward to 2004 at a 10% discount rate, were \$0.37 billion. Our estimate of benefits depends on our econometric estimation technique and the nature of controls included for other factors affecting areas such as the northern towns (Orewa-Whangaparoa, Warkworth, Wellsford). Taking the most conservative of all the estimates, we find a benefit (in 2004) of \$2.3 billion, implying a B:C>6 even after the cost over-runs. This is higher than found using the standard benefit:cost approach. The conservative estimate uses a simple (ordinary least squares) econometric estimator; the preferred spatial lag estimator produces B:C's of around 20, considerably higher than estimates for these projects based on traditional B:C analysis.

Why are the estimates based on land values higher than conventional analyses? One possible reason is that the nature of benefits that arise from a new investment are much wider than is typically taken into account in a conventional B:C analysis. For instance, new residents may be prepared to pay considerably more than conventionally assessed to be situated near a high quality transport link, not just because of access to a wider variety of employment opportunities but also because they can access other amenities more easily. Similarly, firms may value the greater distribution possibilities highly.

---

<sup>5</sup> Income growth around the exits was similar to income growth elsewhere, except around Orewa where income growth was markedly higher than the regional average. However these figures do not control for changing resident types over time.

Furthermore, there be interactions between firms and employees that raise the benefits derived from the new infrastructure. For instance, firms may be able to access higher quality workers who can also access more suitable work opportunities. Resulting improved matching within the labour market is a classic source of agglomeration externality that is thought to characterise production within cities (xx, xx). Such agglomeration externalities are normally excluded from traditional B:C analysis. Whatever the reason, the benefits indicated by the revealed preference approach are large and, in a sense, reassuring given the large costs of the projects.

## 5.2 *Planning Infrastructure – Auckland’s Metropolitan Urban Limit*

Infrastructure includes laws, regulations and other ‘rules of the game’ that affect a range of agents’ decisions. One such set of rules, which may be important in estimating the impact of other infrastructure investments, are planning regulations and restrictions. An example is Auckland’s metropolitan urban limit (MUL), a set of boundaries effectively containing Auckland’s urban form to within set limits. The MUL is shown in Figure 14 as *Metroline\_NZMG*.<sup>6</sup>

Grimes and Liang (2007xx) analyse the effects of the MUL on land values across Auckland. After controlling for a wide variety of factors affecting urban and rural land values, the study finds that land just within the MUL is valued (per hectare) at approximately ten times that of neighbouring land just outside the MUL. A prior study (xx) showed that development in recent years has been concentrated on pockets of land just within the MUL. Thus the MUL does appear to constitute a binding constraint to Auckland’s physical expansion.

There are many reasons that can be adduced to support zoning regulations such as urban limits, including limiting congestion, reducing emissions, and loss of amenity value from open countryside. In the absence of such externalities, the finding that a parcel of land is

---

<sup>6</sup> There are two portions of land within the MUL. The first is the portion around the Auckland isthmus. The second covers Silverdale-Orewa-Whangaparoa Peninsula. The gap between these two non-contiguous areas is reflected in the construction of the Northern Motorway (section 5.1); exits are spaced approximately two kilometres apart within North Shore, with a gap of nine kilometres from the northernmost North Shore exit to that at Silverdale. Correspondingly, there is virtually no population or employment growth attributable to the motorway in the intervening area.

valued at an order of magnitude higher than its neighbour (after controlling for other factors) as a result of regulation, would imply an inefficiency in land use. One could just as easily build a house (or a business or a school) on the cheaper land as on the expensive land and so enhance household welfare or reduce business costs or the costs of providing public services. However in the presence of negative externalities, such as those listed above, the benefits of reducing the external costs must be weighed against the additional costs of living and/or doing business.

The results of the MUL study, while indicating that the MUL is restrictive, does not therefore indicate that the MUL is too restrictive. However it does demonstrate that agents are being forced to pay significantly more for land for housing, business and public services than they otherwise would have to without the MUL (or with wider MUL boundaries). This result, which had hitherto not been carefully established, raises the question of the authorities that have adopted the MUL of whether the benefits of the current boundaries are at least equal to the costs that they are imposing. To date, there has been no formal analysis of the MUL's benefits and so this question remains unanswered. Given the material divergences in land values on either side of the boundary, it is quite possible that the MUL (given its current boundaries) is a form of planning infrastructure that is having a net negative welfare effect. The same concept with wider boundaries may produce a positive net effect. This is a public policy issue that requires further analysis.

### *5.3 Irrigation Infrastructure – Mackenzie District Water Consents*

Water is a critical resource for household, agricultural, industrial and recreational purposes. In some areas, especially dry regions such as Canterbury, it is becoming increasingly scarce and potentially over-allocated. In some cases, large-scale irrigation infrastructure can increase the quantity and reliability of flows available for certain uses, e.g. for agriculture. Water can also be obtained using small-scale infrastructure by tapping ground water or diverting local surface water flows .

Whichever method is used to source water, the commercial user must first obtain a resource consent (water right) under the Resource Management Act (RMA) in order to

use that water. Consents are often granted by regional councils on a first-applied, first-granted system; no charge is made for use of the consented water and, in most circumstances, the consent holder cannot offer the water to another user (even without charge). The granting of a consent to users without any charge for the water is a form of lump sum transfer to consent holders from the underlying owners of the water (whether that be Maori or the Crown). This has equity but no efficiency consequences. However efficiency consequences would arise if water is not allocated to the highest uses, especially given the restrictions on transfer of the water right to other users.

Figure 15 plots the location of water consents by farm within the Mackenzie District of South Canterbury. Approximately 10% of farms hold a consent; some are clearly located around a large-scale irrigation scheme; others are more localised. Grimes and Aitken (2008) obtain data on water consents (maximum rate and volume of water flows plus irrigated area) and farm characteristics (area, land use type, location relative to Timaru and other towns, soil/drainage quality, rainfall, average slope) for every farm in the District. In addition, data is obtained for each triennial farm valuation (land and improvements) and for every farm sale price from 1988-2006. All data are matched at the farm level and is then used to calculate the market value placed on the water rights for farms of different types.

The analysis demonstrates that water rights are valuable for many farms (i.e. they increase productivity of the unit and hence raise farm value and/or farm sale price). Thus existing irrigation projects appear to have positive net returns. More importantly, from an efficiency perspective, is that the return to water varies materially according to the characteristics of the farm. Farms that are located close to town benefit significantly more from (otherwise identical) water rights than does a farm that is more distant from an urban location. One may surmise, for instance, that water-intensive land uses (horticulture and dairying) are most profitably located near processing and transport facilities based on urban areas. Farm rainfall, slope and drainage also affect the value of

the water right, implying that the impact of water on farm performance interacts with each of these characteristics.

These results are important when considering the net benefits of irrigation infrastructure. Production within a region that experiences shortages of water will be enhanced where the water is allocated to the most productive uses. The Mackenzie District results indicate that this may favour granting water rights to dry, flat properties located near towns. Yet the current system of allocation has the effect of granting water rights to farms that make much less productive use of that water. In this case, the return to some irrigation investments may be much lower than others, and the allocation mechanism (coupled with the lack of water trading) will result in productive opportunities being lost in the district. Thus institutional mechanisms are important in determining the returns to infrastructure.

## **6. Lessons and Conclusions**

Recent and distant historical episodes of infrastructure investment, interpreted in the light of economic analysis, provide useful lessons on the role of infrastructure in developing New Zealand's economy. They also provide useful lessons on the roles of institutions in moderating the effects of these investments.

Two key lessons can be learned from the nineteenth century examples (railways and electric telegraph) discussed here. The first is that economic activity responds endogenously to new infrastructure investments. It is therefore imperative that ex ante evaluations of infrastructure benefits do not restrict attention just to how existing patterns of production, population location, etc will respond to the new investment. The effects of the new investment on existing activities may be subsidiary to its impacts in drawing forth new, potentially quite different, activities. The development of the Taranaki dairy industry is a useful example here. Furthermore, the new activity may not constitute just a linear addition to productivity; location of new activity may itself boost productivity of existing units (and/or boost amenity values for existing residents). Infrastructure which has the effect of inducing urbanization and/or localization benefits in urban areas (i.e.

agglomeration benefits), for instance, will raise the benefits of a new investment over and above the extra production attributable to existing units (Mare and xx ). Such agglomeration benefits tend to be discounted or ignored in many New Zealand B:C analyses.

A second lesson relates to time horizons. The New Zealand railway and electric telegraph examples produce the familiar S-shaped adoption curves for new technology over their first 10-15 years of use. However they also both display significant further uptake per person with a long lag (20-25 years after initial investment). This may be partly explained by changing economic conditions over time; even so, it demonstrates that the economic effects of certain types of new infrastructure may have very long-lived dynamic impacts. Thus the pay-offs to major infrastructure investments must be considered over a very long time horizon.

This observation raises the issue of the correct discount rate to use for different infrastructure investments. In the spirit of the modern investment under uncertainty literature, I conjecture that a low discount rate should be used where the resulting infrastructure could potentially be utilized by a wide spread of activities, even if those activities cannot be forecast *ex ante*. Essentially, the infrastructure is a down-payment on the option of developing the new opportunities as they present themselves, since without the infrastructure the payoffs to the new opportunities would be negative. Conversely, a higher discount rate should be used where few new activities would be facilitated as a result of the new investment. For instance, standard discount rate (e.g. 8% real) may be used to value the benefits of a road-straightening investment on a rural highway, since the benefits are quite easily foreseen in terms of faster travel time and reduced deaths and injuries. Few, if any, new activities may arise from the straighter road. By contrast, investment in fast broadband for some regions may have a payoff of making viable new sectors or firms that are currently not even in existence. Without the investment, the opportunities for the new entrants may not even be spotted since the underlying conditions for them to arise would not be present.

The recent infrastructure examples that have been analysed produce lessons that to some extent reflect the lessons from the nineteenth century examples. The ex post evaluation of the Northern Motorway extensions indicates large benefits relative to costs, with the benefits exceeding those calculated ex ante. A potential reason for this result is that the conventional ex ante calculation of benefits misses some categories of benefit (e.g. enhanced amenity values). In addition the traditional method does not consider agglomeration benefits that may arise as a result of improved accessibility between residential and business locations. People located in Rodney and North Shore can now access employment in the CBD and elsewhere more easily than before, while new employment opportunities in the newly serviced areas (especially Albany and Orewa) can be accessed by people both to the north and the south of the Harbour Bridge.

A second lesson from the recent examples is the importance of the regulatory environment and institutional structures in affecting the benefits that are derived from new infrastructure investments. Auckland's metropolitan urban limit (MUL) has had a clearly discernable impact in preventing development along much of the path of the new northern motorway extension. Indeed, this is the expressed purpose of the MUL. What is not clear is whether the lost development benefits have been outweighed by greater benefits elsewhere for the region.

The differing returns to water consents in the Mackenzie District, depending on farm characteristics, is another example of how regulatory barriers have efficiency effects in relation to infrastructure. Analysis shows that the existing irrigation infrastructure in the district has positive effects for many farms. However many other farms that could benefit from a water right have no water consent and, in most circumstances, cannot obtain water from those with a water right. This is the case even if the farm with a water shortage could use that water (and compensate the current consent holder) for a more advantageous use than an existing holder. The results of this study indicate, at least for this example, that the infrastructure is currently producing sub-optimal returns, and agricultural production could be enhanced with a change to permit water trading.

The lessons adduced here have been made on the basis of a limited number of examples – both historical and recent, albeit with the recent studies being based on extremely detailed data. Currently, research is underway or planned (coordinated by Motu, funded by FRST) into other examples of infrastructure investment: broadband, urban accessibility, rural services (e.g. emergency services), urban rail upgrades, export infrastructure, and community amenities. It is likely that new lessons and insights – in addition to specific results - will arise from these studies; and some lessons above may be modified. Some infrastructure investments may prove to be uneconomic. However it is reasonable to expect that, at the broadest level, the full body of analyses will confirm that many infrastructure developments have been vital for New Zealand’s economic development and that the returns to these investments will depend on the quality both of the investments themselves and the regulatory structures that impact on the returns available from them.

## References

Blackley,.

**Figure 1:**

**Figure 2:**

**Figure 3:**