The Role of Infrastructure In Developing New Zealand's Economy

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Motu

MOTU NOTE #1

"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 a 'future maker', New Zealand will be consigned to being a 'future taker' and thus constrained to paths that it would not have consciously chosen."[1]

The Institute of Policy Studies description relating to issues facing New Zealand's future (in the quotation above) places infrastructure at centre stage. In order to look towards the future, it is imperative that we understand the past. 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 20th century relating to impacts of two major nineteenth century infrastructure investments – railways and the electric telegraph. Second, we turn to the early 21st century, examining the state of play of 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. It is the reflections from these lessons that we hope yield some luminescence to provide guidance for future paths.

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

Motu Research is conducting a four-year project examining the net benefits provided by New Zealand's infrastructure. This Motu Note gives a non-technical introduction to the issues of infrastructure investment in New Zealand and presents an overview of Motu's findings to date.

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1. Quotation sourced from Institute of Policy Studies description of the Spring 2008 Lecture Series.

to promote immigration, was centred upon a budgeted £10 million scheme of major public infrastructure investments. Investments through the 1870s included construction of over 1,000 miles (1,600 kilometres) of railway lines, 4,000 miles (6,400 kilometres) of electric telegraph wires, a deep sea cable to Australia, and the establishment of a regular shipping service to San Francisco (McMillan, 1968). [2]

One result of this investment programme was the opening up 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). 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. Long adoption periods may occur especially for technologies that replace earlier technological modes with sunk costs and/or which require some learning to utilise fully (Atkeson & Kehoe, 2007). Atkeson & Kehoe use the example of the electric motor replacing steam engines in the United States. Start-up firms, with no sunk costs in terms of old equipment, adopt the new technology immediately. Existing firms may only replace their initial production technology once it is sufficiently depreciated and/or once the entrepreneur has mastered the new technology (or employed new staff who can do likewise). The result of these behaviours yields an S-shaped diffusion curve for new technology (Aghion & Howitt, 1998).

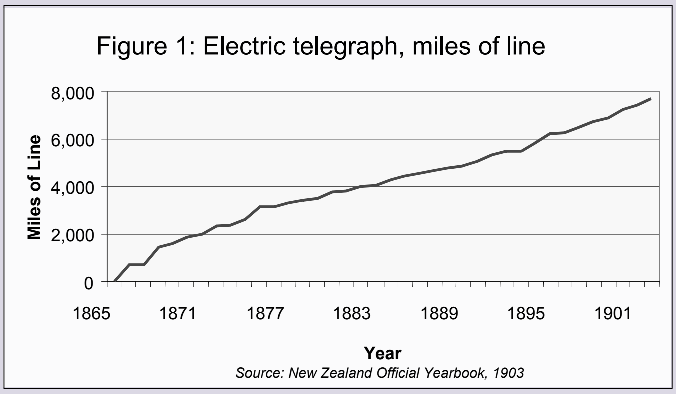
A particular subset of new technologies is constituted by general purpose technologies (GPTs) such as electricity (Helpman, 1998). These technologies (and the infrastructures that support them) are characterised by multiple subsequent uses of the underlying technology, with many of the subsequent uses only being invented decades or even centuries later. An example is computing, which utilises the electricity network.

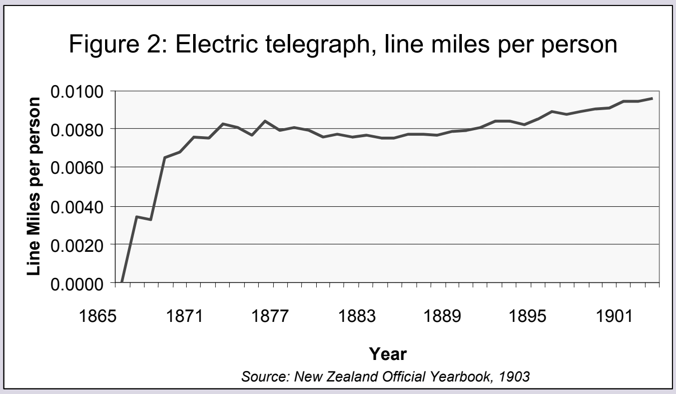
2. The investments eventually cost £20 million, double the budgeted amount.

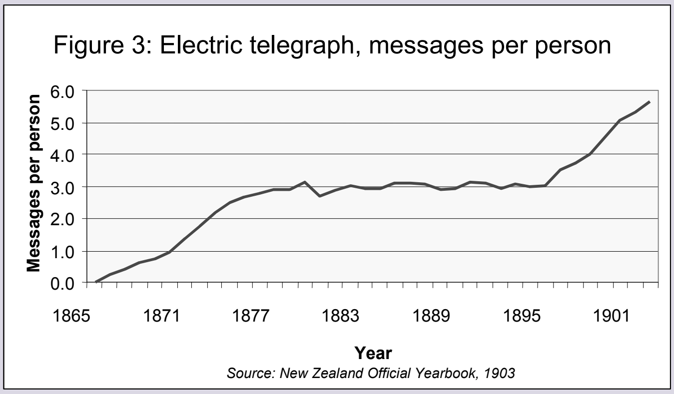
Case study: the electric telegraph and the railway

Adoption of the electric telegraph and the railway in nineteenth century New Zealand exhibits characteristics both of S-shaped diffusion and some elements of a GPT. Figure 1 graphs the length of electric telegraph cable available in New Zealand from its advent 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



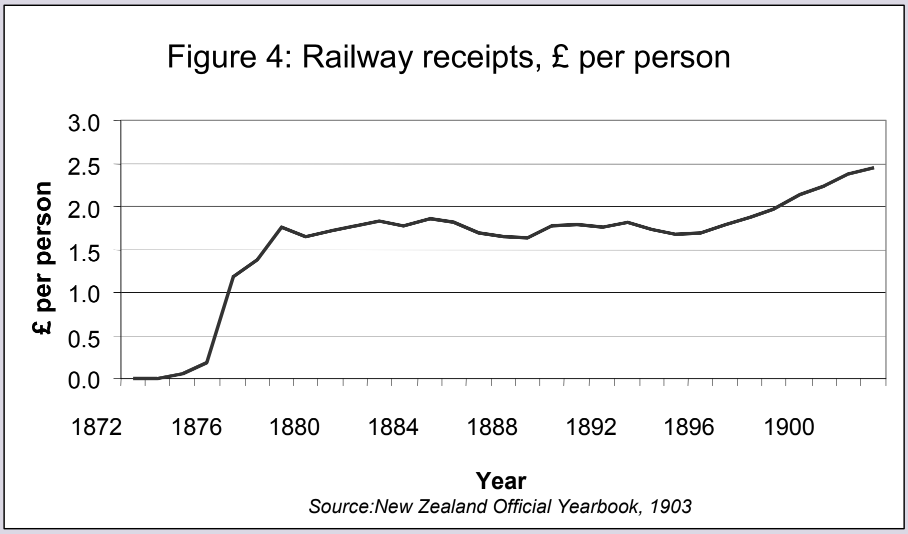




sent per person over the period. As posited by Atkeson & Kehoe, the number of messages per person grew in an S-shaped pattern over its first 12 years and then plateaued for the next 15 years. In the final 10 years of the period, the number of messages per person again rose steadily to be almost double 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. He would have been mistaken almost by a factor of two within ten years.

Use of rail shows similar trends. 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 electric telegraph, the number of track miles per person remained almost constant beyond 1877 as both track miles and population increased. Receipts per person (Figure 4) rose rapidly from 1873 through to 1878 and then plateaued for 20 years (explicable, in part, by depressed conditions for part of that period). Over the final six years, receipts once more began to increase quite sharply. Again, planners both at the initial phase and in 1896 would have had great difficulty in predicting subsequent usage of the rail infrastructure.



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 (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). Recent international assessments of individual infrastructure projects (e.g. new rapid transit lines) indicate that benefits of new investments 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) was "low" relative to nine developed comparator countries. 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. 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 and deferred rail maintenance in Auckland;
– 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 New Zealand's current infrastructure quality are published in Economic Development Indicators 2007 (EDI; MED et al, 2007). Using data sourced from the World Economic Forum Global Competitiveness Report, the publication compares the perceived overall infrastructure quality in New Zealand with that in the OECD and in comparator countries. New Zealand is ranked 34th in the world on this measure, below most developed countries.

One reason that infrastructure stocks may be poor would be if overall investment within the country were comparatively low. *EDI* 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, as it was also for 1995-2000. However the composition of investment may be skewed away from infrastructure investments. *EDI* also reports that 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 exceed 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 data reporting private and government investment as a percentage of GDP. Much of the latter category relates to 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. [3]

While New Zealand's infrastructure stock and infrastructure investment rate both appear to be 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 through raising productivity or through raising amenity values for the public, in each case by more than the full costs of the investment. Until recently, 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, ex post, whether particular infrastructure expenditures have been warranted.

Measuring Infrastructure Effectiveness

How can the effectiveness of an infrastructure investment be measured? Benefit-cost (B:C) analyses are often used ex ante to measure the anticipated effectiveness of an investment (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 Merz, 2001). B:C analysis requires a large number of assumptions in order to measure net benefits, even where costs are reasonably well identified. 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 B:C analysis. Furthermore, it is difficult within such analysis to quantify the benefits that may arise from unimagined opportunities that may in future arise conditional on the new infrastructure being built. The delayed responses to the electric telegraph and railways investments in the nineteenth century are examples of this type of response.

An alternative ex post approach, suitable especially for projects that have identifiable local or regional effects, is to examine the impact of a new investment on land values in the affected areas (Roback, 1982; Haughwout, 2002). 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 (by the present discounted value of expected future additional rents) and that

3. Some of the drop may be due to reclassification of SOEs; nevertheless, the apparently low current public investment rate is consistent with Sanderson's (2004) finding of a low rate, prior to 2004, for "other construction" in New Zealand.

rise in value will equal the productivity and amenity benefits attributable to the new infrastructure. Negative externalities (disamenities) will similarly 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 in evaluating extensions to Chicago's rapid transit system (McMillen & McDonald, 2004).

As an illustration of the technique, consider the advent of a new rail station in an area, as shown in Figure 5. 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 4, with a decreasing increment in values as distance from the station increases. No change in value will be experienced in block 5 since it is assumed to be too distant to be serviced by the station. Some disamenity value may be experienced by people living alongside the track; thus prices in block 6 may actually fall. The total ex post benefit of the new station is given by the sum of all changes in property values, including the negative changes. These benefits are valued explicitly by decentralised agents acting through the market. Total benefits can then be compared with total costs (suitably discounted to take account of time differences) to form an ex post B:C ratio.

This technique has the advantage that the

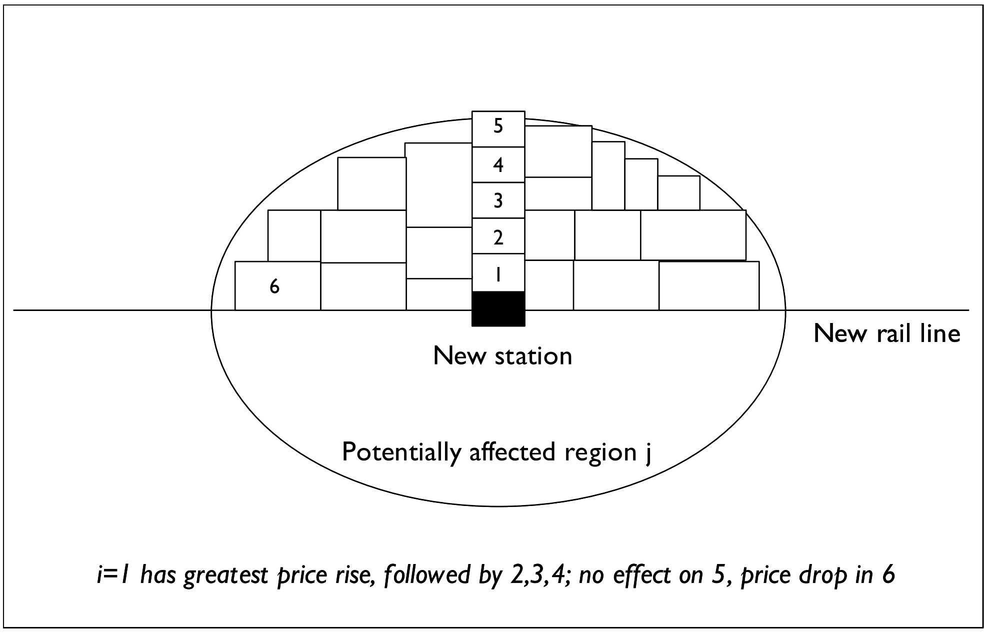


Figure 5: Illustrative effect of new infrastructure on land values

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? Given reliance on observed land value changes, this new approach is more suited to ex post evaluation than for ex ante prioritisation.

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

For the case of infrastructure, this analytical framework needs to be extended to take account of multi-stage investments by different investors. The initial infrastructure investment is required in order for future investment opportunities, that are conditional on the infrastructure being in place, to arise for other agents. The infrastructure investor is unlikely to know the range of opportunities that may 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 in an unforeseen fashion 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 firms (potentially start-ups not yet in existence) will 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 to do so, 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 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 a national broadband fibre network. Effectively, there is a missing market since future 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 values partially capturing the benefits from the infrastructure as rents from new opportunities are impounded in the land price. At the national scale, there is much less recourse made to such financing alternatives. At a minimum, this suggests that further work is required to identify who should pay for new national-scale infrastructure and how these payments should be arranged.

Modern Examples

The impacts of historical infrastructure programmes (such as the Vogel programme) are reasonably easy to discern with hindsight. More difficult is the task of evaluating whether recent infrastructure investments are worthwhile. Motu's FRST-funded infrastructure research programme is designed to evaluate the net benefits of a number of modern examples to assess whether certain infrastructure projects produce a net public benefit. Brief results are summarized here; readers are referred to the full papers in each case for more detail.

Roading Infrastructure - Auckland's Northern Motorway

Major roading projects in New Zealand are prioritised subject to a standard B:C analysis. Between 1995 and 2000, Auckland's Northern Motorway was extended in a number of stages from near Albany to Silverdale/Orewa. 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 16. While costs ran significantly over the ex ante budget (costs, excluding land, amounted to approximately double budgeted costs), an ex post evaluation still found that the project was worthwhile, with a B:C of 5.3 (Sinclair Knight Merz, 2001). That analysis, in keeping with the ex ante analysis, included, as benefits, vehicle operating cost savings, travel time savings, maintenance cost reductions and intangible benefits such as environmental benefits. Notably, benefits do not include the extra carriage of vehicles linking extra employees to extra firms, or extra residents to amenities; agglomeration externalities are similarly ignored.

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 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 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 North Shore and Rodney motorway exits and in the area surrounding Warkworth, to the north of the new northernmost exit at Orewa. Population and employment grew 57% and 67% respectively in North Shore areas within three kilometres of a new exit; figures for Orewa-Whangaparoa were 80% and 120% respectively. These growth rates compared with Auckland region-wide growth for the same variables of 38% and 55%. Areas that were more distant from the nearest new exit also grew, but the rate of growth tailed off as distance to the exit increased.[4]

4. Income growth around the exits was similar to income growth across the region, 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.

Land values within three kilometres of new North Shore exits rose 341%, much more than the values of land 4-7 kilometres distant from a new exit (276%) and considerably more than values in areas within Auckland similarly distant from the CBD. The land value outcomes and the trends in employment and population growth rates are consistent with a productivity and amenity boost for the areas newly serviced by motorway exits, noting that the amenity boost may partly be in the form of improved access 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 of 6.2 even after the cost over-runs. This is higher than found using the standard 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 set of benefits that arise from a new investment is 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. Furthermore, there may be interactions between firms and employees that raise the benefits derived from new infrastructure. For instance, firms may be able to access higher quality workers who correspondingly can access higher paying work opportunities; such improved matching within the labour market is a classic agglomeration externality thought to characterise production within cities (Duranton & Puga, 2004; Rosenthal & Strange, 2004). These agglomeration externalities are normally excluded from traditional B:C analysis.

Planning Infrastructure – Auckland's Metropolitan Urban Limit

Infrastructure can be interpreted to include laws, regulations and other 'rules of the game' that affect a range of agents' decisions. One set of rules, which may also affect the impact of other infrastructure investments, includes planning regulations. An example is Auckland's metropolitan urban limit (MUL), a set of boundaries effectively containing Auckland's urban form to within set limits.

Grimes and Liang (2009) analyse the effects of the MUL on land values across Auckland. After controlling for a wide variety of factors affecting urban and rural land prices, the study finds that land just within the MUL is valued (per hectare) at approximately ten times the rate of neighbouring land just outside the MUL. A prior study (Grimes et al, 2007) showed that Auckland's 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 (as intended) to Auckland's physical expansion.

There are many reasons that can be advanced to support zoning regulations such as urban limits, including limiting congestion, reducing emissions, and reducing loss of amenity values from loss of open countryside. In the absence of such externalities, the finding that a parcel of land is 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, so enhancing household welfare or reducing the costs of business or 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 categorically that the MUL is too restrictive. However it does demonstrate that agents are forced to pay significantly more for land for housing, business and public services than they otherwise would without the MUL (or with wider MUL boundaries). This result raises the question of whether the benefits of the current boundaries are at least equal to the costs that they are imposing. Furthermore, they raise the question of whether the new motorway infrastructure, which runs through the designated rural zone, is being under-utilised. To date, there has been no formal analysis of the MUL's benefits and so these questions remain 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 at the margin. The same concept with wider boundaries may produce a positive net effect. This is a public policy issue that requires further analysis.

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, water is becoming increasingly scarce and potentially over-allocated. Large-scale irrigation infrastructure can, in some cases, 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 is restricted in offering 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, given the restrictions on transfer of the water right to other users.

Motu's research focuses on water consents held by farmers in the Mackenzie District of South Canterbury. Approximately 9% of farms currently hold a consent; some are clearly clustered around a large-scale irrigation scheme; others are more localised. Grimes and Aitken (2008) obtain data on water consents (maximum rate and maximum 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. These data are then used to calculate the market value placed on water rights for farms with different characteristics.

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. Perhaps more important 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 more distant from an urban location. One may surmise 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 for considering the net benefits of irrigation infrastructure. Production within a region that experiences water shortages will be enhanced where the water is allocated to the most productive uses. The Mackenzie District results indicate that this may imply that water rights should be observed mostly on 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, solely by virtue of having applied for a water right in earlier years. In this case, the return to some irrigation investments may be much lower than others. The allocation mechanism coupled with incomplete water trading results in productive opportunities being lost in the district. Thus institutional mechanisms are important in determining the returns to infrastructure.

Lessons and Conclusions

Recent and distant historical episodes of infrastructure investment, interpreted in the light of modern economic frameworks, 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 initially. 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 the reactions of existing firms and residents to the new investment. The effects of the new investment on existing activities may in fact be subsidiary to its impacts in drawing forth new, potentially quite different, activities. The development of the Taranaki dairy industry is a useful historical example. Furthermore, the new activity may not constitute a linear addition to production; 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 agglomeration externalities in urban areas, for instance, will raise the benefits of a new investment over and above the extra production attributable to existing units. Recent work by Maré (2008) indicates that some of these types of benefit may be present within Auckland. Such agglomeration benefits tend to be discounted or ignored in many standard New Zealand B:C analyses.

A second lesson relates to time horizons. The New Zealand railway and electric telegraph examples produced the familiar S-shaped adoption curves for new technology over its first 10-15 years of use. However it also shows significant further uptake with a long lag (20-25 years after initial investment). This may be partly explained by changing economic conditions over time, but it is also consistent with the characteristics of a GPT with new applications being adopted over long periods based on the initial technology. Either way, the responses demonstrate 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 treatment of potential unknown benefits and of the choice of discount rate for different infrastructure investments. In the spirit of the modern investment under uncertainty literature, I conjecture that it may be appropriate to use a lower than normal discount rate 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 new opportunities as they present themselves, since without the infrastructure the new opportunities would not be (privately) profitable.

Conversely, a higher discount rate should be used where few new activities would be facilitated as a result of the new investment. For instance, a standard discount rate 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 through 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 reflect some of 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 more easily access employment in the CBD and elsewhere, while new employment opportunities in the newly serviced areas (especially Albany and Orewa) can be accessed by people both to the north and 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 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 consistent with the expressed purpose of the MUL. What is not clear is whether the lost development benefits are outweighed by greater benefits elsewhere for the region.

The differing return 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 easily obtain water from those with a water right. This is the case even if the farm with no consent could use that water (and compensate the current consent holder) by applying the water to a more advantageous use than can an existing holder. The results of this study imply that the existing irrigation infrastructure is currently producing sub-optimal returns, and agricultural production could be enhanced with a change that enhances 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. Research is currently 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; some lessons and conjectures discussed above may be modified; we may find that some infrastructure investments prove to be uneconomic. Nevertheless, the studies that have already been conducted confirm that certain infrastructure developments have contributed positively to New Zealand's economic development. We also find that the returns to infrastructure investments depend not only on the quality of the investments themselves, but also on the regulatory structures that shape the returns available from them. There is still room for improvement in this latter respect in order to ensure that infrastructure investments are making their maximum possible contribution to New Zealand's economic development.

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