

Trends in infrastructure

Greg Coombs and Chris Roberts¹

The adequacy of Australia's infrastructure has been a long-standing topic of debate. This article provides some insight into the question of infrastructure adequacy by examining trends in investment across OECD countries, and discusses some of the fundamental factors influencing Australia's investment relative to other OECD countries. The article also looks at the question of the changing composition of public and private infrastructure spending in Australia over recent decades.

¹ Greg Coombs is from the Macroeconomic Policy Division and Chris Roberts is from the Industry, Environment and Defence Division of the Australian Treasury. This article has benefited from comments and suggestions provided by Graeme Davis, John Hawkins and Gene Tunny. The views in this article are those of the authors and not necessarily those of the Australian Treasury.

Introduction

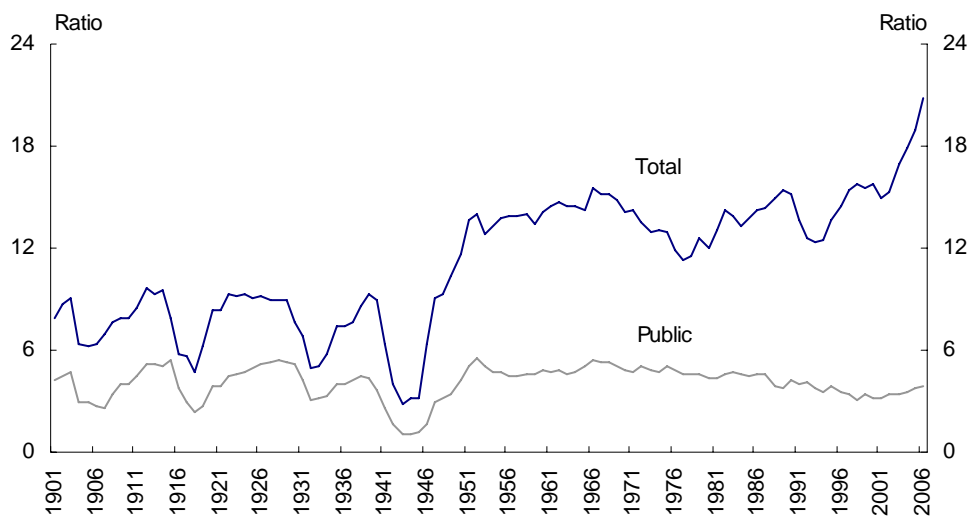
Debate over the adequacy of Australia's infrastructure had its genesis in 1786 with the decision by the British government to establish a convict settlement at Botany Bay. This decision changed the way in which the British authorities dealt with convicts because, unlike the convict trade with North America, the British government committed not just to the transportation of convicts but to a major investment in public infrastructure (Boot 1998). The debate has returned time and time again through our history, and the debate is no less relevant now than it was then. This article presents some stylised facts and identifies some broad factors that should be taken into consideration in such debates.

Trends in Australian infrastructure investment

The very long run

In broad terms, through the period from Federation to the present, total fixed capital investment as a proportion of GDP has fluctuated widely from around 3 per cent of GDP to around 19 per cent of GDP.

Chart 1: Ratios of total and public investment to GDP: 1901-2005



Source: Maddock and McLean (1987) for data from 1901 to 1981, ABS cat. no. 5204.0, Table 62 and 63 for data from 1982-2005, and Treasury calculations. Public investment refers to total gross fixed capital formation by the public sector, which includes machinery and equipment and non-dwelling construction, net of dwelling construction. Chain volume measure, 2004-05.

There was a sustained rise in investment of over 5 per cent of GDP immediately following World War II, mainly attributable to private fixed capital. During the 1950s, just over half of the increase in private fixed capital investment was attributable to non-dwelling investment. Important sectors were manufacturing, commerce and

equipment for agricultural production. In the 1960s, the mining and finance sectors joined manufacturing as the major investing sectors. The resources boom came to a halt in the early 1970s and with it mining investment.

Compared to private investment, public investment has fluctuated by much less: in a band between just over 1½ per cent and just under 6 per cent of GDP. Wide swings in public investment were evident prior to the 1950s, but subsequently, public investment has been a relatively stable proportion of GDP and a declining proportion of total investment.

In the years from Federation to World War II, public investment in infrastructure increased to complement industrial development, the spread of the use of the motor vehicle and utility networks for sewerage and electricity. It then fell as resources were switched to the war efforts during 1914-18 and 1939-45. This period also experienced wide fluctuations in economic growth.

During the period from the end of World War II to the late 1970s, public sector investment was strong. Investment rose quickly to clear the backlog of public works that had accumulated over the 1930s and the war years. Population growth was strong: during the period 1946-1975 more than 2 million migrants (net) arrived in Australia, and the fertility rate peaked at 3.5 children per woman in 1961. Public investment reached a post-war peak of just over 6 per cent of GDP in the mid-1960s, a level of investment not surpassed since the era of 'colonial socialism' of the second half of the 19th century. Strong public investment underpinned the rapid industrial expansion and urban development of Australia in the post-war years.

Recent times

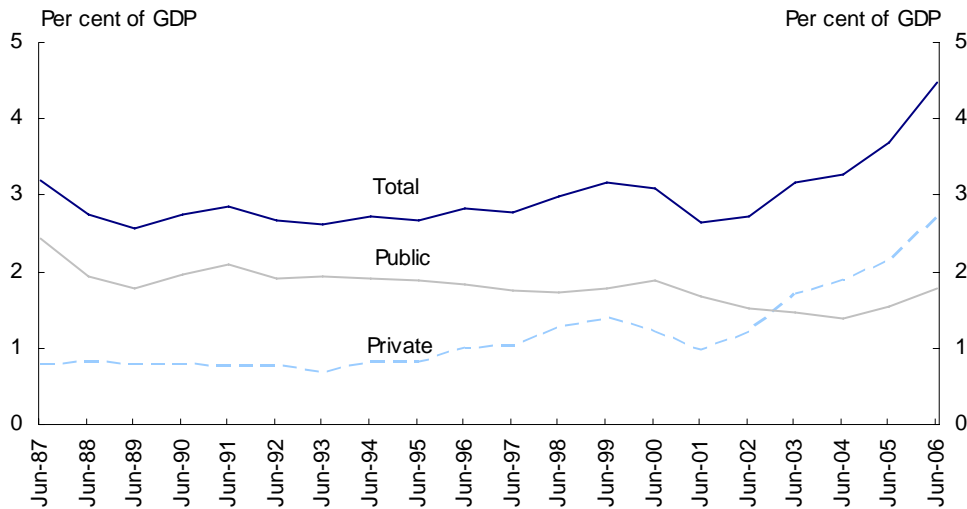
Chart 2 takes a closer look at a recent period – from June 1987 to June 2006 – for a sub-set of fixed capital expenditure – investment in economic infrastructure. Economic infrastructure covers utilities and non-dwelling construction.

Investment in economic infrastructure stood at 4.5 per cent of GDP in June 2006, compared with 3.2 per cent in June 1987.

Since the mid-1990s, the decline in public sector investment in infrastructure has been more than off-set by private sector investment in infrastructure, reflecting in part recent investment in infrastructure for export of commodities but also National Competition Policy reform, as discussed in the accompanying article in this *Economic Roundup*. Total public sector investment in infrastructure has declined as a proportion of GDP, from just under 2.5 per cent to just over 1.8 per cent of GDP. Both Commonwealth and state public sector investment has declined, broadly by the same proportion.

Trends in infrastructure

Chart: 2 Investment in economic infrastructure by sector
As a percentage of GDP



Source: ABS cat. no. 8762.0, Table 5, current prices. Economic infrastructure includes non-dwelling construction excluding buildings.

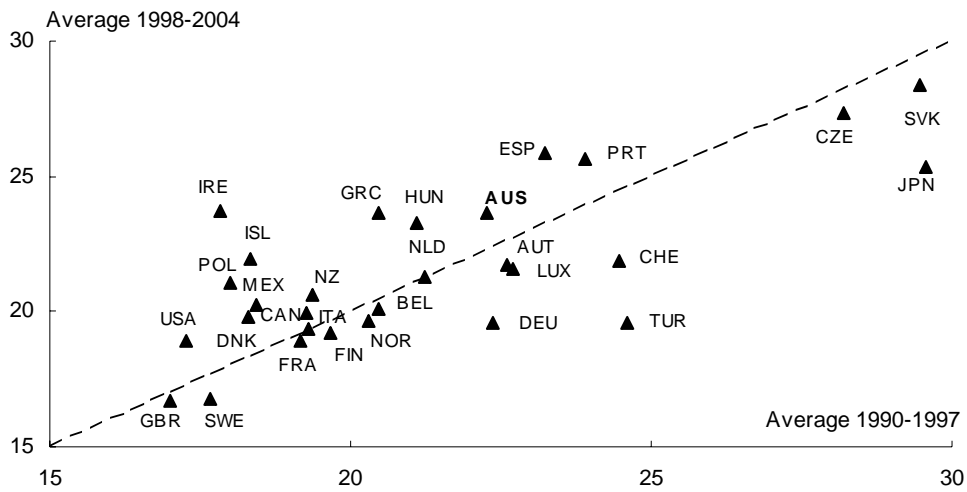
Underlying these trends is that infrastructure investment as a proportion of GDP reflects efficiency gains in the provision of new public investment, as productivity levels in construction increased in the late 1990s compared with historical trends (Dolman et al, 2006).

International comparisons

Total fixed capital investment across OECD countries has been stable over the whole of the period 1990-2004, with as many countries reducing investment over the period 1998-2004 (below the no change line) as increasing investment (above the no change line).

Australia's total fixed capital investment as a proportion of GDP was slightly higher than the OECD average over the period 1990-2004, and significantly higher than that of the United States (Chart 3a).

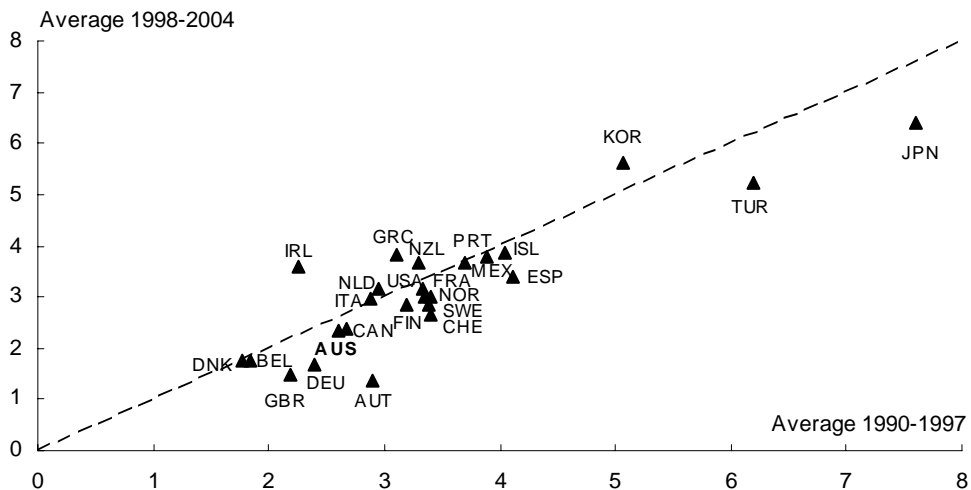
Chart 3a: Total investment, percentage of GDP



Source: OECD (2006c), excludes Korea.

Australia's investment in public infrastructure as a proportion of GDP is at the lower end of OECD countries (Chart 3b), and has only slightly declined from an average of 2.6 per cent of GDP over 1990-1997 to 2.3 per cent of GDP over 1998-2004. The reduction in Australian investment is in keeping with the majority of other OECD countries, although some countries have reduced investment significantly.

Chart 3b: Public investment, percentage of GDP



Source: OECD (2006a), data for 25 OECD countries.

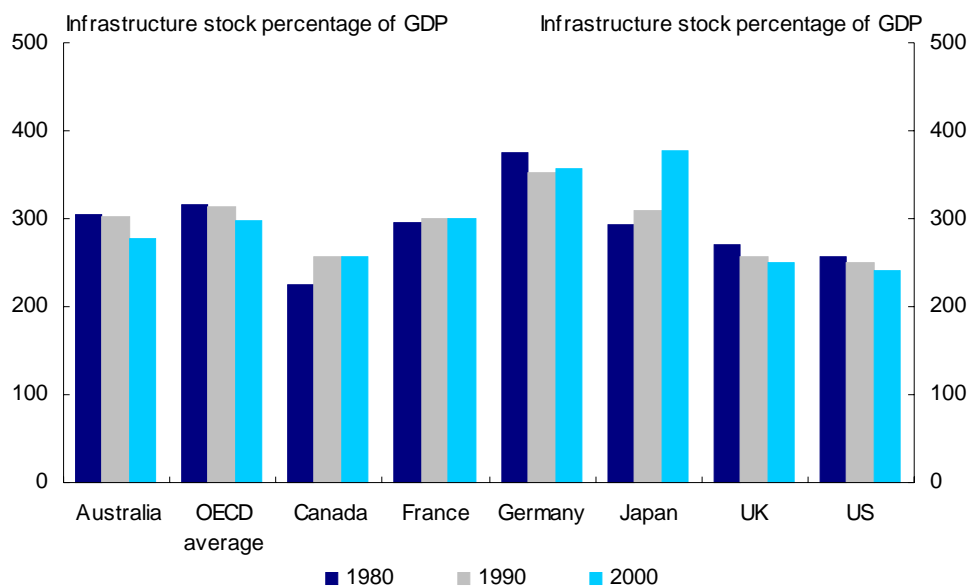
As fixed capital tends to have a long economic life, often spanning many decades, the flow of current investment is unlikely to be a reliable indicator of capital adequacy. A better approach is to measure the value of the capital stock, that is, the cumulated

Trends in infrastructure

value of investment over a long period minus the consumption of that capital used in the process of producing goods and services. Internationally comparative measures of capital stock (and infrastructure) are problematic because of differing definitions, depreciation rates, and data collection methods. Nonetheless research by Kamps (2004) of the International Monetary Fund provides internationally comparable estimates of infrastructure stock using the perpetual inventory method.

Kamps identifies that Australia's capital stock to GDP ratio has gradually declined over the past three decades, consistent with the United States and the average of OECD countries. Many countries undertook major investment during the 1950s to 1970s, particularly in manufacturing and services, reflecting the modernisation of advanced economies at that time. This capital stock has been gradually utilised over the following decades.

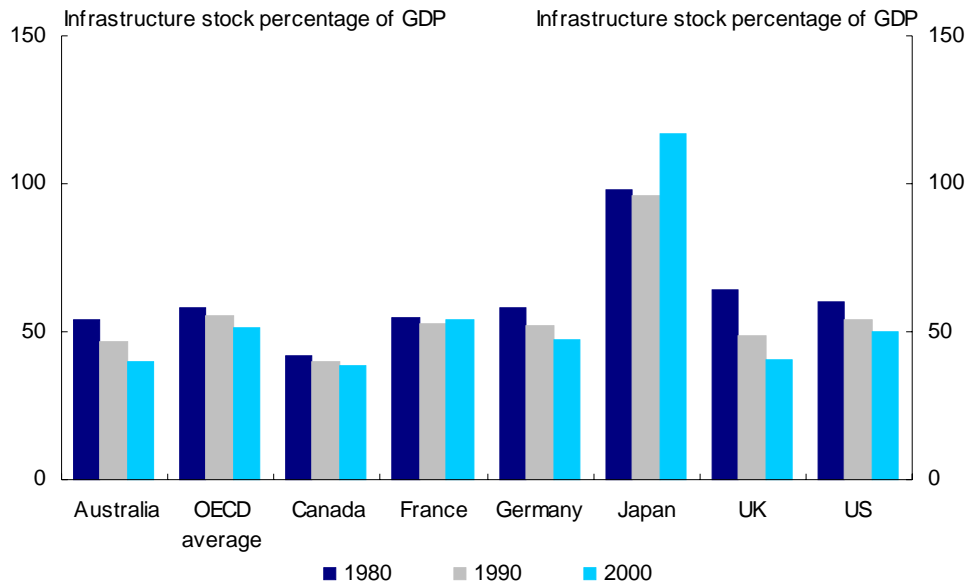
Chart 4a: Total net capital stock to GDP ratio in selected OECD countries at 2000 purchasing power parity, in US dollars



Source: Kamps (2006) and Kiel Institute (2006).

Kamps confirms that the decline in Australia's public investment is also reflected in estimates of the value of the capital stock. Chart 4b shows that on the basis of public capital to GDP ratio, Australia ranked 16th of 22 OECD countries in 2000. Public capital-GDP ratios have tended to decline in most OECD countries since the late 1970s, and there is considerable disparity in public capital across OECD countries even though there has been some convergence in the past two decades.

Chart 4b: Government net capital stock to GDP ratio in selected OECD countries at 2000 purchasing power parity, in US dollars



Source: Kamps (2004).

Interpreting the trends

Is Australia's relatively low rate of investment and low stock of public infrastructure impeding economic performance? There is no simple answer to this question. A number of factors bear on the question, including the impact of structural change, Australia's population concentration, the stage of the replacement cycle and aggregate investment signals – these are considered further below. Policy and policy coordination issues are handled in the companion article in this edition of *Economic Roundup*.

Impact of structural change

The evolving structure of the Australian economy has changed both the level and composition of infrastructure investment, creating ebbs and flows in investment over the past half century. There are several factors at play.

In a period immediately after the Second World War, the manufacturing sector share of GDP peaked at around 25 per cent and then steadily declined to around 10 per cent by the end of the 20th century. During the same period, the agriculture share of GDP also declined from around 20 per cent to less than 5 per cent of GDP. The less infrastructure-intensive services sector's share of GDP rose from around 50 per cent to around 80 per cent. As the main reliance on the economy shifts from manufactures and

Trends in infrastructure

agriculture to the services sector, the composition of its infrastructure also changes. New technologies enabled the extension of the economic life of existing infrastructure and new infrastructure was installed for telecommunications, including fibre optic cable.

Demographic factors have had an important bearing on the level and pattern of public investment in infrastructure. Population growth was a strong factor influencing infrastructure demand in the 1950s and 1960s. The development of new suburbs including public housing created complementary needs for roads, reticulated water, electricity generation and distribution and for schools, health and other public facilities.

Furthermore, increasing longevity and lower birth rates are expected to change infrastructure priorities, with higher needs for aged care facilities and reduced needs for schools. The changing pattern of population settlement has created demand pressures in provincial regions, particularly in coastal areas.

Changing preferences, particularly the preference for a cleaner environment, will also place pressure on infrastructure. For example, there may be more demand for better water quality and power generation involving lower carbon emissions.

Population concentration

Infrastructure is a means to an end: to get people, goods and services from where they are to where they need to be in order to meet the needs of economic and social activity in an efficient manner. An important characteristic of infrastructure – common to transport, communication, distribution and disposal – is the size of the network, which reflects the geographic concentration of the population.

Economic geography sets Australia apart from most other OECD countries. Australia is a vast continent with a small population and thus Australia's population density is among the lowest in the world (at around two persons per square kilometre). However, for the provision of infrastructure, population concentration, not density, is the more important factor. Geographic concentration refers to the degree of unevenness of the spread of the population over a country.

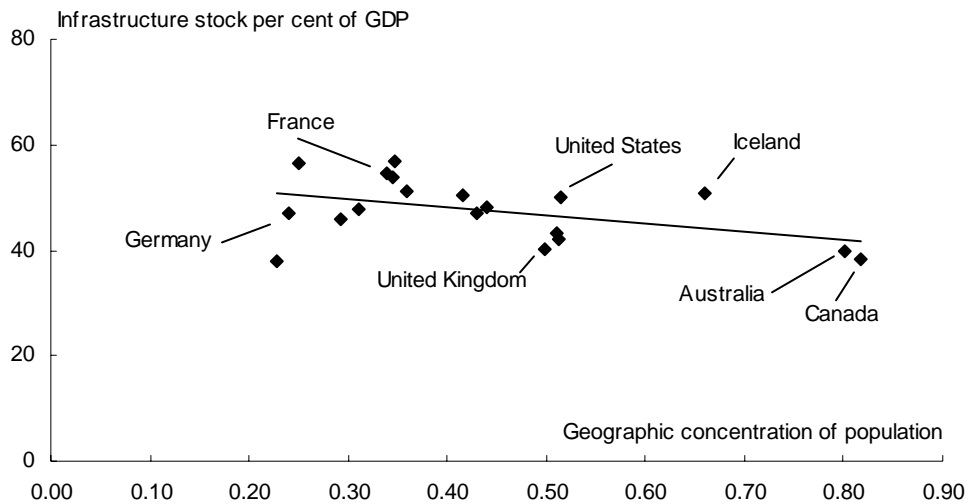
The higher the population concentration, the smaller the infrastructure network because the shorter is the average distance of the connections between people, goods and services necessary for engaging in economic and social activity. Australia has one of the most uneven population distributions in the OECD – most of the population is concentrated in a small number of large cities. In terms of the OECD's population

concentration index, Australia has an index of 0.80, which is twice the OECD average.² Only Canada's population is spread more unevenly than Australia's, and only slightly so, with an index of 0.82.

The lower the population concentration, that is, the more even the spread, the larger the infrastructure network because the longer is the average distance of the connections between people, goods and services necessary for engaging in economic and social activity. With an index of 0.34, France has a low population concentration compared with the OECD average. Even though Paris is a big city, a large proportion of the population is spread throughout the country.

Chart 5 shows that for the OECD high-income group of countries, the greater the population concentration, the lower the infrastructure stock as proportion of GDP.

Chart 5: OECD countries — relationship between geographic concentration of population and public infrastructure stock, 2000



Source: Kamps (2004) for infrastructure stock as a proportion of GDP and OECD (2005) for the geographic concentration index. Groningen Growth and Development Centre (2006) data base was used for high-income countries based on GDP per capita in purchasing power parity terms. Countries included are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

2 The population concentration index measures agglomeration. The index is calculated as the difference between the population share of a region and the area share of a region, summed for each region. In precise terms, $\text{index} = \sum_{i=1}^N |p_i - a_i|$ where p_i is population share of region i , a_i is the area of the region i as a percentage of the country area, N stands for the number of the regions and $| |$ stands for the absolute value.

Trends in infrastructure

While the relationship between concentration and public infrastructure is statistically significant, only about 20 per cent of the change in infrastructure stock can be explained by concentration. This indicates that there are other factors that contribute to the size of the infrastructure stock for any particular country. Thus these results should be regarded as indicative only and warrant further investigation.

For example, population density within cities is likely to influence infrastructure stock as a proportion of GDP. Calling on the discussion above, the population density of Paris is much higher than that of any city in Australia, and thus the infrastructure stock as a proportion of GDP would, all other things the same, be lower. This example brings out the point that countries with a small population such as Australia need not bear high infrastructure costs per capita where populations are agglomerated in a small number of large cities. In other words, to some degree, Australians have adapted economic activity to the geographic context of the continent. The question for investigation is how well Australia has adapted to its geographic context.

The qualifications to the above results run deeper than human geography. For example, in terms of physical geography, temperature variation, degree of undulation of the land, soil type, stability of the land mass and type of raw materials available for construction of infrastructure, all play an important role in determining the cost of infrastructure.

Some of the OECD countries have been excluded from Chart 5 because there is good reason to believe that these countries are some distance away from optimal investment levels and this would distort the results.

Ireland is an outlier, and has been excluded from the scatter plot. Despite low population concentration, the country has low infrastructure stock. As the OECD (2006b) states, investment in infrastructure has not kept pace with Ireland's very rapid economic growth, and that underinvestment may impede Ireland's economic growth in the future.

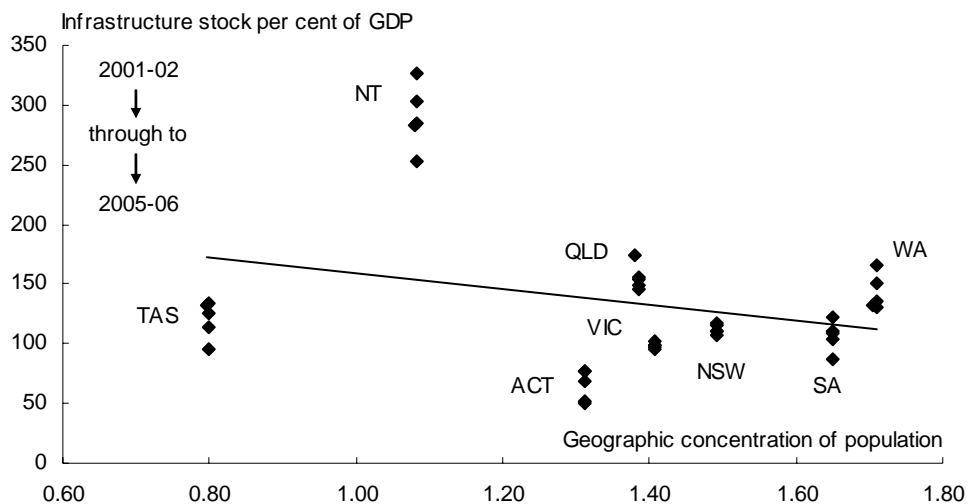
Japan and New Zealand have by far the highest public infrastructure stock-to-GDP ratios, but have been excluded from the scatter plot. It is well known that the Japanese government repeatedly attempted (in vain) to reinvigorate the sluggish economy with the help of large public construction programmes. New Zealand undertook a major infrastructure programme over 15 years to the mid-1980s, thus the average age of the infrastructure stock is young and hence the capital stock value is high relative to other OECD countries. New Zealand also over-provided infrastructure. Since the mid-1990s New Zealand has dropped back to low investment rates of between 2 to 3 per cent of GDP.

The methodological approach for the cross-country OECD comparison above is replicated for the Australian states and territories in Chart 6. The population concentration index was developed from data on statistical divisions.

In Australia's case, most of the states and territories are represented by populations that are heavily concentrated in the capital cities and a few other key areas. It is difficult to identify a strong relationship between the states and territories' population concentrations and public expenditure on infrastructure as most lie around the mean (Chart 6). However, one state, Tasmania, is a stand out example of a population that is more evenly distributed than those of the other states and territories.

In comparing Tasmania with the other states and territories, Chart 6 highlights the additional expenditure on infrastructure associated with lower levels of population concentration, or with a population that is more evenly distributed. The high levels of population concentration among the states and territories also highlight Australia's lower level of public expenditure on infrastructure relative to other OECD countries.

Chart 6: Australian States and Territories — relationship between geographic concentration of population and public infrastructure stock, 2001-2005



Note: The capital stock to Gross State Product ratio of public infrastructure is highest for each state and territory in 2001-02 and falls to 2005-06, the lowest point for each state and territory in the chart.
Source: ABS cat no. 5204.0, 1379.0, 8762.0 and Treasury.

Infrastructure age and replacement cycle

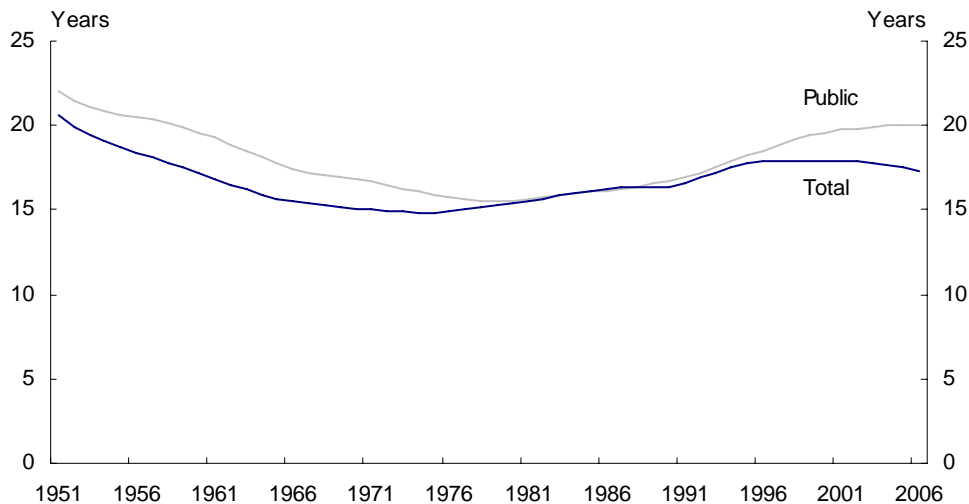
The average age of Australia's infrastructure has been rising since the early 1970s (Chart 7). As mentioned in the previous section, Australia underwent a major expansion in infrastructure from World War II through to the 1960s. In the early 1990s there were concerns that much infrastructure installed during these earlier periods was reaching the end of its economic life and that Australia would undergo a massive asset

Trends in infrastructure

replacement cycle at around the turn of the century that would place governments under considerable fiscal stress.

For example, the South Australian Government Public Accounts Committee presented eight asset management reports to Parliament between August 1986 and April 1987. These reports indicated an enormous replacement task for South Australia. For example, the report noted that in the five years to June 1987, the water authority consumed \$500 million worth of assets but spent only \$80 million on asset replacement (Evans 1989). While the asset replacement cycle did not materialise to the extent projected, in part as a result of technological change including the use of robots for the inner sleeving of water pipes, the report sounded an early warning signal relevant to all Australian governments of the importance of planning to overcome an anticipated increase in asset replacement.

Chart 7: Average age of infrastructure, 1950 to 2005



Source: ABS cat. no. 5221.0.

Investment signals

Proponents of the view that investment in public infrastructure is too low argue that increased investment would have positive spill-over effects on national productivity and growth. That is, there is a high social rate of return to public investment. Empirical work in the context of the United States by Aschauer (1989) and Mundell (1993) finds high pay-offs from investment in public infrastructure. Following Aschauer's approach, Otto and Voss (1994) find similar results for Australia. More recently, Kamps (2004) finds positive and statistically significant returns to public infrastructure across many OECD countries and for the OECD as a whole. For Australia, this study finds that a one per cent increase in the stock of public infrastructure would increase output by about two thirds of one per cent.

Critics of these studies argue that the estimates of the output response to public investment are implausibly high. The criticisms range from problems with modelling (Dowrick 1994), problems with the interpretation of results (Englander and Gurney 1994), inconclusive evidence (Ford and Poret 1991) and evidence of negative returns (Pope and Withers 1995, OECD 1997).

Through the use of cost-benefit analysis, there is a well-established methodology for calculating the rate of return from investment, at the project level. While such techniques are supported, a problem is that for network projects the return to the individual project can be higher than the return to the network as a whole. The Allen Consulting Group (2005) identifies this problem in the context of appraising rail projects that potentially affect the economic viability of road projects.

Overall, the messages are mixed on the relationship between public investment and output. Nonetheless, as Englander and Gurney (1994) suggest, the productivity response to infrastructure will get higher as demand is tighter. In the Australian context, there has been some evidence of infrastructure bumping up against capacity constraints at ports.

The overall position from the above discussion is that analysing trends in infrastructure investment at the macroeconomic level does not provide clear cut answers and that much more empirical evidence is required to form a view about Australia's infrastructure adequacy.

This observation underlines the importance of the microeconomics of infrastructure investment to guide decisions at the project level. Many studies of infrastructure adequacy advocate the rigorous application of cost-benefit techniques both for projects and broader considerations around network development and sector analysis. However, high-quality microeconomic decisions are difficult to make in situations where there are poor pricing signals, a lack of a 'level playing field' for competition, and inappropriate regulatory regimes. Hence, the importance of National Competition Policy (NCP) reforms, which are covered in the companion article in this edition of *Economic Roundup*.

Conclusion

Australian total fixed capital investment as a proportion of GDP took a sustained rise after World War II and from thereon has trended upward with fluctuations. Compared with other OECD countries, Australia is toward the higher end of investment as a proportion of GDP, and investment has been rising in recent times. Consistent with other OECD countries, Australia's total fixed capital stock per head of population is declining.

Trends in infrastructure

Australian investment in public infrastructure as a proportion of GDP has been declining since the 1980s, and this trend is consistent with the trend in most other OECD countries. Australian expenditure on infrastructure investment as a proportion of GDP is at the low end of OECD countries.

The implications of these trends for Australia's economic growth are not clear cut. There has been a string of studies to show that the declining trend in infrastructure in Australia reflects the changing composition of the structure of the economy toward the less infrastructure-intensive services sector and that productivity in the construction sector has played a role in reducing the real cost of infrastructure. Also privatisation and NCP reforms have shifted investment from the public to the private sector and introduced pricing signals which have helped to rationalise infrastructure.

It is not clear where Australia sits in the infrastructure replacement cycle because past experience shows that the timing of replacement is significantly influenced by technology and the changing characteristics of demand. At the microeconomic level, replacement projects should be guided by sound cost-benefit analysis.

An important observation in this paper is that Australia's population concentration plays a role in determining the level of public infrastructure. While Australia has a small population in a vast continent, the population is concentrated in a small number of large cities. Using the OECD population concentration index for advanced economies and IMF measures of infrastructure stock, there appears to be an inverse relationship between population concentration and public infrastructure stock. Thus, for countries with high population concentration – such as Australia, Canada and Iceland – infrastructure stock is at the low end of OECD levels. This relationship was also examined for the States and Territories of Australia. It was found that in the case of a less concentrated population, the stock of infrastructure was at a higher proportion to the other states and territories with higher levels of population concentration.

There does not appear to be strong macroeconomic evidence to support the need for Australia to increase total investment in public infrastructure. There may well, however, be examples of specific areas where new investment is required, for example, in some particular commodity export ports.

References

- Allen Consulting Group 2005, 'Infrastructure investment for a more prosperous Australia', Report to the Government of Victoria, May.
- Aschauer, D 1989, 'Is public expenditure productive?', *Journal of Monetary Economics*, vol 23, pp 179-200.
- Boot, H 1998, 'Government and the colonial economies', *Australian Economic History Review*, vol 38, no. 1, pp 74-101.
- Commonwealth of Australia 2006, Budget Paper No. 1, *Budget Strategy and Outlook 2006-07*, Statement no. 12, Canberra, pp 12-15.
- Dolman, B, Lu, L and Rahman, J 2006, 'Understanding productivity trends', *Economic Roundup*, Summer 2006, pp 35-52.
- Dowrick, S 1994 'Impact of investment and economic growth: externalities and increasing returns?', *EPAC Background paper* no. 39, Canberra, AGPS.
- Englander, S and Gurney, A 1994, 'Medium-term determinants of OECD productivity', *OECD Economic Studies* no. 22, Spring, Paris.
- Evans, D 1989, 'Water assets', in Blandy, R and Walsh, C *Budgetary Stress: The South Australian Experience*, Allen & Unwin, Sydney.
- Ford, R and Poret, P 1991, 'Infrastructure and private-sector productivity', *OECD Economic studies* no. 17, pp 63-89.
- Groningen Growth and Development Centre and the Conference Board (GGDC) 2006, Total Economy Database, University of Groningen.
- Kamps, C 2004, 'New estimates of government net capital stocks for 22 OECD countries 1960-2001', *IMF Working Paper*, 04/67, IMF Publishing, Washington.
- Kamps, C 2006, 'New estimates of government net capital stocks for 22 OECD countries 1960-2001', *IMF Staff Papers*, vol 53, no. 1, IMF Publishing, Washington.
- Kiel Institute for the World Economy 2006, 'Database on Capital stocks in OECD Countries', Germany, www.uni-kiel.de/ifw/ifwinfo_e.htm.
- Maddock, R and McLean, I 1997, *The Australian Economy in the Long Run*, Cambridge University Press, Cambridge.

Trends in infrastructure

McInerney, L, Nadarajah, C and Perkins, F 2007, 'Australia's infrastructure policy and the National reform Agenda', *Economic Roundup*, Summer, pp 17-49.

Mundell, A 1993 'An assessment of trends in and economic impacts of infrastructure investment' in *Infrastructure Policies for the 1990s*, OECD Publications, Paris.

OECD 1997, *Flows and Stocks of Fixed Capital 1971 to 1996*, OECD Publications, Paris.

OECD 2005, *OECD Regions at a Glance*, OECD Publishing, Paris.

OECD 2006a, *Economic Policy Reforms: Going for Growth 2006*, OECD Publishing, Paris.

OECD 2006b, *Economic Survey of Ireland 2006*, OECD Publishing, Paris.

OECD 2006c, *OECD Factbook 2006*, OECD Publishing, Paris.

Otto, G and Voss, G 1994, 'Public capital and private sector productivity', *Economic Record*, vol 70, no. 209, pp 121-32.

Pope, D and Withers, G 1995, 'The role of human capital in Australia's long-term economic growth', paper presented to the 24th Conference of Economists, Adelaide, 25-27 September.

Productivity Commission 2005, 'Review of National Competition Policy Reform', Report no. 33, Productivity Commission, Canberra.