Deloitte Access Economics

Infrastructure and the NSW economy

Prepared for

Infrastructure NSW

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Deloitte.

Deloitte Access Economics

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21 September 2012

Dear Paul

Infrastructure and the NSW economy

I am pleased to present this report, Infrastructure and the NSW economy, to Infrastructure NSW. It is a compendium of the major findings of earlier reports presented to INSW, and it therefore, represents the culmination of our work over the past year.

The report is broken into a series of parts which work through from a general background of economic drivers of infrastructure demand, to the state of the NSW economy (now and in the future), to the challenges of modelling infrastructure and, finally, to the estimated benefits that could arise from successful implementation of the SIS.

Overall, we find that the SIS is likely to result in significant benefits to the NSW economy (in terms of both increased GSP, employment and a boost to income per capita). These benefits are found to accrue to both residents in the metropolitan area as well as regional NSW.

Yours sincerely

Ric Simes
Director
Deloitte Access Economics Pty Ltd

Contents

Charts

Tables

Figures

Nature of forecasts in this report

The forecasts contained in this report bring together a range of state and regional level forecasts from NSW Government agencies. The modelling undertaken by Deloitte Access Economics builds on these forecasts to allow for sensitivity and scenario analysis but relies on underlying forecasts from NSW government agencies.

Glossary

Acronym	
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACMA	Australian Communications and Media Authority
AEMC	Australian Energy Markets Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ANZSIC	Australian and New Zealand Standard Industrial Classification
CBA	Cost Benefit Analysis
CDE	Constant Differences of Elasticities
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CRESH	Constant Ratios of Elasticities of Substitution, Homothetic
DAE	Deloitte Access Economics
DRET	Department of Resources, Energy and Tourism
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GSP	Gross State Product
ICT	Information and Communications Technology
IGR	Inter-generational Report
INSW	Infrastructure NSW
IT	Information Technology
ITS	Intelligent Transportation Systems
IV	Instrumental Variable
MCA	Multicriteria Analysis
NBN	National Broadband Network
NHSC	National Housing Supply Council
NSW	New South Wales
OECD	Organisation for Economic Cooperation and Development
SIS	State Infrastructure Strategy
TRESIS	Transport and Environmental Strategy Impact Simulator
US	United States of America

1 Foreword

This report is a compendium of a series of individual reports developed for Infrastructure NSW during 2011 and 2012. These individual reports represented an ongoing process of developing an understanding of the NSW economy (both as it is today and how it may be in 2032) and how the State Infrastructure Strategy (SIS) might affect the NSW economy.

In this compendium, the individual reports have been recompiled and edited to remove as much repetition as possible and present their findings in a logical order. In undertaking this editing we have, however, not attempted to draw a consistent narrative through each report. Instead, the reports are presented as a series of parts:

- Part A: Drivers of future infrastructure demand;
- Part B: NSW in 2031-32;
- Part C: The economic consequences of the SIS; and
- Part D: Modelling the effect of infrastructure on the economy.

Each part can stand as an individual work but, together, a clear picture of the economic context and consequences of the SIS can be formed. Part A sets out our considerations of what factors are likely to drive demand for infrastructure over the coming twenty years. This is a high level background which sets the scene for later parts. Part B then goes on to detail the current and potential future structure of the NSW economy. This part is based on drawing together a number of NSW government forecasts into a single modelling framework to allow for further analysis. Part B also provides a picture of the regions and industries which are likely to grow over the coming twenty years. Part C brings together the baseline modelling and the results from a literature review to give an estimate of the economic effects of the SIS. Part D draws on a range of recent economic literature to identify the likely effect that infrastructure investment will have on the NSW economy.

The final modelling results indicate that successful implementation of the SIS is expected to increase Gross State Product (GSP) by around 2.4% by 2032, as compared with the baseline scenario. The average impact on employment is expected to be an increase of over 100,000 FTE positions over the same time period. In dollar terms, the size of the NSW economy could increase by around $50.8bn (present value of the total benefits over the period to 2032) which is an increase of around $18.4bn a year by 2032, in today's dollars. Of this increase in economic activity, around $29bn (57%) occurs in metropolitan Sydney with $21bn (43%) occurring in regional areas.

There are also three appendixes. The first is a breakdown of the baseline modelling results within Sydney, this breakdown is done outside the CGE model and is based on geographic population forecasts developed by the Bureau of Transport Statistics. Appendix B is a detailed description of the modelling methodology to accompany the brief description given in Section 11 (in Part C) while Appendix C provides a review and summary of the literature covered in Section 18 (in Part D).

Part A:
Drivers of future infrastructure demand

2 Introduction to Part A

Before modelling the NSW economy, we have considered the driving forces that are likely to shape the state’s economy over the coming decades. This section, therefore, explores the influence of the following forces on the NSW economy:

- population dynamics;
- congestion and housing;
- the growth in China and other emerging economies;
- climate change and carbon pricing; and
- the digital economy.

By influencing the dynamics of the NSW economy, these driving forces will affect the type and location of infrastructure that is required. For example, growth of the digital economy may reduce the need for physical travel to work, and would result in a need for less road infrastructure and more telecommunications infrastructure. Another example is the ageing population which will require a mix of increased supply of hospitals and related services in regional areas for those who migrate within the state and a reconfiguration of infrastructure supply in established suburbs.

Consideration of these driving forces also allows for a fuller picture to be gained of the forces driving the baseline modelling as well as the uncertainties that could be explored in policy analysis.

3 Driving forces of infrastructure demand

The shifting demographics of NSW, both in terms of population growth and ageing, is one of the most fundamental long term economic drivers for the state. Changes in population will have significant effects on increasing congestion (which in itself forces the economy in certain directions) as well as housing (one of the key sectors in the economy).

3.1 Population growth and ageing

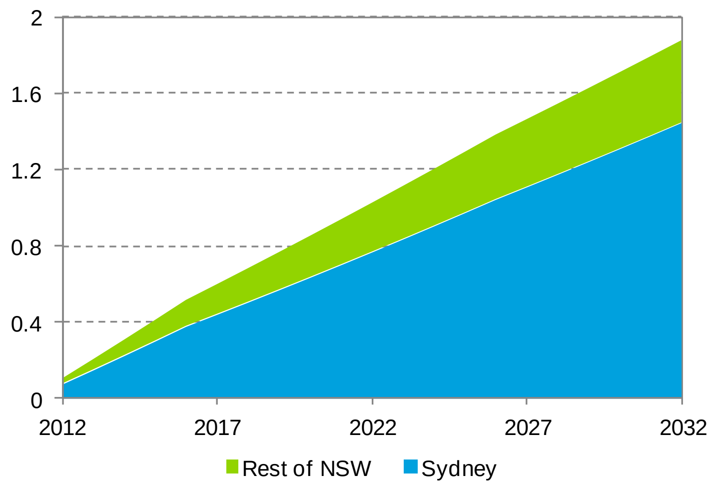
The factors of both population growth and the ageing population will continue to dominate NSW's population dynamics over the coming decades with population growth possibly being the more important factor for infrastructure investment decisions.

Since 2000-01 Australia's population has increased by around 3.1 million (which is over 380,000 people per year). This has been the highest level of growth in Australia's history and, with population growth rates since 2008 averaging around 1.8% a year; it has also been the highest rate of population increase since the early 1970s (ABS, 2008). However, population growth in NSW (being around 1% a year) has been below the national average due to relatively high net interstate migration losses (ABS, 2011a). Despite this, NSW's population has still increased by around 700,000 since 2000-01 (ABS, 2011a).

3.1.1 Baseline forecast

Population growth rates for NSW's regions have been projected by the Department of Planning based on the NSW Government's intergenerational report. These projections suggest an average population growth rate of around 1.1% a year for NSW and 1.3% for Sydney from 2011-12 to 2031-32. This brings the expected population to 9.2 million in NSW and 6.1 million in Sydney, annual increases of around 88,000 in NSW and 68,000 in Sydney, (Department of Planning, 2011).

Chart 3.1: Additional NSW population (millions)



Source: (Department of Planning, 2011)

3.1.2 Changes since the NSW Metropolitan Plan

These population increases can be compared to those forecast in the NSW Metropolitan Plan. The population increases in the Metropolitan Plan were also forecast by the Department of Planning but were made before those outlined above. The forecasts in the Metropolitan Plan indicated a population of around 6 million by 2036, an increase of around 1.7 million. The slight increase since this last forecast is due to higher assumed migration levels as discussed in section 6.2.

Increases in population along the south and north coast are also important to consider. Population forecasts for these areas are discussed in section 6.2. In terms of infrastructure demand, increasing the population along the north and south coast will reduce demand for transport within the metro region but will increase the need for efficient transport connections to the metro area.

A second major significant change to economic prosperity and growth factors is the ageing of the population. The ageing of the population is a function of both the mid-20th Century baby boom and steady increases in life expectancy, particularly for older people. The Australian Government's Intergenerational Report indicates that life expectancy for Australians is currently around 80 years for men and 84 years for women and that life expectancy is expected to increase over the coming decades (Australian Government, 2010).

Some of the effects of an ageing population will, however, be offset by increases in the workforce participation by older Australians. This increase may be driven by a combination of a healthier aged population and the need for greater financial assets to fund a longer retirement.

Overall, the ageing of the population can be seen in changes in the aged dependency ratio (those over 65 compared to those within working age). The aged dependency ratio in NSW is expected to increase from 20.9% in 2010-11 to around 35.0% by 2031-32 (NSW Treasury, 2011).

Population growth affects all areas of infrastructure demand while an ageing population raises issues of housing stock and changes in the profile of demand for goods and services.

3.2 Congestion and housing

Congestion is not a fundamental economic driver; rather, it is a sign of mismatches between past planning and infrastructure decisions and population increases. These mismatches create congestion which can have serious effects on economic activity and reduce the desirability of living in Sydney and NSW. The economic effects of congestion include reduced productivity for road transport (the higher costs then flow on through the economy), lost leisure time for individuals and distortion of housing, work and transport decisions. In a dynamic sense, congestion also affects the desirability of Sydney overall and so makes it difficult to attract and retain highly skilled, mobile workers.

The relationship between traffic and congestion on Sydney's roads has been estimated in Deloitte Access Economics (2011a). That analysis relied on the TRESIS model, developed at the Institute of Transport and Logistics Studies at the University of Sydney. Based on a projected increase in road journeys of around 15% by 2025, the analysis estimated that congestion costs would increase by around 84 million hours (or 32%).

The relationship between congestion and vehicle journeys was also estimated to be non-linear: as journeys increase, congestion costs increase by more and more. This suggests that, at some point in the future, congestion costs are likely to increase to a point where road transport becomes untenable.

The potential for increased congestion costs are also evident in figures such as vehicle ownership and traffic speeds, as shown in Table 3.1

Table 3.1: Summary of traffic volume measures, NSW

	2003	2004	2005	2006	2007	2008	2009
Vehicles (per 1000 population)	474	485	492	498	504	506	507
Change in traffic volume (%)	2.2	1.4	0.2	1.0	-0.2	0.8	0.1
Travel speed, AM peak (km/h)	34	34	31	32	30	30	31
Travel speed, PM peak (km/h)	41	41	41	42	41	43	43

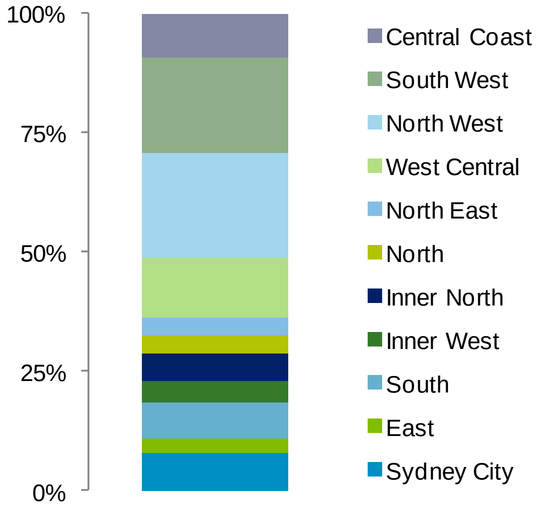
Source: (ABS, 2011d)

This data suggests that the number of vehicles per person has been increasing along with slight increases in traffic volumes. This has led to a decrease in AM peak travel speeds. The decrease in AM peak travel speeds is more significant than the improvement in PM peak travel speeds as the AM peak tends to be the larger peak of the day, as there is less flexibility in work arrival times when compared to work departure times.

Over the coming decades, another important influence on congestion will be the ability of workers to telecommute. Telecommuting could significantly reduce congestion costs as the number of journeys, especially at peak times, could be reduced. Teleworking can work to offset demand for transport created by population increases. Data indicates that currently around 6.5% of Australians have a teleworking arrangement. If the proportion in Sydney was to reach 12%, an Australian Government target, then we estimate this could reduce travel time by around 20 million hours a year (Deloitte Access Economics, 2011b).

The Metropolitan Plan for Sydney 2036 indicates a target of increasing dwellings by 769,000 by 2036 (NSW Government, 2010). But the recent increase in fertility (ABS 2012a) and housing demand suggests that an increase in dwellings in excess of this may be needed in the next 20 years. This overall target was also broken down by geographical region:

Chart 3.2: Geographical distribution of Metropolitan Plan housing targets



Source: (NSW Government, 2010)

The National Housing Supply Council (NHSC) has similar expectations for growth in housing with a forecast of between around 663,000 and 962,000 extra households in NSW from 2009 to 2029 (National Housing Supply Council, 2010). This increase reflects both the higher population in NSW as well as a continued decrease in household size.

Housing and planning also interacts with population ageing, an older population is likely to have different housing requirements to a younger population. In the case where older people move out of Sydney and into regional areas, particularly the north coast, this could create particular demands for infrastructure (such as hospitals and retirement villages). This will also tend to free up a large amount of housing in Sydney, particularly larger family houses. This release of housing will go some way to meet the demand that will be created by increased rates of population growth and continued reduction in household size.

In the case where older people decide to remain in the family home or relocate nearby, issues are raised around how to provide adequate infrastructure and services related to health, community support and transport. This scenario would also have implications for the supply of larger residential properties in established areas and the spatial distribution of other government services including education.

3.3 The two speed economy

Australia's two speed economy is fundamentally being caused by economic development in emerging economies. This development has created increased demand for inputs to industrial production (particularly iron and coal) which has benefited mineral exports. Increased demand for Australian minerals has not only drawn real economic resources into these industries but has also increased the value of the Australian dollar. This creates pressures in other industries, which must cope with higher input costs and a deterioration of international competitiveness.

The two speed economy, has also seen an increase in demand and prices for some Australian agricultural products (Hogan & Morris, 2010). Increased demand from the emerging economies in Asia is also resulting in rapidly increasing demand for services in tourism, finance and education, which will bring new opportunities for NSW businesses over coming years. This raises questions of the ability of our infrastructure to enable capture of this increased demand as well as issues of substitution by developing nations away from services currently provided by Australia and into domestic production of services.

3.3.3 The role of emerging economies

Over the past 30 years the geographical centre of global economic activity has been shifting towards Asia (Quah, 2011). This has been driven by fast paced economic development in east and south east Asia. Arising from this, there have been significant changes in Australia's main export and import partners, with countries in Asia now playing a much larger role in Australia's trade relationships.

Over the last ten years, the role of China has dominated global growth. Since 2000, Chinese GDP per person has grown at an average rate of around 9.2% a year, in real terms, which means that wealth per person would be expected to double in size about every 8 years. This could be compared to Australia, a relatively successful developed country, which has seen real GDP per capita grow at around 2.3% a year over the same period, implying a doubling time of around 32 years.

There are still other countries in Asia which, although they have been developing strongly, still have a long way to go in terms of economic development. Primary among these is India but also countries like Indonesia and Vietnam have large populations and are achieving high rates of economic growth.

Overall, development in emerging economies has driven a significant increase in volumes traded through Australia's ports. Since 2000-01 the containerised volume being traded through ports operated by Sydney Ports Corporation has increased by around 6.4% a year, on average (Ports Australia, 2011), while NSW GSP has increased by only around 0.9% a year on average (ABS, 2011b). That is, for every million dollars of GSP in 2000-01 there were around 3 TEUs moved through Sydney's Ports while by 2010-11 this had increased to 4.8 TEUs.

This growing importance of trade with countries near Australia has, of course, been driven by patterns with individual trading partners. Australia's trade tends to be concentrated on a small number of markets, trade with our top five partners accounts for around 50% of total trade over the past 20 years. Changes in the pattern of trade with these top five partners are therefore important in determining the composition of Australia's trade.

As our trading partners develop, they demand different exports from us and supply different imports to us. For example, Australian exports to China in 1990 tended to be relatively low value food and fibre products. On the import side, imports tended to be dominated by clothes and other products produced from textiles. In this sense Australia was tending to export the material for clothes production and import the finished goods. By 2010, the pattern of trade between Australia and China had completely changed. Iron ore and wool remain in the top five exports but the role for iron ore increased dramatically and it had been joined by coal. This reflects the industrialisation of China over the past 20 years and the strong demand for steel that goes along with that. Other inputs to industrial production, petroleum products and copper, have also entered the top five. An even greater change occurred in imports where, by 2010, the top five import categories were all information technology and electronics related.

Over the next 20 years the development of our trading partners will likely mean that demand for Australia's mineral exports increases in line with continued industrialisation in China and other developing countries such as India and Vietnam (Australian Government, 2011).

In terms of direct infrastructure effects, the continued presence of emerging markets mean a continued increase in the sheer volume of goods that must be moved through NSW's ports, the need to distribute goods efficiently within our cities and a potential shift in the mix of bulk and containerised freight. Indirectly, emerging markets will also continue to foster the two-speed economy in Australia and so will have further effects, discussed below.

3.3.4 Influence on industry structure

The two-speed economy is likely to be mostly felt in terms of the state's sectoral composition. Higher prices and increased demand for energy and industrial commodities will constrain growth in other trade-exposed sectors (such as parts of agriculture, manufacturing and tourism). The underlying causes are a stronger than normal exchange rate and greater competition for labour and capital resources.

The presence of an increased exchange rate and strong competition in labour and capital markets is generally known as the "Dutch Disease". The classic formulation of the Dutch Disease involves an expansion in the mining sector of a particular country which then draws away economic resources from other industries, potentially leading to the long term decline of these other industries.

An example of increased infrastructure pressure resulting from the positive side of the two speed economy is in the black coal sector, which is mostly transported by rail. NSW accounts for 40 per cent of Australia's black coal production facilities, and production is expected to rise over coming years (DRET, 2011b). Rail and port capacity as well as natural disasters have held back production in recent years. While the Port of Newcastle is a key link in the supply chain, over the past few years, the Hunter Valley Coal Chain Coordinator has gone a long way towards ensuring more efficient operations along the entire supply chain and getting the most out of existing infrastructure.

In the medium term, it is unclear whether the net effects of the two speed economy will be positive or negative for NSW. The potential benefits for NSW in terms of energy, tourism, education and financial exports are strong but with a number of factors affecting the states overall economic performance (particularly relative to other Australian states):

- Tourism: losing share of international travellers, but China has already overtaken Japanese market for visitor numbers. Main implication is for transport: airport capacity and regional roads.
- Agriculture: rising incomes in China and India will drive per capita daily food intake. Increasing pressure on road transport and for higher-productivity vehicles.
- Manufacturing: is expected to decline in relative terms, but imported goods will still put pressure on existing transport networks.

A possible result of these sectoral changes is further growth in service-focused industries.

Over the longer run, however, the pressures of the two speed economy will likely shift as developing nations in Asia begin to demand services such as education and tourism. This increased demand will likely see a reverse of the short run trends (where tourism and education were particularly affected) as the positive influence of demand increases swamp the negative influences of foreign exchange appreciation. At the same time, substitution of Australian produced services for domestic services may lead to declines in some other service sectors.

Considering regional NSW, the two speed economy, particularly the emergence of Asian markets will have significant effects on the agriculture sector. Some of the key factors influencing prospects for agriculture include:

- Global food prices, which the OECD forecasts will continue rising, will encourage the expansion of NSW Agriculture (OECD, 2011). Some sectors have fared better than others: improvements in prices for wool, beef, sugar and wheat have been higher than for wine grapes and some horticultural industries.
- Rising incomes in key Asian markets, with China and India driving per capita daily food intake higher. Over coming years, livestock industries will experience strong growth because when incomes rise in developing countries their diet will increase more in meat (protein) and sugar, compared with grains.

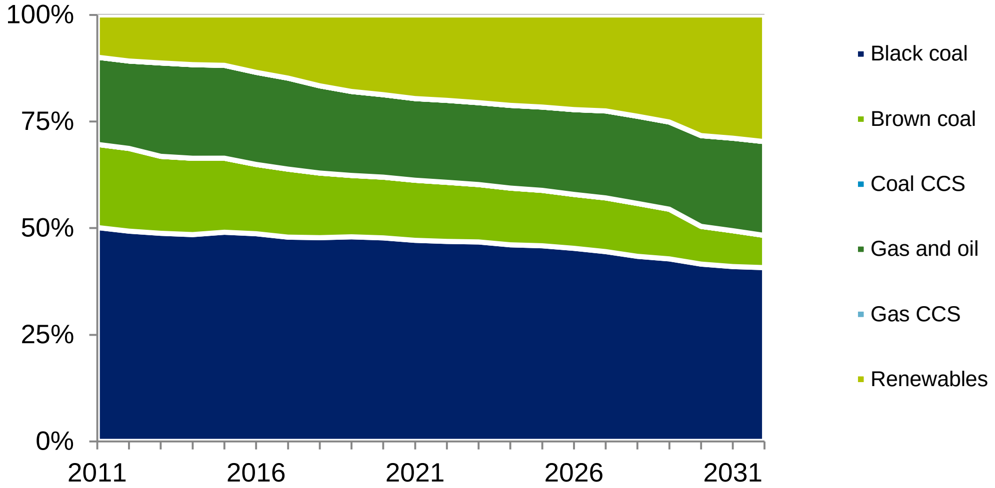
This growth in demand for certain agricultural goods will potentially increase pressure on road transport and increased demand for road access for higher-productivity vehicles as well as a relative shift away from bulk freight towards containerised and refrigerated transport.

3.4 Climate change and carbon pricing

Recent modelling released by the Australian Government Treasury suggests that NSW is likely to be among the more adversely affected states following the introduction of carbon pricing (a likely reduction in GSP of around 1% below a base case scenario by 2031-32) (Treasury, 2011). Although there is uncertainty about the impacts of climate change and carbon pricing, there are a number of clear implications for NSW:

- Carbon pricing means reduced competitiveness of coal as an electricity source, with greater use of gas in the future and hence an increased need for gas supplies (DRET, 2011a);
- There will be increased pressure for new electricity generation capacity, with a question of how much is located in NSW compared with elsewhere in the National Electricity Market (AEMO, 2011); and
- Carbon capture and storage is likely to play a role in the long run in meeting electricity demand and this has implications for the location of gas storage (Treasury, 2008a).

Chart 3.3: Australian electricity generation mix (2011-2032)



Source: (Treasury, 2011)

Carbon pricing will also have a range of industry and infrastructure impacts on the NSW economy. Some sectors (such as forestry and rail transport and broadband infrastructure) will benefit from the introduction of carbon constraints while others (such as metals refining and road transport) will be adversely affected (Treasury, 2011).

3.4.4 Water

The main factor affecting the Murray-Darling Basin, agriculture west of the Great Dividing Range, and overall regional economic and population growth in coming years will be decisions over water entitlements and allowances. That is, changes in the allocation of water rights in the Murray-Darling Basin largely reflect historical over-allocation. Changes in water allocations will result in an overall reduction in the quantity of irrigation water available to NSW's farmers.

In the decades ahead, climate change may also begin to have impacts on the availability of water. There will be reduced and more variable water supplies for agriculture both in the Murray-Darling Basin and along the coast.

To minimise the potential impact of reduced water supplies it will be important that productivity improvements in irrigation areas are pursued. This could involve efficiency-enhancing investments in water delivery infrastructure, which also aim to improve environmental flows, as well as fostering new businesses in water management (Roberts, Mitchell, & Douglas, 2006).

The effects of climate change, particularly when combined with population growth in some regional centres also raise critical questions for the security of town water supplies in regional NSW. Improvements in urban water supply necessary to account for population growth and reduced water availability will need to incorporate both increases in the capacity to supply town water (through improvements in water collection) and the ability to transport town water through renewing and maintaining town water infrastructure.

3.5 Digital Economy

The digital economy and information and communications technology (ICT) have a somewhat unique role to play among the drivers considered so far:

- Development of the digital economy will require ICT infrastructure investment in its own right.
- The digital economy will drive changes in demand for infrastructure, such as reducing demand for transport and increasing needs for smart infrastructure.
- The digital economy will affect industry structures and competitiveness throughout the economy.

For example, Australia is currently investing in the NBN, which will create a significant piece of physical infrastructure. This infrastructure investment will create a multitude of flow on effects in other industries: improved ability to telework will affect demand for travel, potentially reducing congestion, telehealth will allow for reduced investment in physical hospital infrastructure and better machine to machine communications may allow for improved maintenance of other significant built infrastructure (such as bridges and pipelines).

The Australian economy is now at an inflection point in the shift towards a digital economy. A combination of trends are now converging which will drive a major behavioural change. For example, after some years of anticipated change to retail, we are now seeing extensive reshaping of who the major retailers are and how they deliver their product. The key converging trends are greater broadband capacity through the National Broadband Network and mobile technologies (4G and WIFI), more convenient devices such as smart phones and tablets, and the growth of effective online platforms for conducting business.

Growth in the digital economy is being led by individuals, as consumers and employees, changing their approaches to work and leisure. This ground up change will have implications for business and government service delivery.

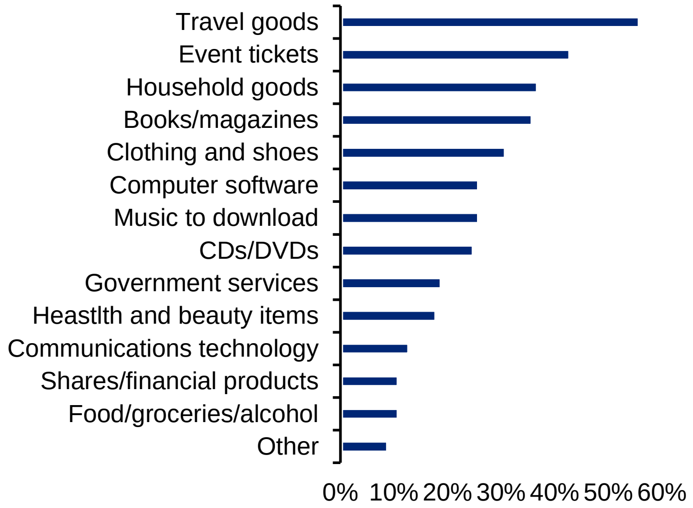
3.5.3 Retail

An example of a sector that will be strongly affected by developments in ICT is retail trade, particularly through the impacts of information and communications technology on online retailing vs bricks and mortar shops. Australia has been slower to adopt online retailing compared with some overseas countries like the United Kingdom and United States (Frost and Sullivan, 2010).

As online retailing expands, it will constrain the growth of traditional shopping centres and main street shopping districts. This will have differing impacts on specific retailers. Chart 3.4 shows that online retail purchases are highest for goods that do not require freighting – accommodation and event tickets. The backbone of shopping centres, food and groceries retailing, remain the lowest proportion of goods purchased online. As online retailing grows, a greater proportion of shopping centre retailers will have a service component that is less able to be sold online – such as hairdressers, salons and cafes.

Changes in retail will have consequences for transport networks. Although there will not be a reduction in demand for freight, goods will increasingly be transported from warehouses to consumers rather than to shopping centres. However, if shopping centres can transform from being goods distribution centres to more recreation based centres then the burden on their surrounding transport networks will continue.

Chart 3.4: Goods and services purchased online in Australia in the last six months



Source: (ACMA, 2010)

Online retailing will place additional burdens on broadband infrastructure. The widespread adoption of smart phones and increased demand for mobile data will put additional pressure on mobile infrastructure at shopping centres. As online retailing becomes more sophisticated, with virtual stores and dressing rooms with high definition video, this will increase demand for fixed broadband infrastructure.

3.5.4 Smart infrastructure

One of the major trends affecting the infrastructure sector in coming demand will be smart infrastructure that is enabled with machine-to-machine digital technologies.

Smart energy grids will potentially be a large future driver of efficiency gains in the electricity network, transforming the way electricity is used and delivered. These grids will enable the real-time use of information throughout the grid and potentially significant reductions in losses through the system. Smart electricity meters will also be part of developments.

Intelligent Transportation Systems (ITS) technologies encompass a range of information technologies that can be integrated into transportation system infrastructure. ITS technologies have the potential to address a range of transport issues and can help in improving safety, improving efficiency, improving competitiveness and reducing environmental impacts of transport. In particular, technologies such as diagnostic traffic tools can help to improve the efficiency of traffic flows and save time and money.

Smart networks can also provide real-time public transport information, to improve their operations and performance. This can encourage the shift towards the use of public transport, reducing congestion and environmental impacts. There is scope to provide the consumer with information about times based on congestion levels rather than timetable estimates.

3.5.5 Other trends in the digital economy

Digital technologies will also affect business organisation. Work will be transformed by the eventual growth of teleworking, where there is a government target of 12 % of workers by 2020 (NBN, nd). This may have significant impacts on transport within and between cities.

Additional demand for ICT infrastructure will be driven by growth in the use of mobile communications, video-based applications, and the Cloud:

- Mobile communications: existing applications have been gradually migrating to mobile devices (such as smart phones and tablets) and this will be further supported by new location-based services. For example, by 2015, mobile data demand is expected to reach around one third the size of fixed data demand (Cisco, nd).
- Video: households will take-up entertainment options from smart TVs, and in longer term, video will provide more education and health applications. Video takes up a very large amount of internet traffic and is expected to take up around 81% of consumer internet traffic by 2015 (Cisco, nd).
- Cloud: will have impacts on individuals and business. Individuals will expect to be able to connect anywhere and anytime. For business, the Cloud offers an alternative to the traditional IT department and services; with on-demand IT allowing greater flexibility in how businesses engage with the digital economy.

Fixed broadband infrastructure will mainly be delivered by NBN Co, with the network scheduled to be rolled out by 2020.

Part B:
NSW in 2031-32

4 Introduction to Part B

4.1 Background

Infrastructure NSW (INSW) engaged Deloitte Access Economics to prepare a baseline model of the NSW economy to 2031-32. The first step of this process was to identify assumptions being incorporated into current Government thinking and develop a common set of assumptions across agencies. In addition to testing the assumptions behind the modelling, we asked Government agencies to share data and internal reports on current thinking on key topics such as mining opportunities and infrastructure bottlenecks. Key assumptions have been sourced from the NSW Treasury Intergenerational Report and NSW Budget Paper 6.

While the broad themes of the 2020 foresighting project remain relevant, a number of the key policies and assumptions underpinning the modelling have changed since the previous report was published. Additionally, the computable general equilibrium (CGE) model has been updated to a more recent database – the model is now more current. This has had important implications for the forecasts of the mining sector as well as the relativities between some service sectors in the model.

INSW is seeking to use this baseline model as a starting point to compare how different drivers (particularly infrastructure investments and technology changes) might affect the NSW economy. That is, INSW is seeking to identify the key long term economic drivers of infrastructure supply and demand and then translate these drivers into infrastructure responses. INSW is seeking to ensure that the infrastructure investments identified should support (or help create) competitive advantages in NSW and help boost productivity.

This issues paper proposes some key economic drivers which will affect the NSW economy over the coming decades and then considers various potential infrastructure responses to these drivers. The following analysis of specific economic drivers is framed against a broader economic background, particularly Australia's lacklustre productivity performance over the last few years.

Lower productivity manifests itself as lower wages growth, reduced international competitiveness and increasing private and public budgetary pressures. If Australia's productivity growth could be increased above the long-run average the economy would be bigger, living standards would be higher and fiscal pressure from the ageing of the population would be reduced (Australian Government, 2010).

The assets which enable productive activity in the NSW economy, our infrastructure, are also under strain. On the demand side the largest strain comes from large increases in population, explored further below. On the supply side, both public and private funding sources have become more scarce in recent years. In private markets there has been a sharp increase in debt funding costs, with spreads on BBB rated bonds more than doubling from their 2007 level (Black, Brassil, & Hack, 2010) while state and federal government budgets have faced extreme strain, particularly with the full effect of the Global Financial Crisis now being felt in the world's sovereign debt markets (ABS, 2011c).

Overall, NSW is at an important point for infrastructure investment, where underlying factors (such as population) are increasing demand in the face of increasing difficulty in supplying new infrastructure.

4.2 Goal and purpose

The focus of this report is to briefly present the results from a baseline model of the NSW economy, forecast through to 2031-32. The modelling results are primarily an update from those presented in the Access Economics report “The NSW economy in 2020 – a foresighting study”, which was prepared for the NSW Innovation Council in August 2010.

Since the previous report, the baseline model has been updated with a more recent database. Commodity prices have increased and this has been reflected in mining taking an increased share of output in the NSW economy. The carbon price, to become effective in 2013, has also been included in the analysis, and is broadly consistent with NSW Treasury guidelines. This has implications for the shares of value added produced by the manufacturing and mining industries when compared to the previous report (which did not include a carbon price in the baseline). The results have also been disaggregated into a number of regions to highlight differing economic drivers and trajectories as well as allowing for future consideration of different infrastructure options.

The analysis has primarily been undertaken to draw together a range of assumptions about future economic conditions (such as population growth, productivity improvements and GSP growth) from across the NSW government into a single framework. These results are to form the baseline around which different scenarios, created through different infrastructure investment decisions, can be considered. These infrastructure options and their impact on forecasts will be developed over the coming months.

5 Snapshot of the NSW economy

- **Population** 7.2 million | **Labour force** 3.8 million | **Unemployment rate** 5.1% | **Employment** 3.6 million

- **Economic composition**
  2010-11 estimate: Services: 75%, Industry: 23%, Agriculture: 2%
  2031-32 estimate: Services: 77%, Industry: 21%, Agriculture: 2%

- Top five exports:
  - Coal;
  - Travel and education services;
  - Non-ferrous metals;
  - Professional consulting services;
  - Medicinal and pharmaceutical products

5.1 Key forecasts

Table 5.1: Key indicators

	2010-11	2031-32
Gross state product ($ billions; 2010 prices)	419.9#	730.9
Previous GSP estimate	438.5*	
Population (millions)	7.2	9.2
GSP per capita ($000)	58	80
Employment (jobs; millions)	3.6	4.4

ABS 5220.0, November 2011.

* This figure is an initial estimate developed in late 2011, before availability of ABS data

Source: NSW Treasury, Deloitte Access Economics, ABS

5.2 Key indicators

- The NSW economy is projected to grow by over 70% over the next two decades.
- The number of employed workers in NSW is expected to increase from around 3.6 million in 2010-11 to about 4.4 million in 2031-32.
- The State's population will increase from around 7.2 million in 2010-11 to approximately 9.2 million in 2031-32.
- The economy will become more services based, with a shift away from agriculture and industry.
- Overall, construction is around 6.8% of value add in the NSW economy in 2010-11; this is expected to increase around 7.4% by 2031-32.

A summary of these statistics is provided at Appendix A. This summary includes a breakdown within the Sydney Metropolitan area which has been developed based on a geographical distribution of population within Sydney from the Bureau of Transport Statistics.

6 The NSW economy in 2031-32

NSW Treasury's IGR GSP forecasts were used as an input into the baseline model update. These forecasts were then adjusted to account for climate change policy – the modelling results below are inclusive of a carbon price. As such, the rate of growth in NSW GSP in the baseline model is marginally lower than NSW Treasury's forecast. Between 2010-11 and 2031-32 NSW real GSP is forecast to grow from $420 billion (in 2010-11 prices) to just over $730 billion (in 2010-11 prices).

6.1 Gross State Product

NSW Treasury projections for real GSP from the latest Intergenerational Report suggest that the NSW economy will grow by an average annual rate of approximately 2.4% to 2031-32.

This forecast is below the NSW 20 year average growth rate (2.8%) and the national average growth rate (3.2%). These differences are primarily a function of (i) workforce growth and (ii) productivity.

- Much of the variance between historical growth for NSW and these forecasts can be attributed to differences in workforce growth (due to changes in population and participation rates).
- The gap in economic growth between NSW and Australia from 2000-01 to 2007-08 can be attributed to differences in both population growth and productivity.

The NSW Treasury projections do not account for a number of factors including higher than expected mineral export prices, a higher Australian dollar and carbon policy. The modelling results below take these factors into account and so they differ slightly from the overall estimates of NSW Treasury.

Table 6.1: Real GSP – NSW

	2010-11*	2019-20	2031-32
Real GSP ($ billion)	419.9	541.7	730.9
Ten year average annual growth (%)	2.1	2.9	2.5

Note: * represents actual figure

Source: ABS cat no 5220.0; NSW Treasury, 2011, DAE modelling results

6.2 Population

Population projections from the Department of Planning have been used in this baseline model. These population projections were developed by the Department of Planning to match the NSW Treasury's intergenerational report, which has formed the basis of the modelling in this report. In the time since the development of the intergenerational report and the modelling for this report, the Bureau of Transport Statistics and the Department of Planning have updated their population forecasts.

The NSW population is expected to grow at an average annual rate of 1.1% (similar to the last 30 years), rising from 7.2 million people in 2010-11 to 9.2 million people in 2031-32.

State level forecasts are based on the assumption that there will be 180,000 net migrants to Australia each year, of which 30% will settle in NSW. The ageing of the population will continue to dominate demographic trends, with the ratio of people aged 65 and over to those between 15 and 64 expected to increase from 20.9% in 2010-11 to 34.2% in 2031-32. With the baby boomer population having reached retirement age in 2011, there is expected to be 18 years of increased growth in the aged dependency ratio.

Table 6.2: Population projections

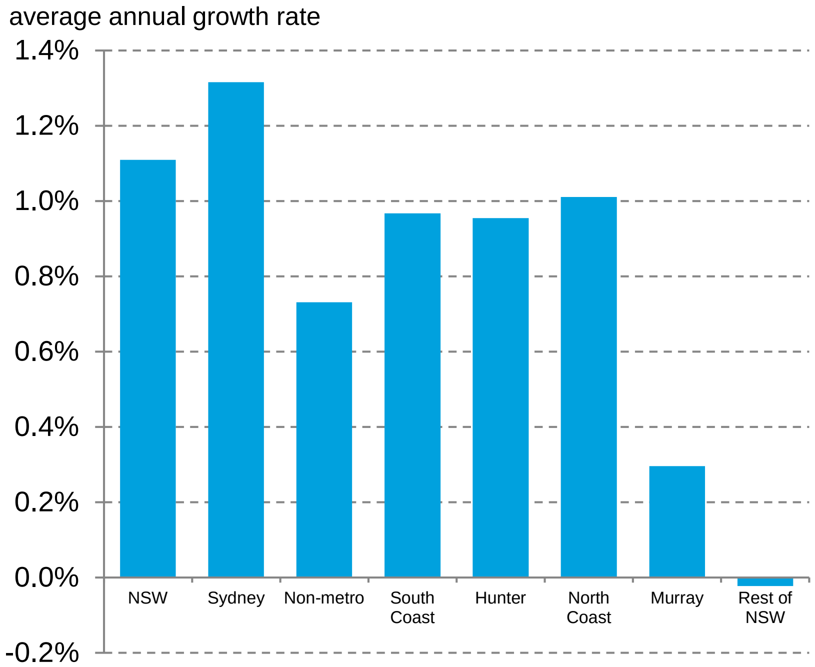
(000s)	2010-11	2015-16	2025-26	2031-32	Growth	Average annual growth
NSW	7,197	7,808	8,678	9,174	27%	1.1%
Sydney	4,558	5,007	5,674	6,077	33%	1.3%
Non-metro	2,638	2,801	3,004	3,097	17%	0.7%
South Coast	653	703	773	807	24%	1.0%
Hunter	648	697	765	799	23%	1.0%
North Coast	555	600	663	693	25%	1.0%
Murray	276	286	293	294	7%	0.3%
Rest of NSW	505	515	510	502	-1%	0.0%

Source: Department of Planning and Infrastructure, 2010

A summary of these statistics is provided at Appendix A. This summary includes a breakdown within the Sydney Metropolitan area which has been developed based on a geographical distribution of population within Sydney from the Bureau of Transport Statistics.

These projections indicate that Sydney is expected to experience the highest level of population growth in NSW and is expected to increase in size by 33% between 2010-11 and 2031-32 (average growth across the state of 27%). The average annual growth rate for Sydney, as shown in Chart 3.1 is greater than the overall growth expected in NSW as a whole due to lower growth in the non-metropolitan regions, particularly the Murray and remote areas of NSW (within 'rest of NSW'). Coastal NSW and the Hunter region are expected to experience population growth higher than the non-metropolitan NSW average.

Chart 6.1: Average annual population growth rate, 2010-11 to 2031-32



Source: Department of Planning and Infrastructure, 2010

6.3 Productivity and employment

Productivity is a crucial driver of economic growth. Over the period to 2031-32, productivity is expected to increase across the state. Continued influences on productivity will be the remaining effects of microeconomic reform, capacity constraints in parts of the labour market and infrastructure, and the effects of business investment, particularly in mining, as projects become operational.

Table 6.3: State labour productivity index

	2010-11*	2019-20	2031-32
Index (2005-06 = 100)	102.6	120.0	142.8
Average annual growth (%)	1.7	1.6	1.6

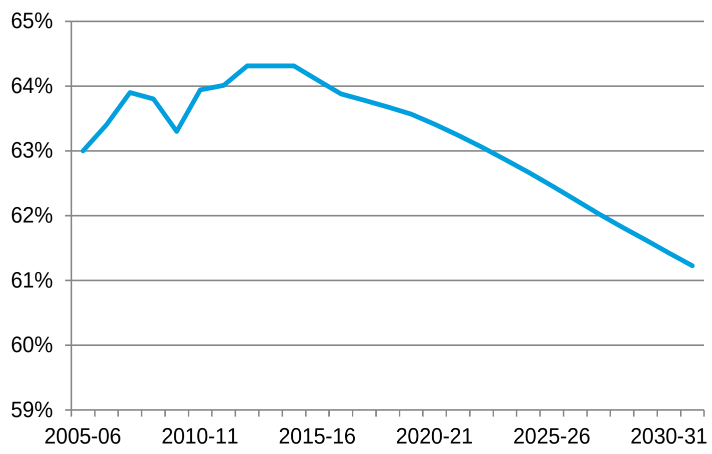
Note: * represents actual figure

Source: ABS cat no 5220.0; ABS cat no 6291.0.55.001; NSW Treasury, 2011

As part of the Intergeneration Report, NSW Treasury has projected labour force participation in NSW to peak at 64.3% in 2014-15 and steadily fall through the projection period (Chart 4.2). This is driven by demographic trends – namely the ageing of the population.

Combining the declining participation rate with constant migration implies NSW Treasury foresees workforce and employment growth lagging behind population growth.

Chart 6.2: Labour force participation rate - NSW



Source: NSW Treasury, 2011

Between 2010-11 and 2031-32 the level of employment in NSW is expected to grow at an average annual rate of 0.9%, from 3.6 million workers to 4.4 million workers. These employment projections are based on the NSW Treasury's intergenerational report, which has formed the basis of the modelling in this report. In the time since the development of the intergenerational report and the modelling for this report, the Bureau of Transport Statistics and the Department of Planning have updated their employment forecasts.

Table 6.4: Employment level (millions)– NSW

	2010-11*	2019-20	2031-32
NSW	3.6	4.0	4.4
Sydney	2.3	2.6	2.8
Non-metro	1.3	1.4	1.6
South Coast	0.2	0.3	0.3
Hunter	0.3	0.3	0.4
North Coast	0.2	0.2	0.3
Murray	0.1	0.1	0.2
Rest of NSW	0.4	0.4	0.4
NSW 10 year average annual growth (%)	1.7	1.1	0.7

Note: * represents actual figure

Source: NSW Treasury, 2011

6.4 Gross Regional Product

The differences in GRP across the regions reflect (i) differences in population growth and (ii) the differential impact of the carbon price given each region's industry composition. For example, population in metro NSW is expected to grow at an average annual rate of 1.3% (compared to the state average of 1.1%) and the region is comparatively less exposed to a carbon price than non-metro NSW (which has a heavy reliance on mining and manufacturing).

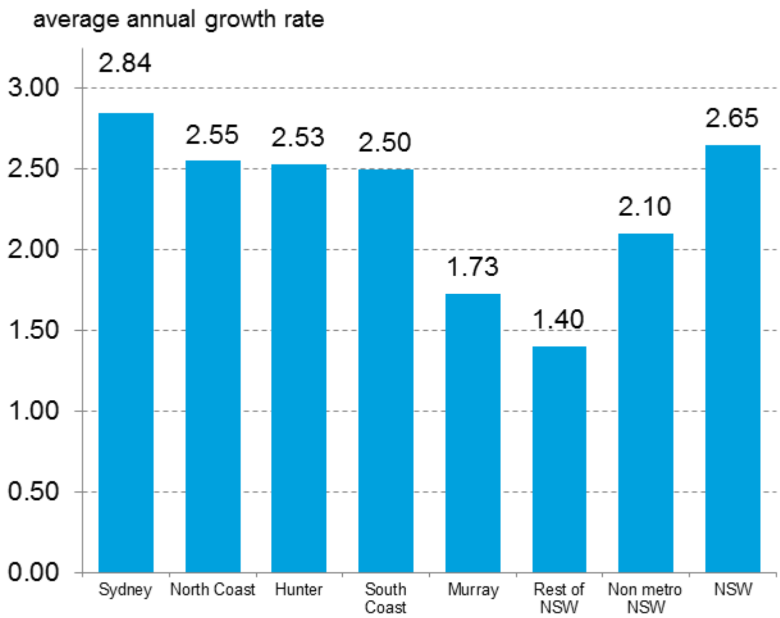
The introduction of the carbon price, effective from 2013, is expected to result in a dip in production, with the greatest shock felt in the Hunter region. All regions are still modelled to experience positive economic growth but at a level lower than historical averages. This initial shock is expected to dissipate in the following years, although the recovery is not expected to be significant enough to return the economy to the level of production that would have been in the absence of the carbon price.

Following the shock, the growth rate of GRP in all regions is anticipated to be slightly lower than pre-carbon price levels; this reflects a combination of the effects of carbon pricing and the natural pattern expected in a mature economy.

6.4.1 Average annual GRP growth

The coastal regions of NSW are expected to grow more strongly than inland areas in terms of GRP over the coming twenty years. Sydney, for example, is expected to grow by an average of around 2.8% a year (compared to the state average of around 2.6% a year). The lower than average growth in inland regions is largely a result of lower than average population growth. As shown in the following section, these two factors tend to balance out to result in fairly similar GRP per capita growth throughout the state.

Chart 6.3: Average annual GRP growth, 2010-11 to 2031-32



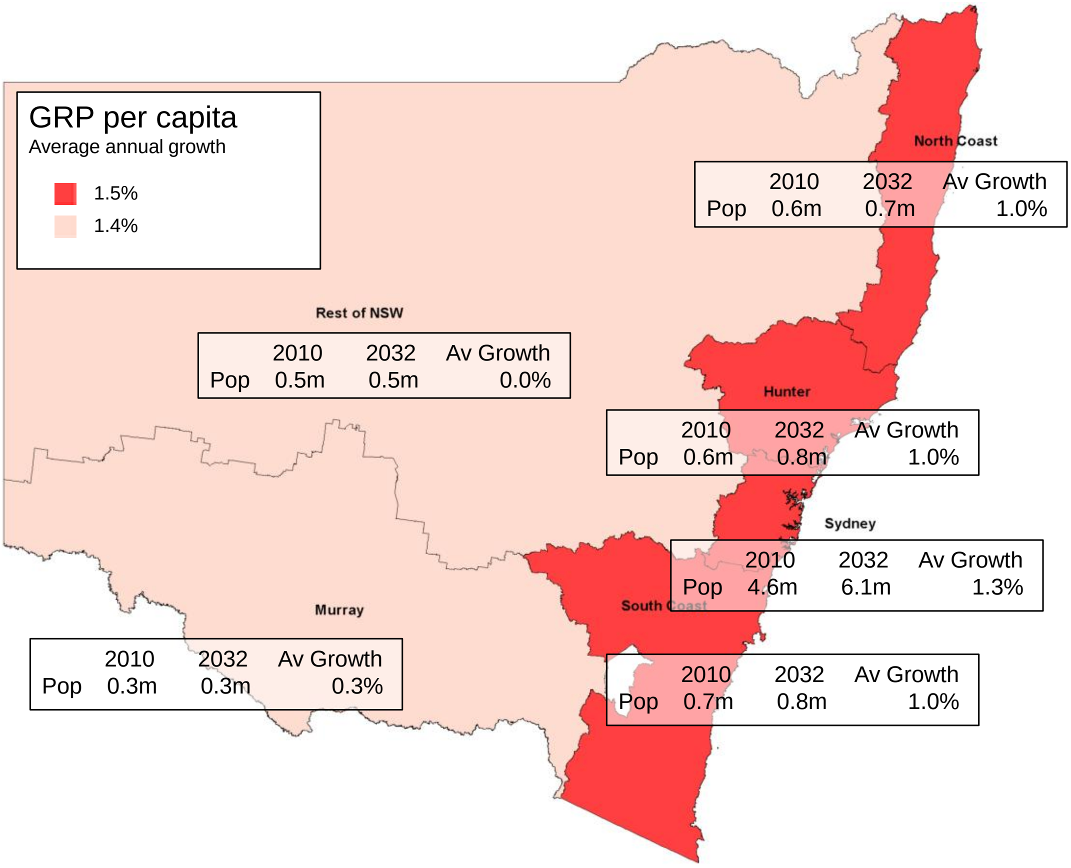
Source: Deloitte Access Economics analysis based on Department of Planning and Infrastructure, 2010 and NSW Treasury, 2011

6.4.2 GRP per capita

Growth in GRP per capita is usually reported as a broad measure of living standards. Figure 6.1 illustrates average annual growth in GRP per capita across the regions in NSW, highlighting that the coastal regions of NSW will experience similar growth in GRP per capita of around 1.5%.

West of the divide, Murray and rest of NSW are expected to experience both low population growth and low GRP per capita growth, culminating in relatively lower annual growth in GRP per capita of 1.4%.

Figure 6.1: Average annual growth in GRP per capita by region

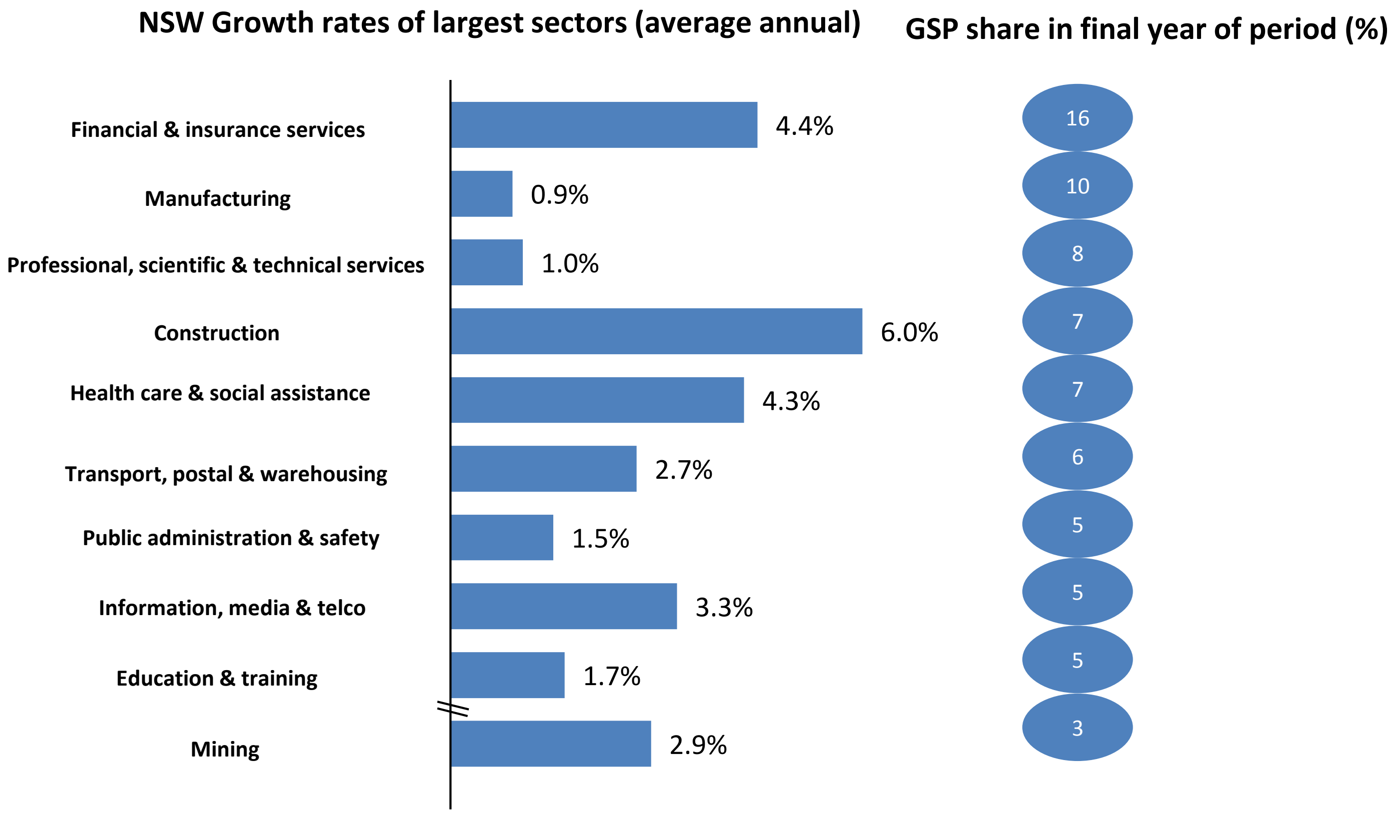


Source: Deloitte Access Economics analysis based on NSW Department of Planning and Infrastructure, 2010

7 NSW's regions and industries in 2031-32

The industry structure of selected sectors in the NSW economy between 2000-01 and 2010-11 is illustrated below. Comprising the largest share of the NSW economy at the end of this period, the finance and insurance industry grew at an average annual rate of 4.4%. Other service based industries – including professional, scientific and technical services, health care and social assistance and education – have also experienced strong growth over this period. Growth in construction was driven by strong demand from the mining sector over this period.

Chart 7.1: GSP growth rates of selected sectors, 2001-2011



Source: ABS cat. no 5220.0.

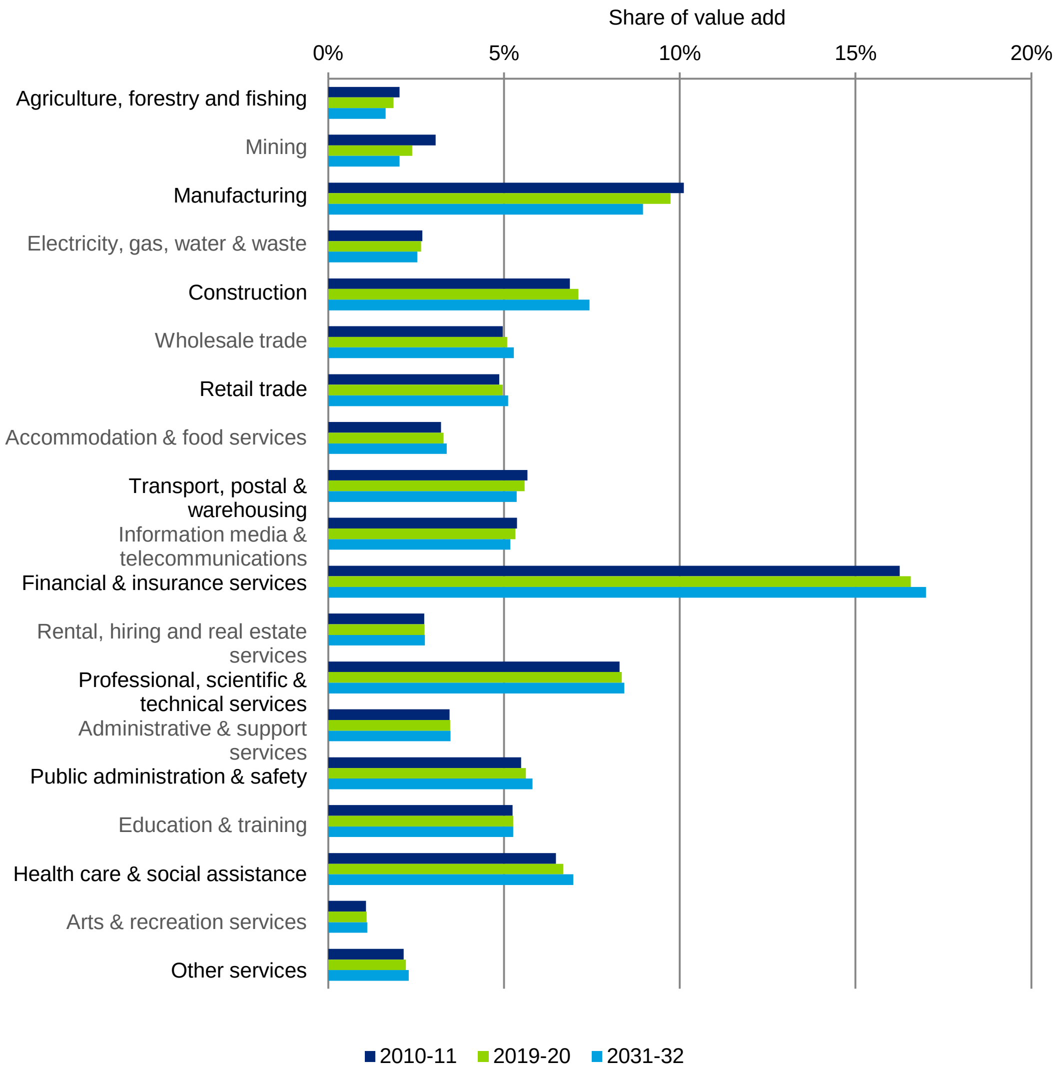
7.1 NSW

The modest growth forecast for the NSW economy is expected to be driven by growth in the mining industry (to 2019-20), advancements in technology (information media and telecommunications) and health care. Other service industries are also expected to increase as a share of the economy.

Continuing the downward trend of the last decade, manufacturing is expected to decline as a share of the state's economy over the next 20 years, as will agriculture, forestry and fishing.

Finance and insurance is expected to remain the largest industry (by share of value add) in 2031-32.

Chart 7.2: Industry structure – NSW



Source: ABS cat. no. 5220.0, Deloitte Access Economics

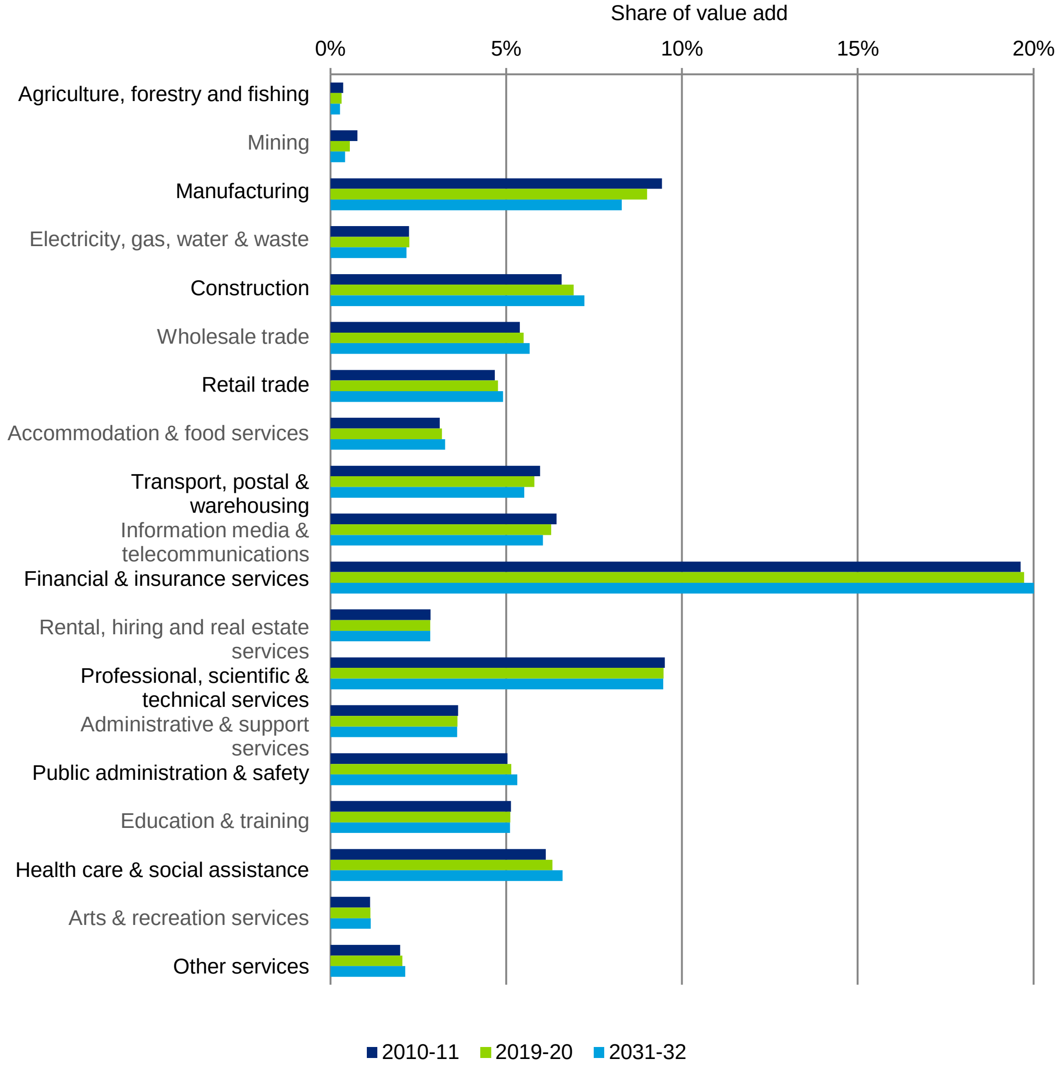
7.2 Metro NSW

The split between metro and non-metro NSW is largely determined by the regional population projections provided by NSW Department of Planning. It is assumed that the differences in growth rates between the regions reflects higher incomes and population growth in the cities and the negative impact of reduced water on non-metropolitan NSW over the coming decades.

Metro NSW's industry structure is expected to continue to be dominated by Sydney's financial industry and professional, scientific and technical services. Manufacturing in metro NSW is expected to remain on a downward trend.

Mining and agriculture comprise a much smaller share of metro NSW's economy than the state as a whole.

Chart 7.3: Industry Structure - Metro NSW



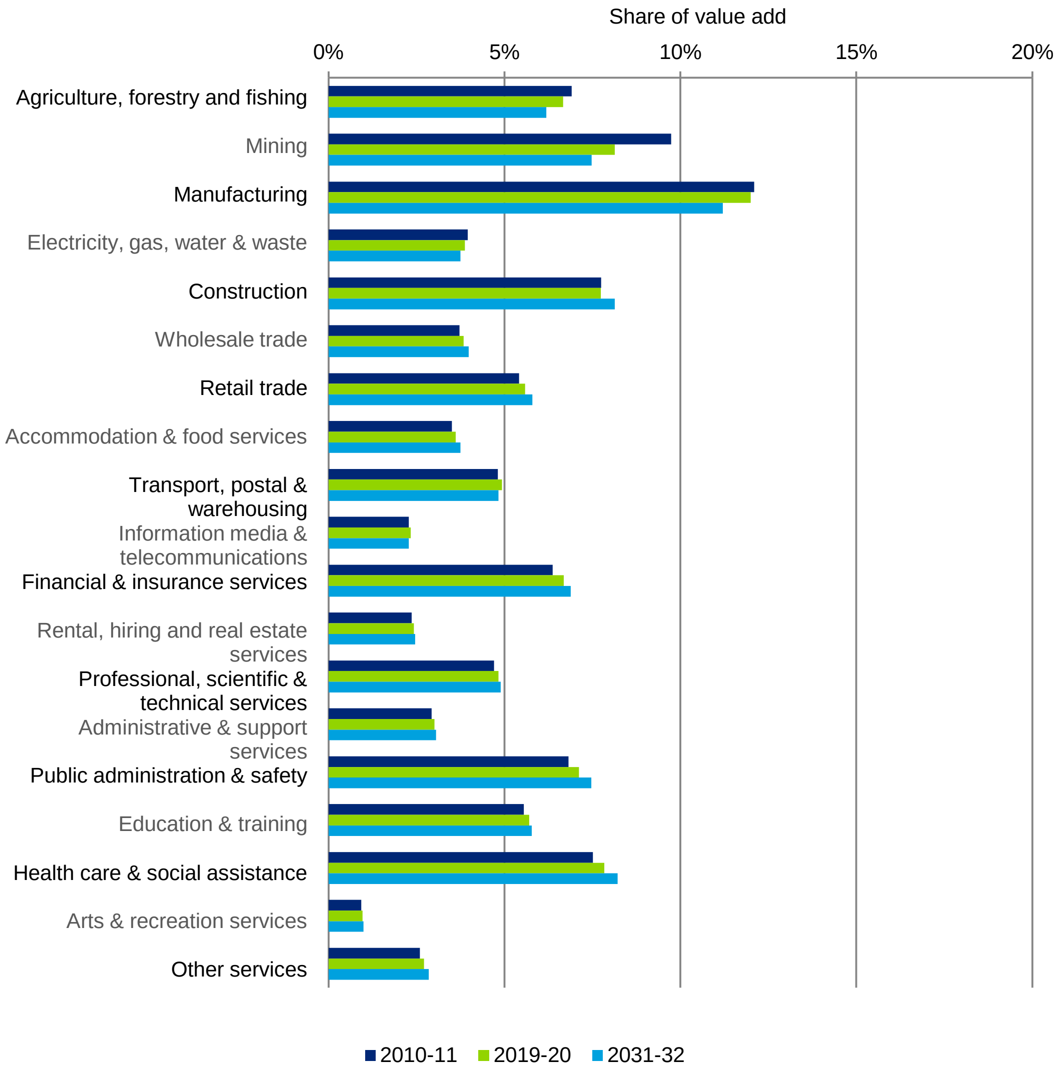
Source: ABS cat. no. 5220.0, Deloitte Access Economics

7.3 Non Metro NSW

In contrast to metro NSW, non-metro NSW is expected to benefit from expansion of the mining sector over the coming decades. Strong growth will also be experienced in health care and social assistance.

Manufacturing is expected to continue to decline as a share of the region's economy.

Chart 7.4: Industry structure - Non Metro NSW



Source: ABS cat. no. 5220.0, Deloitte Access Economics

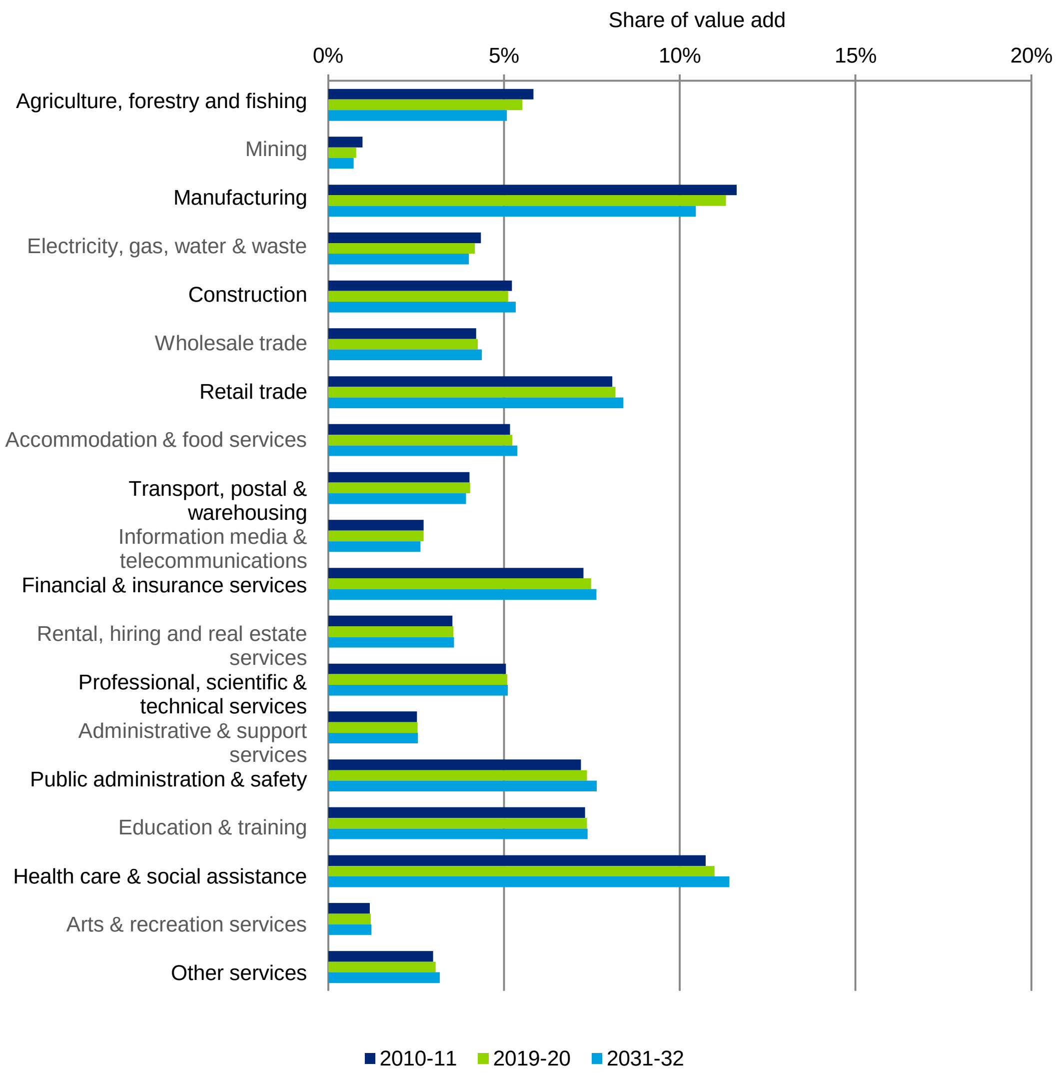
7.4 Subregions

The disaggregation of non-metro NSW modelling to the sub-regions is based on (i) differences in population (and population growth) and (ii) differences in industry structure in 2010-11.

7.4.1 North Coast

The North Coast's economy will continue to be dominated by manufacturing, although this is expected to decline as a share of the region's economy. Consistent with the demographic profile of the North Coast, health care and social assistance will increase as a share of industry value add over the coming decades.

Chart 7.5: Industry structure – North Coast

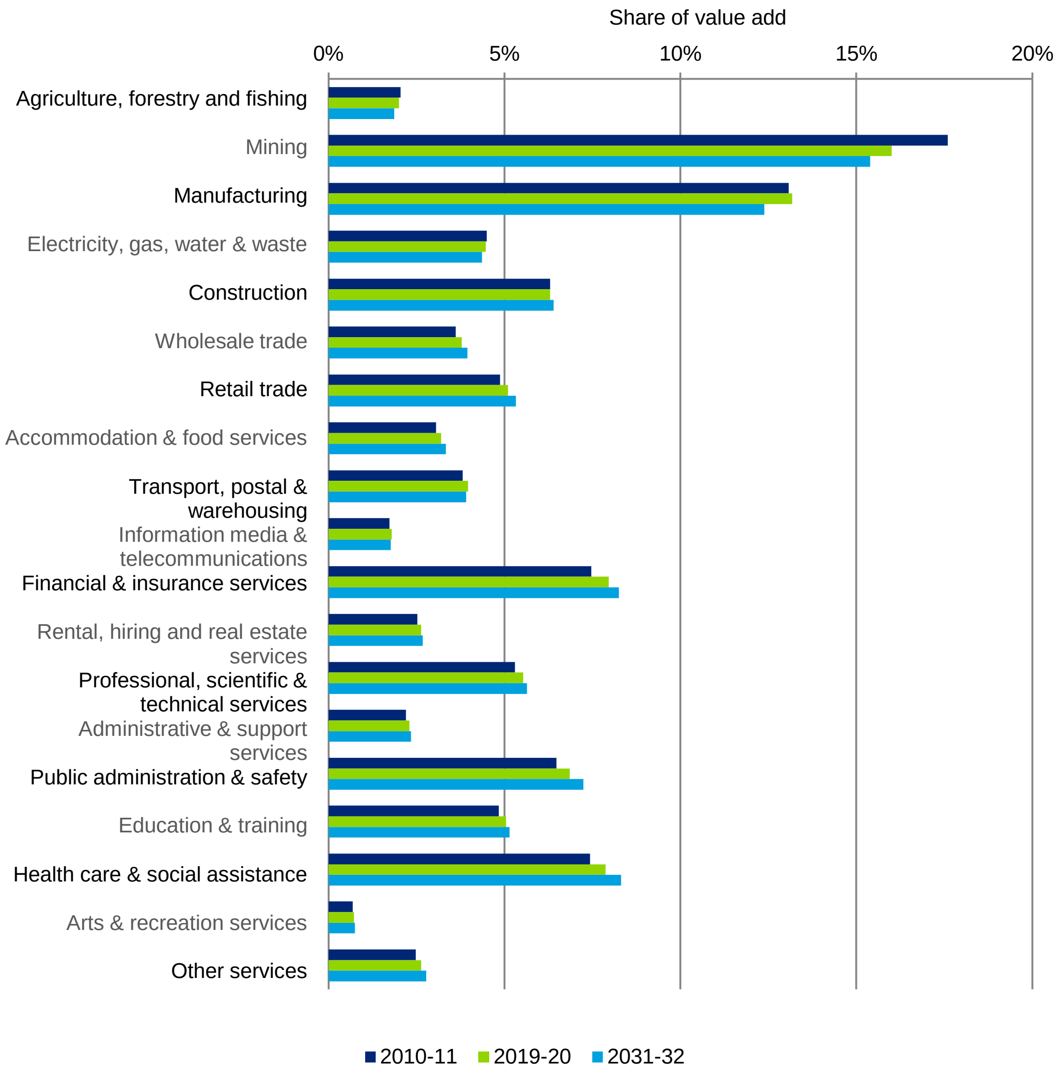


Source: ABS cat. no. 5220.0, Deloitte Access Economics

7.4.2 Hunter

Over the next 20 years, economic growth in the Hunter region will be boosted by the fortunes of the mining sector in the Upper Hunter. Consistent with the rest of non-metro NSW, manufacturing will decline as a share of the region’s economy.

Chart 7.6: Industry structure - Hunter

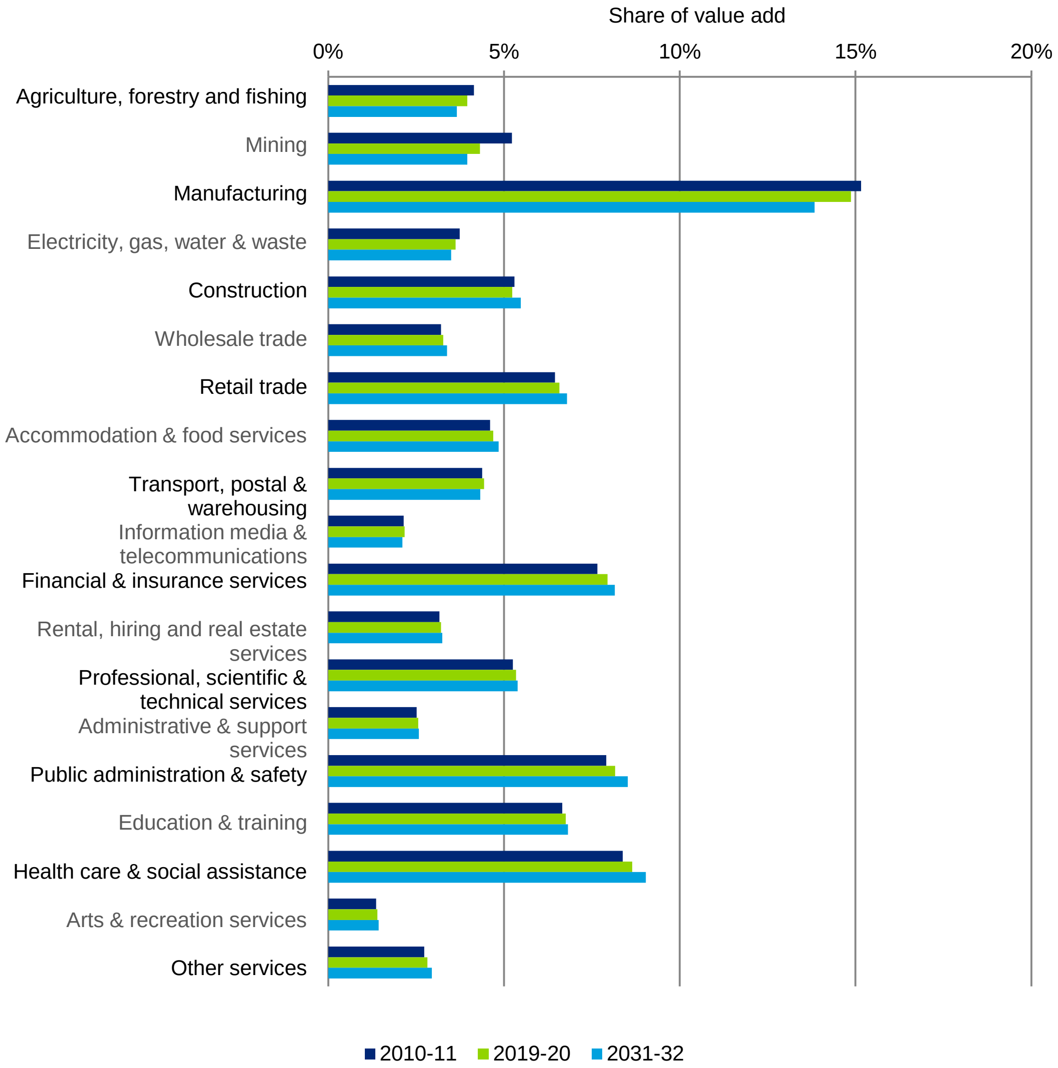


Source: ABS cat. no. 5220.0, Deloitte Access Economics

7.4.3 South Coast including Illawarra

Manufacturing in the South Coast (including the Illawarra) will remain the region's major industry, despite an expected decline in share of industry value add. Similar to the North Coast region, the age profile of the South Coast will see the region's health care and social assistance industry expand as a share of the economy.

Chart 7.7: Industry structure – South Coast including Illawarra

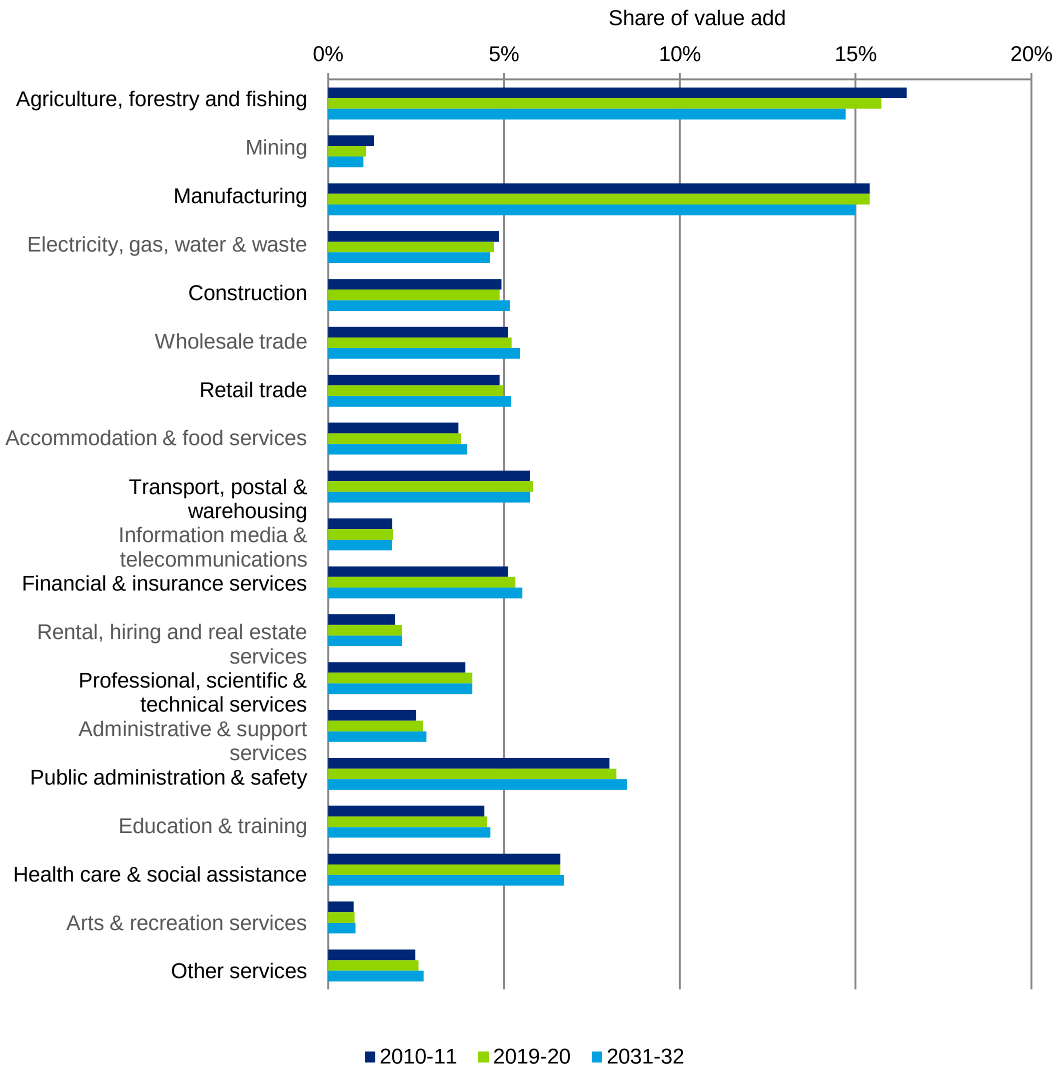


Source: ABS cat. no. 5220.0, Deloitte Access Economics

7.4.4 Murray

The decline in the manufacturing industry's share of regional industry value add is also reflected in the Murray region. Of the four sub-regions analysed, the Murray region has the greatest share of its industry value add derived from agriculture. However, this too is expected to decline in the upcoming 20 years, related to the impacts of water restrictions and the carbon price. Industries anticipating growth include health care and social assistance and public administration and safety.

Chart 7.8: Industry structure - Murray

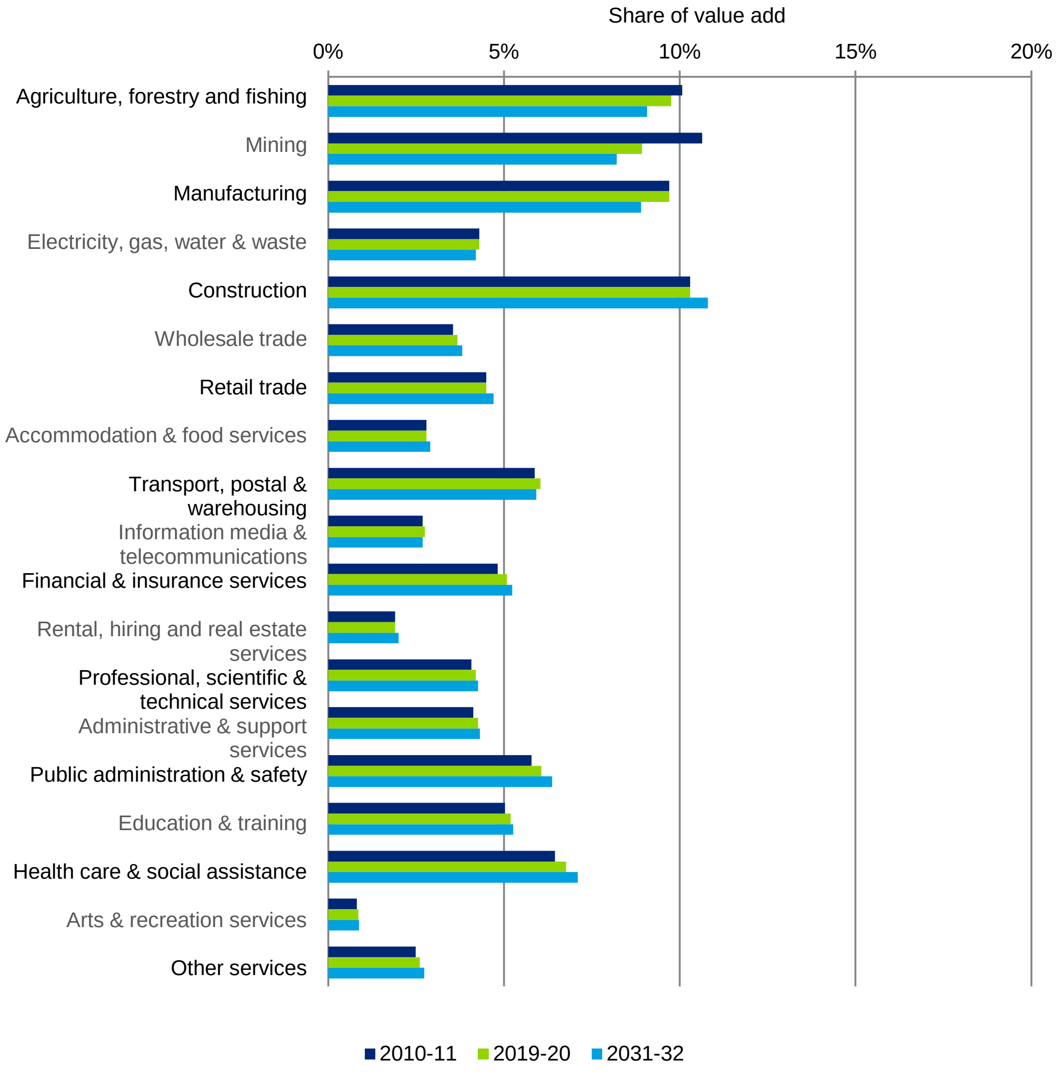


Source: ABS cat. no. 5220.0, Deloitte Access Economics

7.4.5 Rest of NSW

The Rest of NSW region encompasses all of NSW excluding the sub-regions discussed above. Construction, mining, agriculture and manufacturing comprise the largest share of industry value add; however, this industry structure differs across the state (e.g. mining and construction in the Gunnedah Basin).

Chart 7.9: Industry structure – Rest of NSW



Source: ABS cat. no. 5220.0, Deloitte Access Economics

8 Sensitivity testing

The NSW economy baseline forecasts are subject to a number of uncertainties. In the short term, factors such as the current state of global financial markets and the timing of the business cycle will have implications for economic growth and productivity over the next five years. Over a longer period, more persistent trends – such as demographic change, developments in technology and the sustainability of demand from China – will also alter the shape of the NSW economy.

8.1 Historical ranges of variables

For the purposes of modelling medium to long-term infrastructure requirements, the baseline model ignores cyclical influences. However, in saying that, it is important to identify the factors expected to affect the baseline to determine whether the baseline model's growth path assumes a medium trajectory and how this trajectory corresponds with historical economic growth.

To gauge the extent of the uncertainty surrounding the baseline projections, two approaches have been considered:

- analysis of the range of uncertainty around the major drivers of economic growth identified above. Section 5.1 explores uncertainties around the finance sector to demonstrate how an industry sector could expand or contract over time; and
- understanding how the forecasts compare to variation in past.

The following reflects the latter approach.

Table 8.1 presents a summary of the historical and forecast growth rates of key NSW economy variables. This comparison provides a useful overview of how the NSW economy has performed across key measures and determinants of economic growth and provides context for the sensitivity analysis below.

Table 8.1: Average growth rates of key NSW economy variables (% per annum)

	Decade average			
(per cent)	1991-92 to 2000-01	2001-02 to 2010-11	2011-12 to 2020-21	2021-22 to 2031-32
Nominal GSP	5.3	5.8	5.2	4.8
Real GSP	3.6	2.3	2.7	2.5
Productivity	2.3	1.0	1.6	1.6
Population	1.1	1.0	1.1	1.0
Labour force	1.2	1.6	1.1	0.8
Employment	1.4	1.7	1.1	0.8
Participation	0.0	0.3	-0.6	-0.3
GSP per capita	2.5	1.1	1.6	1.3

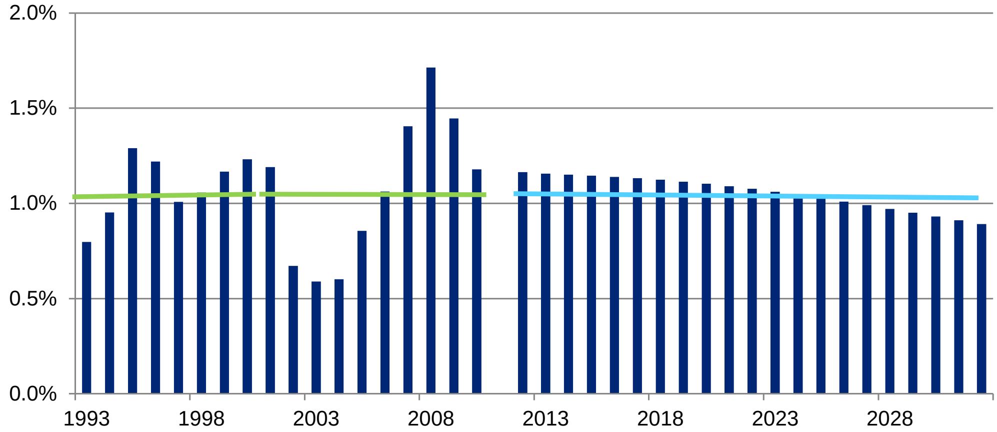
Source: NSW Treasury, 2011 and DAE estimates

8.1.1 Population

Growth in the NSW population is a significant driver of economic growth over the forecast period. The last 20 years has seen the NSW population grow at an average annual rate of 1.1% (see Chart 6.1). While the average growth expected over the next 20 years is expected to be similar over the forecast period, this masks the steady decline in growth expected over the projection period consistent with lower net migration and the rise in the dependency ratio.

The historical range on population growth (ignoring cyclical fluctuation) suggests that over the forecast period population growth could reasonably range from 0.75% to 1.25% average annual growth.

Chart 8.1: Historic and forecast population growth forecasts



Note: green lines represent historical averages, while the blue line represents the forecast average

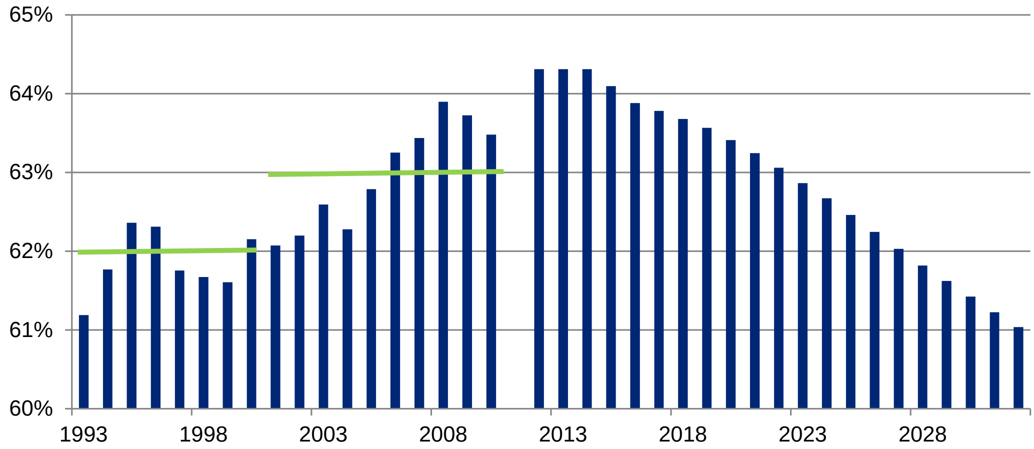
Source: ABS cat. no. 3101.0, NSW Treasury, 2011

8.1.2 Participation

Labour force participation rates in NSW provide a key indicator of future economic growth. As Chart 6.2 illustrates, the baseline model assumes that participation rates peak early in the forecast period and decline steadily over the next 20 years. This pattern is driven by the main demographic trend facing the NSW labour force – population ageing. Even after factoring in an expected rise in workforce participation among the elderly, economic growth is projected to be negatively affected by the ageing workforce over the forecast period. This will also reduce economic growth.

The historical range on participation rates suggests that participation rates over the forecast period could lie between 62.5% and 63.5%. However, the effect of population ageing has not been as critical in the past; as such, over the latter half of the forecast period it is expected participation rates could range between 61% and 62%.

Chart 8.2: Historic and forecast participation rate forecasts



Note: green lines represent historical averages, no average forecast line provided due to declining trend

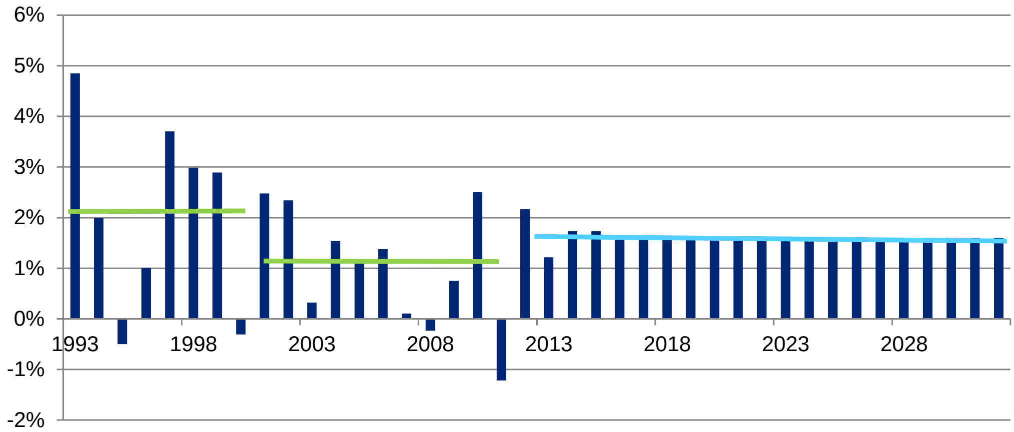
Source: ABS cat. no 6202.0, NSW Treasury, 2011

8.1.3 Productivity

Finally, the baseline model assumes a rate of growth in labour productivity higher than that seen in the last 10 years, but below growth between 1993 and 2001. The accelerated labour productivity growth of the early 1990s has been attributed to the microeconomic reforms which began in the 1980s. This projection for labour productivity is based on the Commonwealth Treasury's 2010 Intergenerational Report.

Labour productivity growth has ranged, on average, between 1% and 2% over previous cycles. This range could be reasonably assumed to continue over the forecast period.

Chart 8.3: Historic and forecast labour productivity forecasts



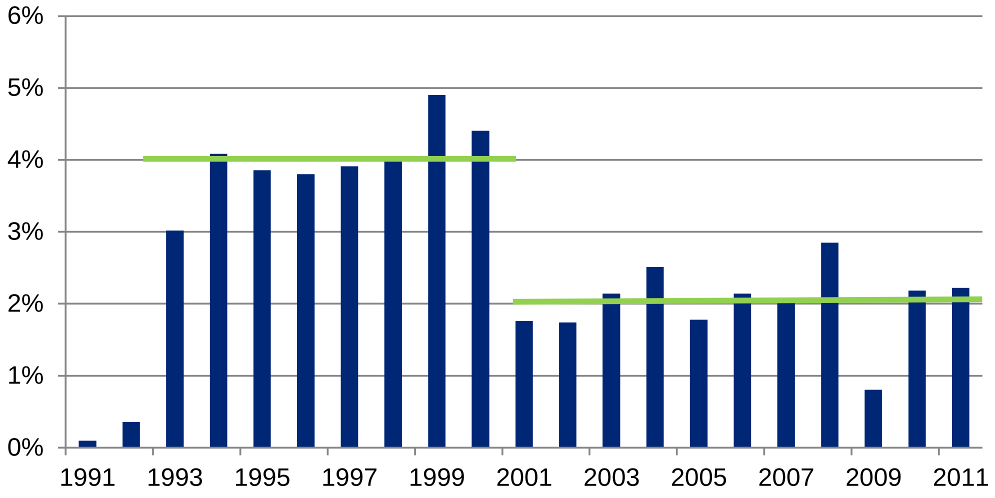
Note: green lines represent historical averages, while the blue line represents the forecast average

Source: ABS cat. no. 5220.0, ABS cat. no 6202.0, NSW Treasury, 2011

8.2 Sensitivity of forecasts

Over the last 20 years NSW real GSP growth has experienced two distinct periods – between 1993 and 2000 the NSW economy grew at an average annual rate of approximately 4% while during 2001 to 2011 average annual growth was approximately 2%.

Chart 8.4: Historical GSP growth



Note: green lines represent historical averages

Source: ABS cat. no. 5220.0

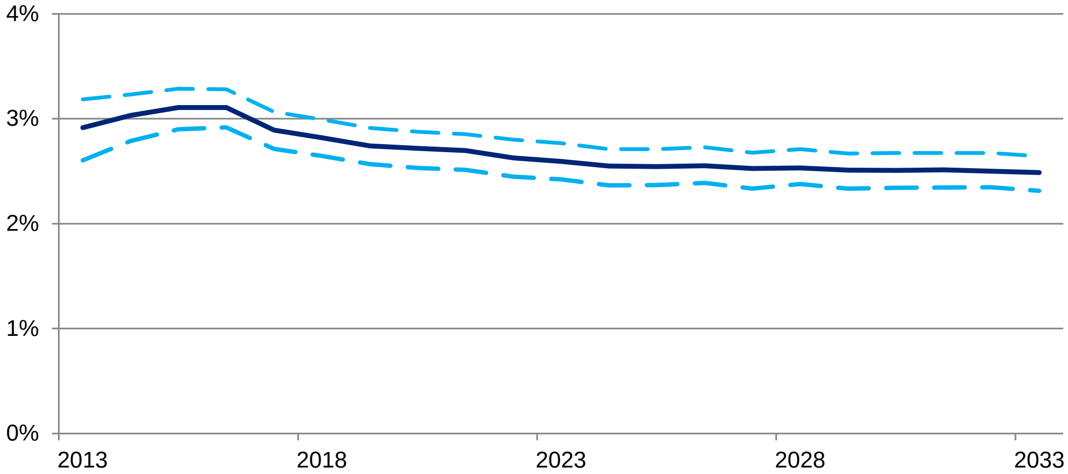
The sections below demonstrate the expected range in GSP growth forecasts under different productivity and population/participation scenarios. The purpose of this analysis is to illustrate the likely sensitivities around GSP growth over the forecast period.

8.2.1 Productivity

The chart below illustrates the range in GSP growth in NSW over the forecast period assuming a high and low productivity scenario. The baseline forecasts are based on productivity growth of 1.6% while the high scenario assumes 1.8% and the low scenario assumes 1.4% (consistent with NSW Treasury's IGR sensitivity analysis). This range is relatively narrow in comparison to historical productivity growth (see Table 8.1).

The productivity scenarios result in a range of approximately ± 0.2 percentage points around GSP growth.

Chart 8.5: Sensitivity of GSP forecasts to productivity scenarios



Note: blue dotted lines represent the range on the forecast

Source: Deloitte Access Economics modelling based on NSW government forecasts

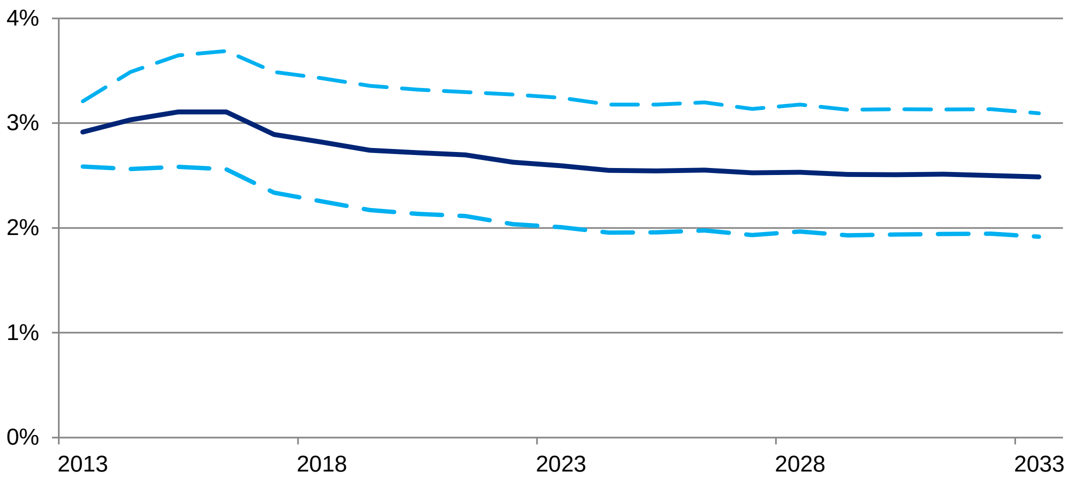
8.2.2 Population and participation

The population scenario is based on the historical range in NSW population growth – the baseline is modelled assuming approximately 1.1% average annual growth, while the high population growth scenario assumes 1.7% and the low population growth scenario assumes 0.6%. The participation scenario is based on the Commonwealth Treasury's IGR sensitivity analysis around labour force participation rates – the baseline assumes approximately 63% participation rate while the high scenario assumes 3.1 percentage point increase and the low scenario assumes 3.6 percentage point decrease.

As the chart illustrates, this will result in a sizeable impact on GSP growth over the forecast period. The addition to/reduction in workers (via population and participation increases/decreases) results in a range of approximately ± 0.7 percentage points around GSP growth.

However, GSP per capita is a more representative measure of living standards. Growth in population will counteract some of the growth in GSP, with the overall impact in the range of ± 0.1 percentage points of GSP per capita.

Chart 8.6: Sensitivity of GSP forecasts to population and participation scenarios



Note: blue dotted lines represent the range on the forecast

Source: Deloitte Access Economics modelling based on NSW government forecasts

Comparing the two sensitivities, the range for GSP growth for the productivity sensitivity is far smaller than the range for the population and participation sensitivity. This solely reflects the assumed ranges of variability put into the model. For productivity, as discussed, the variability considered in the NSW IGR isn't truly representative of the potential decade to decade variability in productivity that has been experienced. The range for productivity also does not take into account the potential effect that better infrastructure investments could have on productivity. In contrast, the range considered for population and participation likely reflects the higher end of what could be expected given historical variability.

A final consideration is that, in practice, we are unlikely to see changes in population and participation independently of changes in productivity. Different demographic profiles for immigrants will have different effects on productivity; immigration of prime working age individuals will tend to increase productivity. It is likely that these two sensitivities would, in fact, work together, with higher population and participation also leading to increased productivity, ultimately leading to a compounding effect.

8.3 The finance sector

The following discussion explores the resilience of one of NSW's largest industries: finance. The purpose of this review is to demonstrate, in detail, how an industry sector could expand or contract over time.

Within the ANZSIC classification, the finance and insurance industry consists of:

- the finance subdivision;
  - made up of the central bank, banks, other depository corporations (credit unions, building societies, cash management trusts and registered financial corporations), central borrowing authorities, securitisers, public unit trusts excluding property trusts, public development authorities, investment companies, common funds, cooperative housing societies, public housing schemes and other financial corporations.
- the insurance and superannuation funds subdivision; and
  - made up of pension funds, life insurance corporations, friendly societies and non-life insurance corporations.
- the auxiliary finance and insurance services subdivision
  - units providing auxiliary financial services, such as fund managers, brokers, dealers and financial consultants

The table below disaggregates the finance and insurance industry using employment numbers from the 2006 Census. As a share of total employment, the banking sector comprises the largest proportion of the finance and insurance industry, followed by auxiliary finance and investment services.

Table 8.2: Share of employment in finance sub-sectors

Industry	Share of employment nationally	Share of employment in Sydney
Finance	7.6%	6.9%
Banking	33.8%	37.4%
Non-depository financing and financial asset investing	5.9%	4.8%
Insurance	17.1%	18.0%
Superannuation	1.5%	1.8%
Auxiliary finance and investment services	32.2%	29.2%
Financial and insurance services nfd	2.0%	2.0%

Source: ABS 2006 Census of Population and Housing

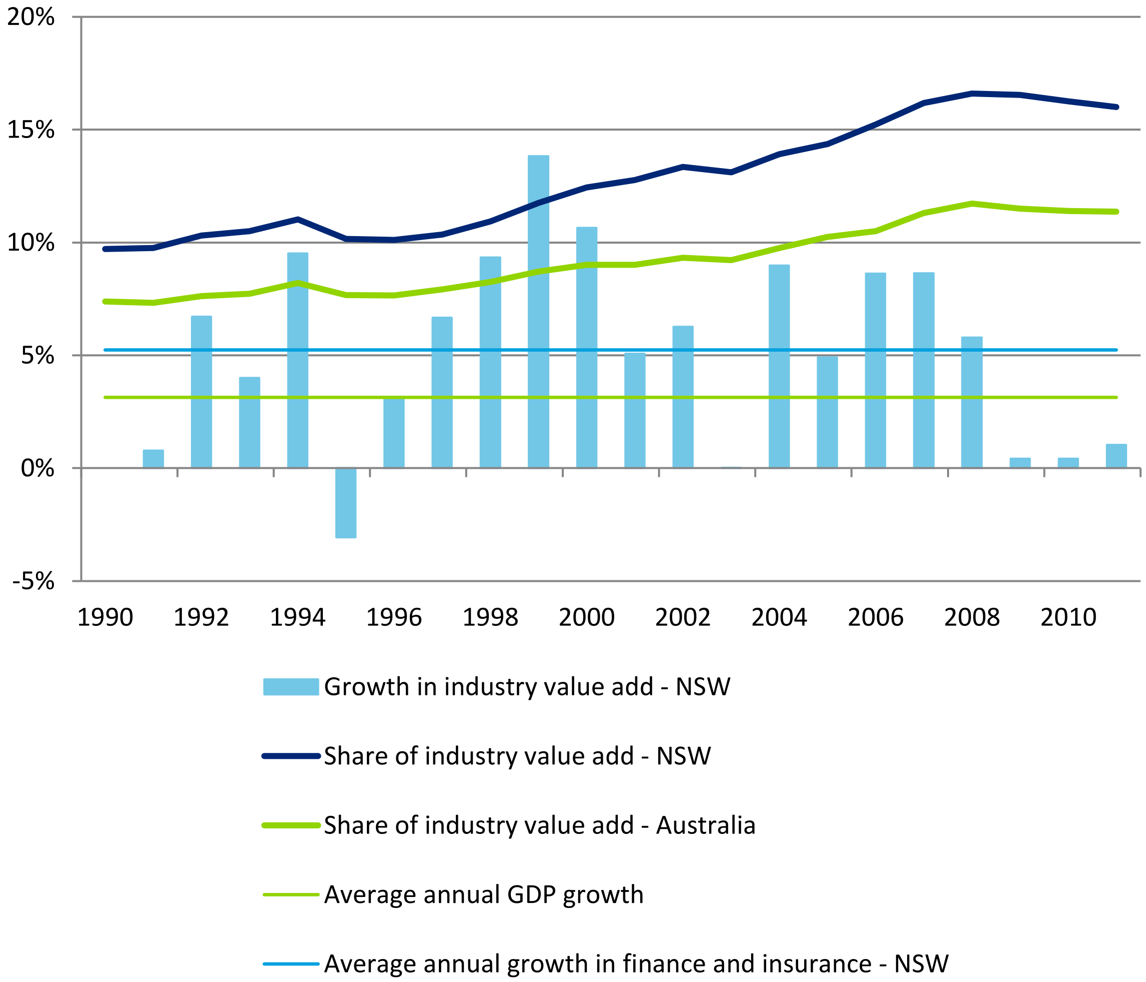
8.3.1 Trends in the finance sector

The Australian finance and insurance industry is predominantly directed towards providing services to the domestic market. As the largest industry in the NSW economy (in terms of value add) it is important to understand how the industry has grown in the past, what factors have driven this growth and whether this trend will correct over coming years.

Over the 10 years to 2008, the finance and insurance industry rapidly increased its share of the NSW economy from 10.8% to 16.6% as expanding household wealth, funds under management and economic activity increased demand for financial products and services.

The chart below illustrates the relationship between average annual growth of the NSW finance and insurance industry and average annual growth in GDP. Over the 20 year period, the NSW finance industry grew at an average rate of 5.2% while over the same period the national economy grew at an average rate of 3.1%.

Chart 8.7: Finance and insurance



Source: ABS cat no 5220.0; ABS cat no 5204.0

8.3.2 Pressures on the finance sector

A number of key factors are expected to shape the finance and insurance industry and its share of the economy over coming decades. Whether the industry continues previous growth trends, remains at current levels or declines as a share of the economy will depend on these countervailing forces.

- Growth in the superannuation industry will be reinforced by the ageing population.
- There will be a growing need for financial advice as individuals are increasingly facing more financial risks themselves.
- Specialisation within the industry will result in more outsourcing of financial functions that support the finance industry.
- Sydney is a national financial hub, and has potential for increasing presence in the Asia Pacific region (this has important implications for foreign banks in Australia who can market specialised financial products to emerging Asia).

These factors will consolidate previous growth trends in the finance and insurance industry and are expected to continue to add to the growth of the industry going forward.

On the other hand:

- the financial crisis resulted in some failures and a consolidation of the industry, culminating in a small decline in its share of the NSW (and national) economy in recent years;
- less debt creation and a more cautious approach to financial innovation will only be marginally offset by the requirement to devote more resources to compliance; and
- the combination of a high Australian dollar (and other costs) as well as improvements in ICT may result in pressure for offshoring investment banking and back-office functions of banks. However, this is an ongoing process and cannot be done easily in all instances.

The global financial market will remain under pressure for the next few years; however, over the medium to long-term the fundamental drivers of the finance and insurance industry will continue to boost demand for this sector. The shape of the sector will ultimately be determined by these countervailing forces.

Part C: The economic consequences of the SIS

9 Introduction to Part C

The State Infrastructure Strategy (SIS) identifies and prioritises a set of key infrastructure investments required in NSW over the next 20 years. More than that though, the SIS encourages a focus on the outcomes of infrastructure investment: the benefits for the people of NSW and the NSW economy. In this way it sets the scene for the revitalisation of the NSW economy by making NSW both a better place to live and a better place to do business.

However, the prioritisation and analysis of infrastructure investment options is, necessarily, restricted to the direct consequences of the project. That is, Cost Benefit Analysis (CBA) tends to focus on benefits such as the reduction in travel times, improvements in safety and changes in operating costs for users. This can be expanded in multicriteria analysis (MCA) to include things such as the achievement of broader government goals. These measures are all direct consequences of the project itself and do not, for example, consider how the resources freed up by reducing travel times are redirected in the economy.

This tends to miss the main economic consequences of infrastructure investment which result from the flow on benefits. Reduced travel times reduce transportation costs which leads to lower costs for consumers and an improved standard of living. Or, alternatively, making NSW a more appealing place to live will lead to reduced interstate emigration leading to more workers, skills and ideas remaining in the state – eventually fuelling more overall economic activity and a higher standard of living for NSW residents.

Capturing these flow on benefits requires more detailed economic modelling. In this report we apply Computable General Equilibrium (CGE) modelling to track how the initial consequences of infrastructure investment eventually result in changed economic outcomes. CGE modelling is explained in more detail in Appendix B. but, essentially, it represents the NSW economy as a series of interconnected producers and consumers and allows us to trace how changes in one area flow through the economy while also allowing calculation of common economic yardsticks such as GDP growth, GDP per capita and employment.

The CGE modelling measures the flow on benefits of the recommended strategies from a whole of economy perspective. The results of the modelling suggest that effective implementation of the strategy could increase the size of the NSW economy by around $50.8bn (present value of the total benefits over the period to 2032). This results in an increase is GSP of around $18.4bn by 2032, in today's dollars. This is around a 2.4% increase from the baseline. This increase in growth means that there could be up to 100,000 more jobs in the state by 2032.

Of this $51bn increase in economic activity, around $29bn (57%) occurs in metropolitan Sydney with $21bn (43%) occurring in regional areas. The share of increased employment varies over time, with regional areas benefiting relatively more in early years. Overall the employment gains are modelled to accrue largely to metropolitan Sydney; this is mostly due to the large modelled increase in metropolitan population.

The rest of this paper outlines the various ways in which infrastructure affects economic activity, the approach used to model this relationship, the results of the modelling and a consideration of benefits (such as reduced congestion) which are outside the modelling framework but which have significant economic value. Appendix B provides a detailed methodology with a worked example for a particular infrastructure project.

10 The effect of infrastructure on economic activity

Infrastructure affects economic activity in two main ways:

- Capital and operating expenditure directly increase measured economic activity; and
- The services provided by the infrastructure enable increased economic activity by affecting productivity, population and participation.

The first of these effects tends to be a short run boost to measured economic activity and competes for existing economic resources. In contrast, the latter effect tends to result in a long run improvement in economic performance and living standards. Each of these effects is discussed below.

10.1 Capital and operating expenditure

Infrastructure projects normally require large capital expenditure outlays and ongoing operating expenditure. Both of these contribute directly to measured economic activity. The final effect of this expenditure on GDP is complicated by the action of the spending multiplier. For example, a $5bn infrastructure project will initially add $5bn of expenditure to the economy but this initial expenditure will generate income for those working on the project, which will then be spent on other goods and services. In this scenario, the final measured economic activity resulting from the initial expenditure will be greater than $5bn (a multiplier greater than one). Alternatively, the infrastructure project may draw workers and resources away from other economic activity which would result in a final effect on GDP of less than $5bn (a multiplier less than one). Recent research suggests that the government expenditure multiplier can often range from 0.8-1.5 suggesting that, in some cases initial government expenditure can have positive flow on effects while in others it can compete resources away from other projects (Ramey 2011).

A further factor which could affect the way in that capital and operating expenditure impacts GDP is how the project is funded and financed. Relying on government funding (either through issuing debt or increasing current taxes) compared to user charges or a public private partnership is likely to affect the spending multiplier.

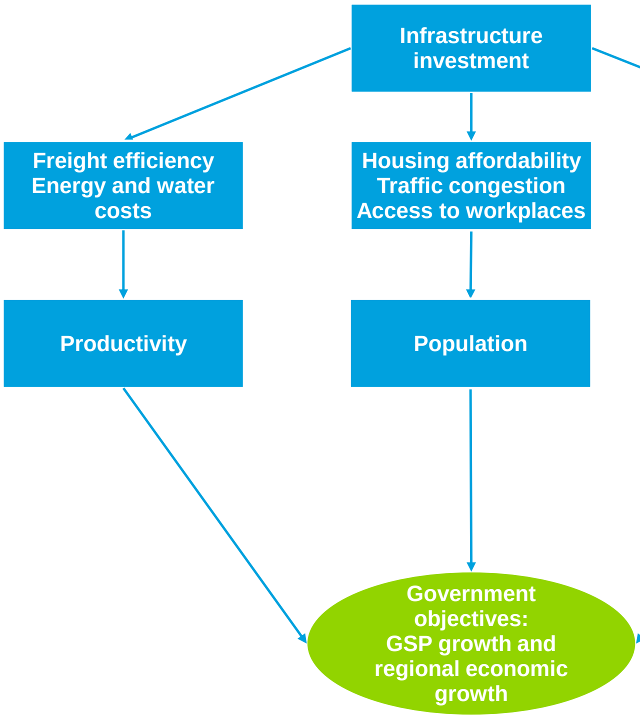
Overall, this pathway is of little long term economic performance. In the short run it may either boost employment or draw resources away from other areas of the economy but, over time, this effect will pass leaving only the infrastructure itself and the services provided by the infrastructure. This means that the long term value of expenditure on infrastructure to the economy depends on the economic benefits generated by the services provided by the infrastructure: the transport provided by roads and rail, the power provided by electricity grids, the knowledge provided by schooling and the health secured by hospitals.

This long term benefit is described below and is the focus of our economic modelling.

10.2 Longer term effects

Once the initial economic effect of the capital and operating expenditure pass, the long term economic effects of infrastructure investment are to be found in how the services provided by the infrastructure enable increased economic activity by affecting productivity, population and participation. This conceptual relationship is shown in the figure below.

Figure 10.1: The conceptual relationship between infrastructure and the economy



For example, if the infrastructure investment package includes

- roads to allow goods to be transported from Sydney's ports more efficiently as well as making it easier to travel from home to work;
- electricity network upgrades to increase the security of supply; and
- funding of new schools and hospitals,

then placing this set of investments in the productivity, population and participation framework suggests that the new road and the electricity network upgrades will reduce costs for businesses which use road transport and electricity (a productivity improvement), and will increase the desirability of NSW as a place to live by reducing congestion and making it easier to get to work (increasing population). More people will lead to more jobs, more ideas and more demand for goods all of which enhance economic activity. Considering the effect of schools and hospitals, a healthier and better education populace is more likely to participate in the workforce again improving economic outcomes.

Ultimately, the long run effect of infrastructure investment is to encourage growth in the number of people employed and growth in productivity. These are also the long term factors which determine the rate at which the NSW economy will grow in the future. The pathways of productivity, population and participation are therefore the critical ways in which infrastructure influences economic activity.

11 Overview of modelling approach

The most important economic effects of infrastructure investment are through the channels of productivity, population, and participation (discussed above). The initial capital expenditure effects disappear once operation commences and the operating expenditure has to compete for resources in the economy. In contrast, the productivity, population and participation effects are permanent and work to increase the total amount of economic activity. They represent the full impact of the infrastructure investment in the long term and reflect the true benefits of the infrastructure investment to the NSW economy

Productivity, population and participation therefore form a bridge between infrastructure investment and economic activity. The next step involves identification and quantification of this relationship. By clearly defining and quantifying these relationships it is possible to represent an infrastructure investment in the CGE model.

Each type of infrastructure project will have a different mechanism for how population, participation and productivity are affected and so, in quantifying these relationships we need to consider each type of infrastructure investment, its pathway through the three conceptual bridges and how each of the pathways can be quantified. The details for different types of infrastructure investment are provided in Appendix B.

Generally, we have relied on relationships identified in economic literature and have adapted these to the specific circumstances of NSW as required. This has led to a focus on productivity and population as it is these areas where there is good evidence available on the relationship between certain types of infrastructure investment and economic outcomes. The participation link is most strongly influenced by social infrastructure investments such as schools, hospitals, childcare and aged care facilities. These investments do have important economic consequences (their effect on participation) but their economic consequences are likely to be only one component of a much broader assessment of why these projects are needed and where investment should be focussed.

As an example of how results found in the literature have been adapted to local circumstances, the literature indicates that increasing the stock of roads in a city by 1% reduces transport costs by between 0.05% and 0.1%. These results are largely based on analysis undertaken in the United States. To test how applicable these results are to the NSW circumstance, we analysed transport modelling undertaken by Roads and Maritime Services of the M4 east and M5 east projects. The transport modelling suggested that the relationship in Sydney was at the top end of the range identified in the literature. This led us to use the relationship that a 1% increase in the stock of roads reduces transport costs by 0.1% in our modelling.

The following section outlines the overall effects on the NSW economy from implementing the SIS. That is, for each project we have traced through its economic consequences in terms of productivity, population and participation and aggregated this into a total effect on economic activity.

12 Modelling results

Using the modelling approach outlined above in a CGE model allows us to estimate the total impact of implementing the SIS on the NSW economy. A CGE model traces the connections between industries and consumers and provides a tractable way to follow the impacts of a policy decision through the economy (the functioning of a CGE model is more fully described in Appendix B).

A CGE model presents results comparing scenarios against a baseline. In this case the baseline does not represent a particular set of infrastructure investments but rather is set to match long term forecasts from the NSW Treasury contained in the long-term fiscal pressures report from the 2011-12 budget (Budget paper number 6). This means that the effects outlined below are, essentially, deviations from what would be expected given current long term economic and demographic trends, this is important to keep in mind, particularly when considering the percentage changes.

Table 12.1: Average annual (non-cumulative) effect on key economic variables (2013-2032)

	2012-2016		2017-2021		2022-2026		2027-2031	
	Levels	Per cent	Levels	Per cent	Levels	Per cent	Levels	Per cent
GSP ($m 2011-12)								
Sydney	-48	0.0%	727	0.2%	5,566	1.4%	12,649	2.8%
Rest of NSW	811	0.6%	3,220	2.1%	3,049	1.8%	2,764	1.5%
NSW	763	0.2%	3,947	0.8%	8,615	1.5%	15,413	2.4%
Population								
Sydney	1	0.0%	25	0.5%	106	1.9%	210	3.5%
Rest of NSW	1	0.0%	1	0.0%	1	0.0%	1	0.0%
NSW	2	0.0%	26	0.3%	107	1.3%	210	2.4%
Employment (FTE)								
Sydney	511	0.0%	11,512	0.5%	48,848	1.9%	96,208	3.5%
Rest of NSW	272	0.0%	292	0.0%	314	0.0%	332	0.0%
NSW	783	0.0%	11,804	0.3%	49,162	1.3%	96,540	2.4%

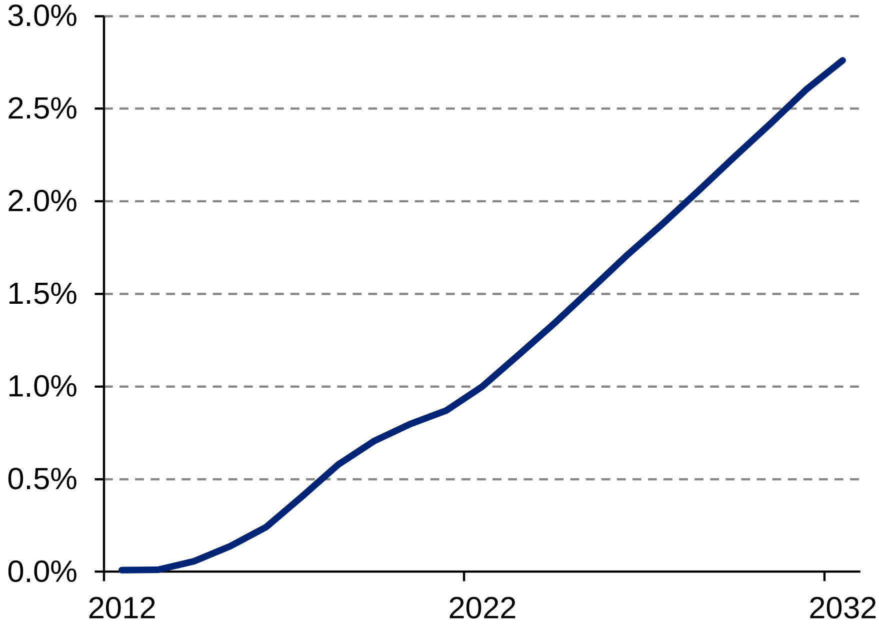
a. Defined as the Sydney statistical division

Source: Deloitte Access Economics

The results indicate that GSP is expected to increase by around 2.4% in the long run, as compared with the baseline scenario. Table 12.1 also shows the average impact on population employment over the same period. The average impact on employment is expected to be an increase of over 100,000 FTE positions in the long run.

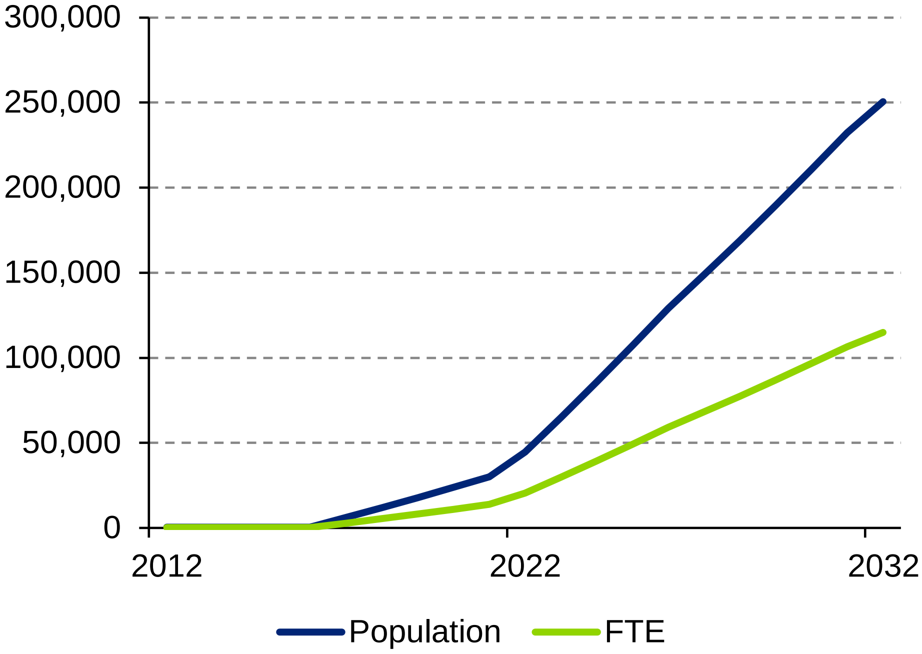
These effects are also estimated to increase over the period to 2032. The figures below plot the expected impact on each of the key economic variables over the forecast period.

Chart 12.1: Effect on GSP (%)



Source: Deloitte Access Economics

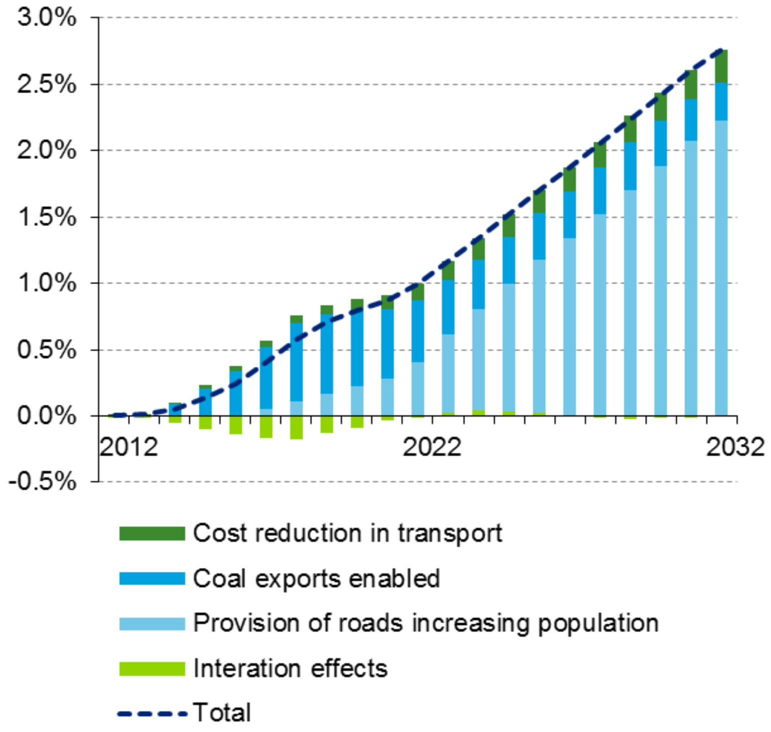
Chart 12.2: Effect on population and employment



Source: Deloitte Access Economics

We are then able to disaggregate these results into their driving causes. This disaggregation is shown in the figure below.

Chart 12.3: Disaggregation of drivers of GSP effects



Source: Deloitte Access Economics

This disaggregation reveals that population increases account for the majority of the estimated increase in GSP. Population has the largest effect for two reasons: first we estimate a strong increase in total population due to improvements in the quality of life in NSW, the relationship underlying this is discussed in section 11. This large increase in population then translates to a large increase in economic activity as each additional worker is essentially an increase in the productive capacity of the economy and so each person adds a significant amount of economic activity.

The increase in population also reflects the relatively poor performance of NSW in terms of interstate migration over the past decade. The sensitivity of the results to population flows are investigated in more detail in section 13.

Within these high level results there are also a number of more detailed findings which bear discussion. An important result is that there are significant benefits for regional NSW. GRP in regional NSW is expected to increase by around 0.5% in the long run, even though the majority of infrastructure spending is within the Sydney Metropolitan area. This reflects the close economic ties between the Sydney economy and the economies of regional NSW.

The modelling also indicates that the SIS could lead to an increase in GSP per capita in the period to 2032. The modelling results in an increase in both the GSP and population of NSW but, as GSP is estimated to grow faster than population, there is a slight increase in GSP per capita. This increase reaches a maximum in the period around 2020-21 when GSP per capita is estimated to be higher by around 0.5%. This increase is reduced over time as population increases faster than GSP until it is essentially nullified by 2032.

13 Sensitivity analysis

Population increases are one of the main drivers of the results discussed above. The estimation of this effect has relied on historical averages of the relationship between infrastructure provision and population movements. But there is, of course, uncertainty in the precise relationship between infrastructure provision and population. For example, a well selected and executed project may have a greater effect on population movements while a poorly selected project could lead to lower than expected effects.

Going into more detail, the relationship between infrastructure provision and expected population movements in the literature is defined in terms of the increase in the stock of roads. The definition of which roads are included in the initial stock is somewhat arbitrary. In the base case we have taken the stock of roads to be the orbital network in Sydney. This does not include roads such as the Hume Highway, Princes Highway, the Pacific Highway and Victoria Road which form integral parts of Sydney's arterial network. If these roads are included in the initial stock of roads which the SIS adds to (essentially broadening the definition of the class of roads that the SIS is improving) then this will result in a reduced effect on population growth from the SIS in the model. The modelling presented in this section expands the initial stock of roads to which the SIS adds to, to include the Hume Highway and Pacific Highway within the Sydney statistical division. As a result of expanding this initial stock of roads the population effects of the SIS are lower than those modelled above.

The results of modelling lower population growth are presented below.

Table 13.1: Average annual (non-cumulative) effect on key economic variables (2013-2020)

	2012-2016		2017-2021		2022-2027		2028-2032	
	Levels	Per cent	Levels	Per cent	Levels	Per cent	Levels	Per cent
GSP ($m 2011-12)								
Sydney	-68	0.0%	231	0.1%	3,317	0.8%	7,760	1.7%
Rest of NSW	811	0.6%	3,210	2.1%	3,009	1.8%	2,683	1.4%
NSW	652	0.2%	3,030	0.6%	5,907	1.1%	10,062	1.6%
Population								
Sydney	1	0.0%	14	0.3%	62	1.1%	123	2.1%
Rest of NSW	1	0.0%	1	0.0%	1	0.0%	1	0.0%
NSW	1	0.0%	15	0.2%	63	0.7%	124	1.4%
Employment (FTE)								
Sydney	288	0.0%	6,541	0.3%	28,453	1.1%	56,516	2.1%
Rest of NSW	272	0.0%	292	0.0%	314	0.0%	332	0.0%
NSW	560	0.0%	6,833	0.2%	28,767	0.7%	56,848	1.4%

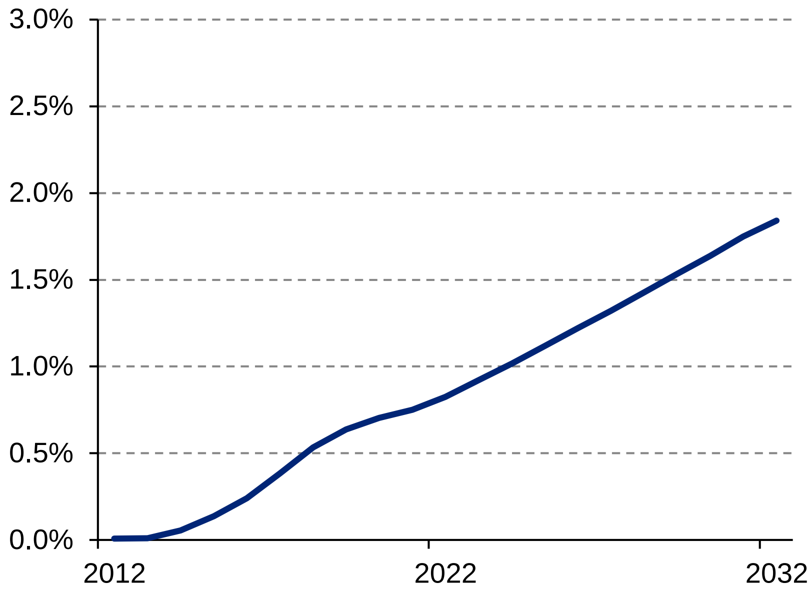
a. Defined as the Sydney statistical division

Source: Deloitte Access Economics

The results indicate that GSP is expected to increase by around 1.6 per cent in the long run. In 2032 this is 33% below the modelling results for the central case.

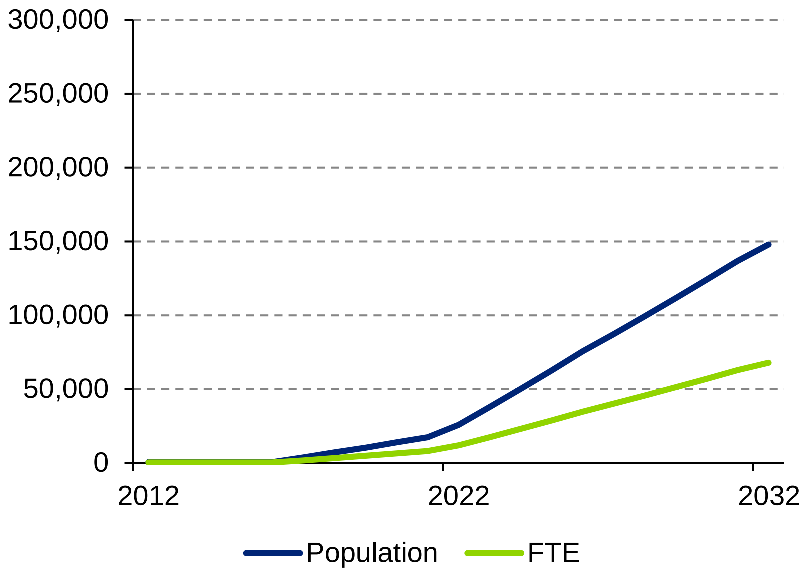
The effects are expected to follow roughly the same pattern over time as those previously estimated. That is, over the period to 2032 a roughly steady increase in GSP is expected with growth in population and employment accelerating slightly over time. The figures below plot the expected impact on each of the key economic variables over the forecast period.

Chart 13.1: Sensitivity test – effect on GSP



Source: Deloitte Access Economics

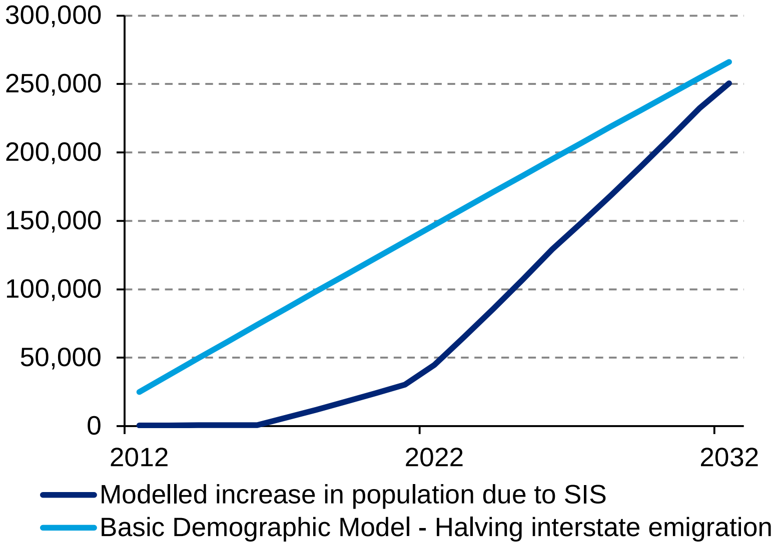
Chart 13.2: Sensitivity test – effect on population



Source: Deloitte Access Economics

We have undertaken a further test of the scale of these population changes by considering a basic demographic model of NSW. This model is based on demographic information on fertility, death rates and migration in NSW and extrapolates existing historical trends into the future. In this modelling exercise we have halved the migration of residents from NSW to other states from 2012 onwards and then estimated the effect that this would have on the population in the Sydney Metropolitan area. Halving of interstate emigration from NSW reflects the fact that NSW has, in recent years, seen a net loss of residents to other states and the SIS may help address this outflow.

Chart 13.3: Comparing potential increases in Sydney's population – SIS and a basic demographic model



Source: Deloitte Access Economics

The results of the basic demographic model indicate that halving the level of interstate emigration from NSW over the period from 2012 to 2032 would result in an increase in the population of Sydney by around 266,000 people by 2032, this is slightly higher than the roughly 250,000 resident increase modelled to result from implementation of the SIS. This provides strong support that the increases in population modelled for the SIS are reasonable as making NSW a better place to live and a better place to do business is likely to result in not only a reduction in interstate emigration but also an increase in interstate migration. This means that the population increases modelled to result from the SIS could easily result from shifts in interstate migration patterns.

14 Additional benefits of infrastructure investment

The economic benefits described above are a result of applying a CGE model. This modelling approach allows us to trace the flow on impacts of the strategy through the NSW economy and produce results which are in terms of common economic indicators (such as GSP). This approach only measures benefits which are captured in the national accounts. The national accounts (and therefore GSP) focus on measuring the value of market transactions and so miss some of the benefits of infrastructure investment.

The non-market benefits which are missed in the national accounts are highly dependent on the type of infrastructure investment that is being considered. In our case, the main benefits which are missed are the reduced travel time costs that follow provision of transport infrastructure and benefits from improving the reliability of electricity supply.

14.1 Travel time benefits

Considering travel time benefits first, transport network modelling of the M4 and M5 east projects conducted by Roads and Maritime Services presents a way to assess the travel time benefits that could be created by the SIS. The M4 and M5 east projects are the two major projects in the SIS that will affect commuter travel times and so the results from this modelling is likely to represent the bulk of travel time benefits generated by the SIS.

The modelling conducted by Roads and Maritime Services involves the introduction of the transport network scenarios in 2016 and the generation of modelling results for the years 2021 and 2026 for both AM and PM peak. The transport model results covered vehicle kilometres and vehicle hours and were broken down by vehicle type (car and truck) and road type (freeway, arterial, sub-arterial and local). Some key model outputs are included in the table below.

Table 14.1: Estimated transport network effects from the M4 and M5

		Base		Policy		Change	
		Vehicle Kilometres	Vehicle Hours	Vehicle Kilometres	Vehicle Hours	Vehicle Kilometres	Vehicle Hours
2021	AM	10,291,467	332,440	10,286,030	321,601	-0.1%	-3.3%
	PM	10,801,218	335,645	10,797,074	325,817	0.0%	-2.9%
2026	AM	11,072,253	370,942	11,067,314	356,332	0.0%	-3.9%
	PM	12,205,313	392,042	12,199,726	378,194	0.0%	-3.5%

Source: Deloitte Access Economics based on data provided by Transport for NSW

These transport network benefits were then converted into travel cost benefits and transport cost benefits by applying a model which takes into account factors such as:

- the composition of road traffic (to break down car and truck travel into subgroups such as business/commuter and rigid/articulated);
- the value of travel time;
- morning and afternoon peak travel's share of total travel; and
- vehicle operating costs.

This model produced the benefits set out in the table below.

Table 14.2: Estimated transport benefits ($m, net present value, 2016-2032)

Benefit	Value ($m)
Passenger Travel Time Savings	5,204
Freight Travel Time Savings	452
Vehicle Operating Cost Savings	278
Accident Cost Savings	80
Total	6,014

Source: Deloitte Access Economics

This modelling indicates that the benefits in terms of travel time savings for passengers are expected to be worth around $5.2bn in the period to 2032. This represents a significant benefit as it is around 10% of the benefits estimated in the CGE model. These travel time benefits represent the value of the time that is freed up by having faster transport around the metropolitan area. It does not rely on particular assumptions about how the extra time is used but, instead, values travel time on standard assumptions used by Roads and Maritime Services NSW and average weekly earnings.

14.2 Reliability of electricity supply

While the SIS does not explicitly set out to improve the reliability of electricity supply, by supporting the ongoing renewal of the electricity distribution network in NSW and interconnectors joining the NSW network to other states it is likely that there will be an improvement in the reliability of supply.

Recent years have seen a relatively stable level of electricity supply disruptions, sitting at around 99.96% uptime (AER 2011). Past statements by the NSW Government have indicated a high level goal of improving average uptime to around 99.98% (I&I 2010); this translates to an improvement of around 158 minutes a year.

Table 14.3: Estimated uptime in NSW electricity distribution networks

Year	Uptime (%)
2000-01	99.92%
2001-02	99.84%
2002-03	99.95%
2003-04	99.92%
2004-05	99.93%
2005-06	99.93%
2006-07	99.92%
2007-08	99.94%
2008-09	99.93%
2009-10	99.96%

Source: DAE calculations and AER (2011).

While this is only a marginal improvement in the reliability of supply, recent research by the AEMC (2012) indicates that electricity users place a high value on reliability of electricity supply. A survey of a range of energy users in NSW found that they had an average willingness to pay for improved electricity supply of around $95,000 per MWh. To put this into perspective, the weighted average spot price in the wholesale electricity market in NSW in 2010-11 was $43 per MWh.

Table 14.4: Value of improved reliability of electricity supply

Electricity customers	3,274,272
Energy delivered (GWh)	63,139
Average energy delivered (MWh)	19
Average KWh lost	
99.96% uptime	7.5
99.98% uptime	3.9
Difference	3.7
Value per customer ($)	349
Total value ($m)	1,144

Source: DAE calculations and AEMC (2011).

Combining this estimate of the willingness to pay for reliability of supply with data on the number of electricity customers and total demand in NSW suggests that the value of improving the reliability of electricity supply could be in the order of $1.1bn in 2012 alone.

Both of these calculations (for travel time and reliability of electricity supply benefits) are indicative of the scale of non-monetary benefits which could be achieved by implementing the SIS. They are both based on willingness to pay for services and so do not represent an increase in economic activity (and so are not captured in the CGE model) but instead represent an estimated value that individuals place on improved service quality and the activities that improved service quality enable them to undertake.

Part D: Modelling the effect of infrastructure on the economy

15 Introduction to Part D

While it is conceptually possible to extend a CBA analysis to take into account overall economic benefits, the modelling approach used does not normally lend itself to tracking key economic variables such as the national accounts and employment. This means that, at this strategic level, it is beneficial to move into an economic modelling framework. Computable General Equilibrium Models (CGE) provide a framework for analysis which is designed to track high level economic indicators (such as GDP, employment and trade flows between regions) in a single, consistent model. CGE modelling will help INSW measure the likely economic benefits of an infrastructure investment strategy.

While CGE modelling is the best available approach for measuring the effect of policy decisions on the entire economy, it has not been applied to infrastructure policy as frequently as it has in other areas of policy interest (such as international trade, carbon policy and taxation). This reflects the fact that traditional CGE models do not account well for some of the effects of infrastructure investment.

For CGE modelling to be successfully applied to answering INSW's questions, there is need for a consideration of some historical examples of infrastructure investment and economic activity as well as a review of the literature.

There has recently been a blooming of economic literature in this area, and there has been significant progress in disentangling the problems of cause and effect in infrastructure investment. Past analysis had the problem that more productive, larger cities are more likely to experience economic and population growth as well as receive new infrastructure. Recent progress in econometric techniques (particularly in the areas of structural modelling and instrumental variables) has allowed for analysis which overcomes this problem and clearly identifies the causal relationship of infrastructure investment on economic activity.

By undertaking this literature review, we will be able to enhance our CGE model to better account for the effects of infrastructure on the economy. This will allow INSW to build a clear picture of the overall economic impact of the set of infrastructure investments that it identifies.

The following section of this report sets out the conceptual relationship between infrastructure and economic activity that can be represented in a CGE model.

16 Infrastructure in a CGE model

Infrastructure has an important role to play in determining the performance of the economy. A substantial proportion of activity in NSW depends on our transport, energy, water, and telecommunications networks. Infrastructure also affects the key drivers of economic growth in the long term.

The link between infrastructure and economic growth has long been recognised by economists and policy makers:

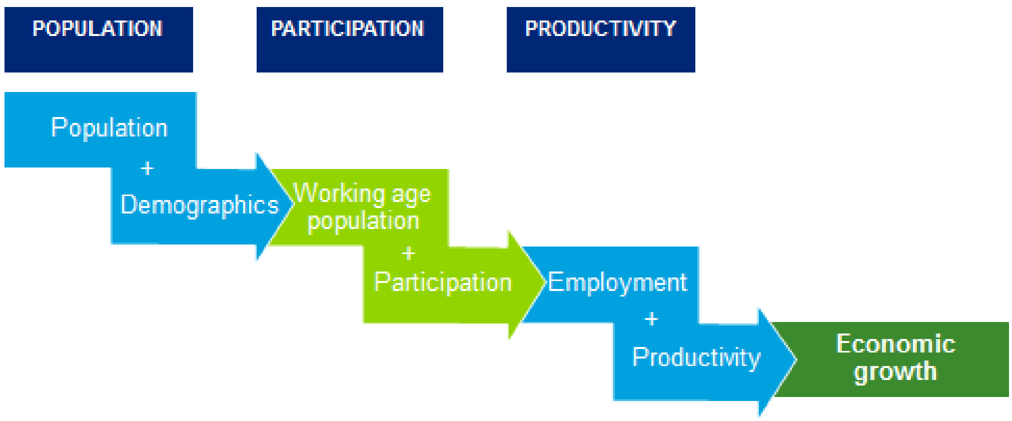
> *"Well targeted investment in physical infrastructure can increase productivity by both increasing the capital stock and improving the efficiency of other factors of production."*
>
> *(Treasury, 2008b)*

CGE modelling can help articulate the link between infrastructure and economic activity – by taking infrastructure policies and assessing how they might affect key economic outcomes such as GSP growth, regional economic growth, employment and industry structure.

A useful way of understanding how infrastructure projects will affect long-term economic growth in NSW is via the three "Ps": population, participation and productivity. As the diagram below explains:

- Population growth, and the demographic structure of the population, determine the size of the future working age population;
- The size of the future working age population combined with expected participation rates will determine the number of persons employed in the NSW economy; and
- Growth in the number of persons employed and growth in productivity ultimately determine the rate at which the NSW economy will grow in the future.

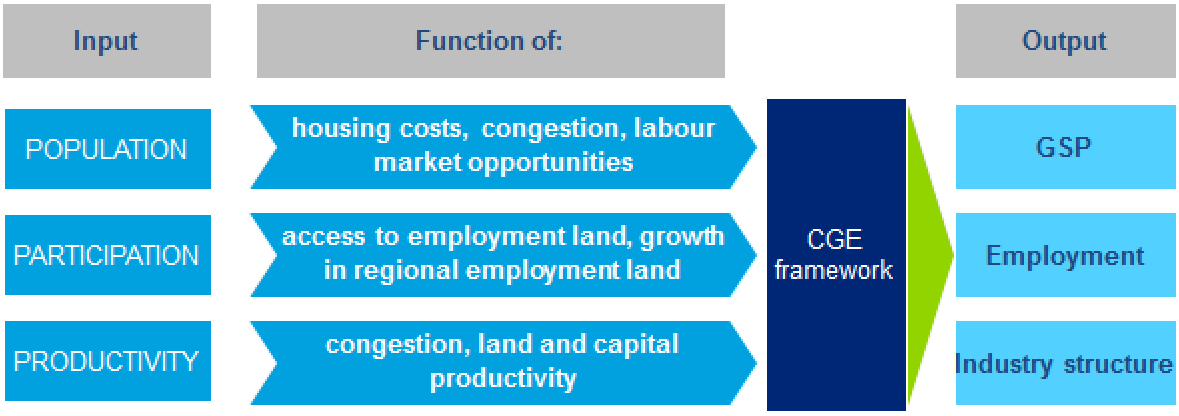
Figure 16.1: The three Ps and economic activity



Source: Deloitte Access Economics

Baseline projections for population, participation, productivity and economic growth are set out in earlier parts of this document. The next stage of the analysis therefore involves identification of the relationship between infrastructure projects and economic activity through the pathways of population, participation and productivity. The diagram below illustrates the key links through which we expect infrastructure policy to influence the growth path of population, participation and productivity:

Figure 16.2: Modelling the relationship between the three Ps and infrastructure



Source: Deloitte Access Economics

The nature of this relationship can be best understood with an example. A transport infrastructure project would likely affect economic activity via the three Ps in the following way:

- **Productivity**, by:
  - Reducing freight costs:
    - Improved roads will reduce congestion costs for freight vehicles; this will flow through as reduced costs to industries that rely on freight.
    - Reducing land and capital costs:
      - Better access to alternative employment lands will give businesses the opportunity to reduce their capital costs by lowering rents.
- **Participation** in the labour force, by:
  - Improving access to employment land:
    - Participation is likely to increase as more employment land will be within reasonable commuting times.
  - Increasing the amount of employment land:
    - Better transport connections will lead to development of housing and relocation of businesses into new areas, increasing and diversifying employment land.
- **Population** and demographic characteristics, by:
  - Reducing housing costs:
    - Population will migrate from higher cost to lower cost areas, which have been made more accessible by improved transport connections.
    - A small amount of inter-state migration will result from improved housing affordability in Sydney.
    - Working age population will migrate closer to labour market if relatively more cheaper to live there with policy change
  - Reducing congestion:
    - A reduction in the time taken to travel around the city will increase the relative attractiveness of Sydney as a place to live.
  - Improving labour market opportunities:

- Better access to jobs will make Sydney a more appealing place to live.

The link between productivity and economic activity is relatively well understood and well represented in all CGE models. For example, most proposed transport projects will contain estimates of the improvement in travel time that could be expected and this can be relatively easily converted into a reduction in transport costs. It is also relatively easy to compare capital costs (such as rent) and labour costs between areas to determine possible changes in these as a result of improved infrastructure.

Participation is likely to be largely the result of social infrastructure and so is outside the scope for the present analysis.

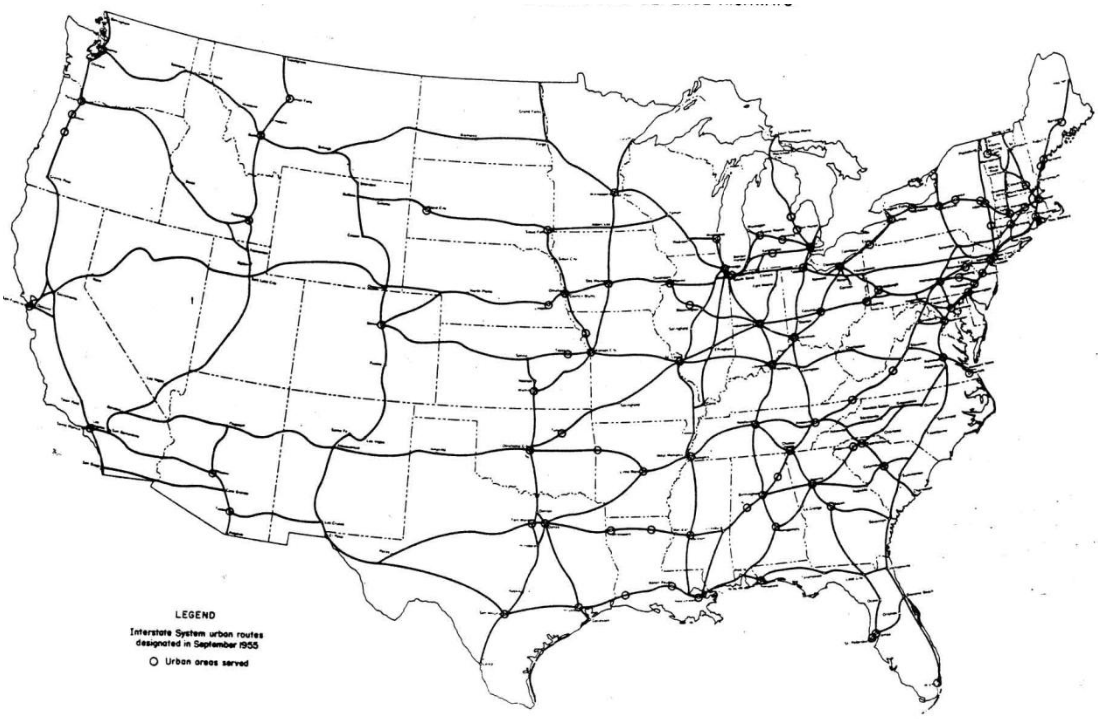
The following two sections of the report will therefore focus on approaches for quantifying the link between infrastructure and population. First, some case studies of large infrastructure investments and their estimated effect on economic activity are reviewed. Then a number of recent papers which have analysed this link will be used to identify key relationships which can be incorporated into the CGE model.

17 Infrastructure case studies

A starting point for this analysis is to consider some other cases where large infrastructure renewal and construction projects have been undertaken. Some good examples can be seen in the interstate road network in the US, the expressways of China and Sydney's toll roads.

The plan for the US interstate highway system was originally set out in Federal-Aid Highway Act of 1956. The plan for the highway system involved around 66,000km of highways by 1975. Construction began in 1956 and, after an expansion to around 76,000km, the original plan was finally completed in 1992 at a cost of around US$425bn (Neuharth 2006). This timeframe and cost makes the US interstate network one of the world's largest single infrastructure projects.

Figure 17.1: Original US interstate highway plan, 1956



Source: Duranton and Turner (2011)

The interstate highway network increased the ease of transport between major population centres in the US and reduced road transportation costs. This has resulted in significant economic benefits for areas serviced by the highway system. Nadiri's review in 1996 found that each dollar invested in the highway system resulted in an annual reduction in production costs of around 23-30cents, although this effect was estimated to fade over time. This means that the cost of the initial investment was recovered in around 4 years. The same review also found that highway investments accounted for around 25% of total productivity growth throughout the United States generating a 16% return on investment nationwide.

Looking from the other perspective, some studies have estimated the consequences of a lack of investment in transport infrastructure. Analysis of the Portland Region in the United States identified a range of responses from industry to congestion costs:

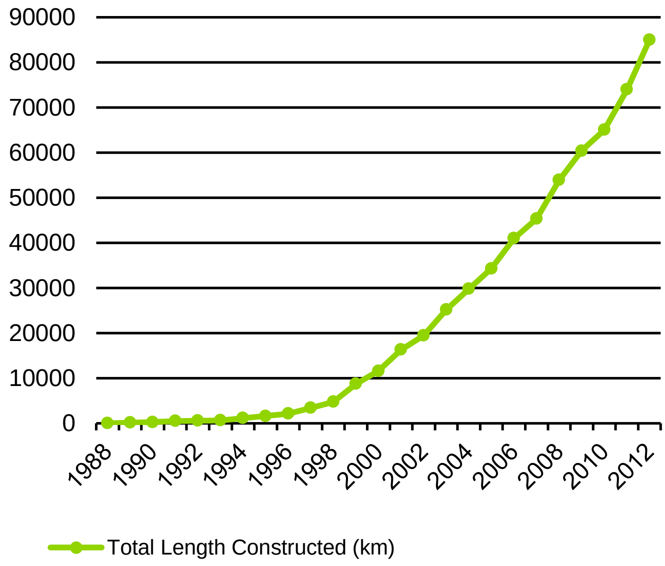
- A number of business had opened additional distribution centres or relocated warehouses to ensure supply during congested periods;

- Intel altered its shipment schedules to avoid periods of high congestion; and
- One large business increased its inventory levels by between 7-8% to better manage congestion delays (EDRG 2005).

These behavioural effects from increasing road congestion were estimated to result in costs of around $300m a year by 2012.

A similar investment has been made in recent decades in China, with construction of a network of national expressways. Construction of the expressways began in 1989 and now extends over 80,000km (making it slightly larger than the interstate network in the US). By 2010 the cost of the project has been estimated at around US$240bn.

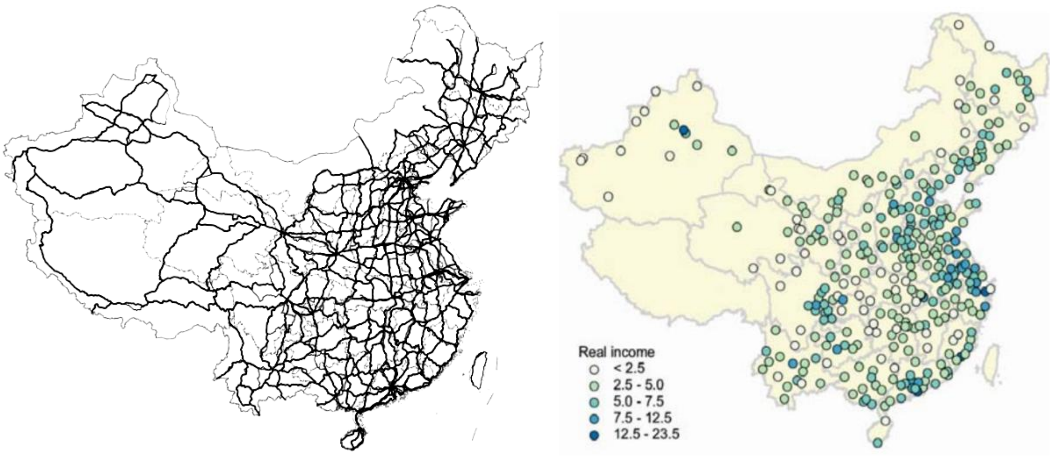
Chart 17.1: Total distance of expressways constructed in China (km)



Source: (Roberts 2009)

Analysis of the results of this investment indicate that the expressway system may have benefits in the order of 4.5% of real income in 2007 with the greatest benefits found in highly populated areas. Some areas are, however, estimated to experience a decline in their real wage level as a result of the construction of the expressways. A slight decrease in the overall urban-rural wage gap is also estimated to result from the construction of the expressways (Roberts *et al* 2009).

Figure 17.2: Expressways constructed in China and the estimated effect on income
a. expressways **b. effect on income**



Source: Roberts (2009)

Sydney's nine current toll roads were developed over a 20 year period and play a major role as part of the Sydney Orbital network. They include the Sydney Harbour Tunnel, M5, M4, M2, Eastern Distributor, Cross City Tunnel, M7 and the Lane Cove Tunnel.

Figure 17.3: Sydney's toll roads as part of the orbital network

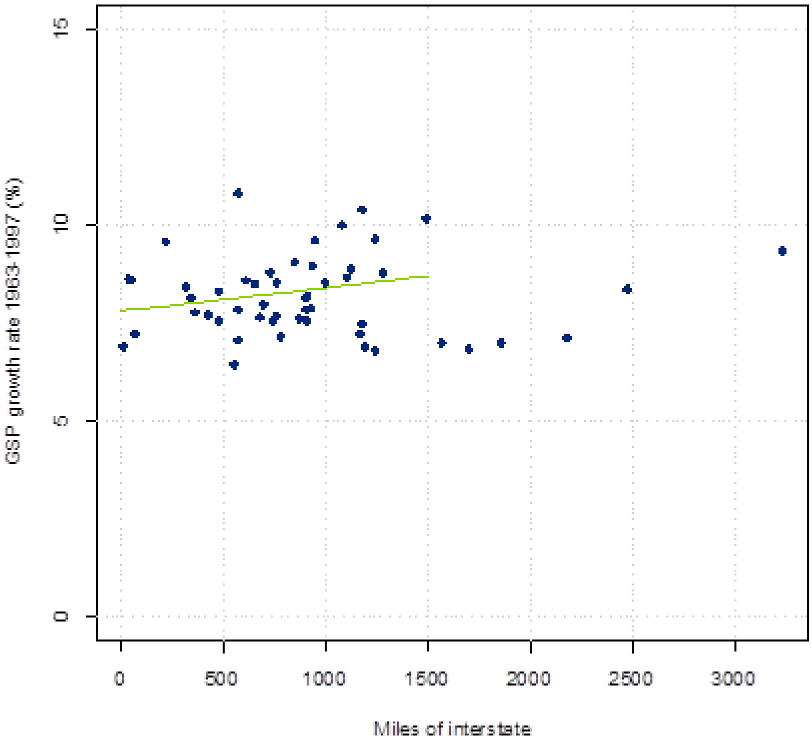
Source: Transurban, 2008, presented in Ernst and Young, 2008

The most thorough post-hoc analysis for Sydney's orbital network indicates that Sydney's toll road network contributed a net present value of $22.7 billion in 2008. It noted that actual traffic flows on these toll roads were 6% higher than estimated in the original environmental impact statement forecasts, which lead to a 20% increase in benefits relating to vehicle operating costs, a 19% increase in travel time savings and a 41% increase in accident reduction benefits (Transurban, 2008). These results are based in standard cost benefit analysis, and so place considerable weight on factors such as travel time savings and accident costs which, although being true economic benefits, are not directly captured in GSP figures.

The report also found that actual capital costs for the Sydney orbital network were 33% higher than forecast and actual operating and maintenance costs were 30% higher than anticipated. Network benefits from improved connectivity, development and employment opportunities were valued at $600 million in 2007 (Transurban, 2008).

Returning to the example of the US interstate System, a high level analysis of state growth rates and the presence of interstate highways, does not indicate a strong relationship between highways and economic growth. In the diagram below a number of potential outliers are excluded and the relationship between the two variables is still only slight (and statistically insignificant). This is an example of the problem faced when attempting to identify the relationship between infrastructure and economic activity: the two are linked to each other.

Chart 17.2: Relationship between interstate highway provision and GSP growth in the United States



Note: each dot represents a state; the green line is a linear trend.
Source: DAE estimates based on data from the Bureau of Economic Analysis and the Federal Highway Administration

This problem can be more precisely thought of as the simultaneous determination of the growth of a city and the growth of its infrastructure. It could be the case that a strongly growing city is likely to attract relatively more infrastructure than a slow growing city, which will likely help it grow faster and attract further infrastructure. But another option is that infrastructure could be seen as a way to provide stimulus for a slowly growing city. Both of these cases mean that a high level analysis of the relationship between infrastructure provision and how a city has grown is unlikely to capture the actual effect of the infrastructure but may only capture the anticipated growth path of that city. Finding ways to disentangle cause and effect has been the focus of recent economic research into the relationship between infrastructure investment and economic activity, this research is set out below.

18 Literature review

18.1 Background on this literature

There are problems with accurately identifying the relationship between infrastructure, population and economic activity. A strongly growing city is likely to attract relatively more infrastructure than a slow growing city, which will likely help it grow faster and attract further infrastructure. Thus a circular relationship between the variables of interest exists: investment in infrastructure, leads to stronger economic performance, leads to investment in infrastructure, which then leads to stronger economic performance. The simultaneous determination of infrastructure and economic growth presents a problem of identifying cause and effect.

In the past 10 years or so there have been developments in econometric techniques which examines exogenous variation to determine the effects that infrastructure has on aspects of growth such as population, employment and productivity. These developments are, essentially similar to trying to find cases of infrastructure investment which are closest to natural experiments rather than the result of economic circumstances.

If cases of exogenous variation can be found, this is useful as it enables estimation that disentangles cause and effect often using the techniques of structural modelling and instrumental variable estimation. Many of the papers cited below apply these new approaches to allow us, for the first time, to get a clear picture of the causal effect of infrastructure on population and economic activity.

The literature presented in this section primarily identifies the effects of transportation infrastructure, in the form of additional roads and rail, on economic activity. Most of the papers analyse the effects of transport infrastructure in developed economies, with one analysis of the effects of infrastructure in a developing economy (China). This will allow us to understand the effects of infrastructure in economies which are similar to Australia.

While there is some variability across the level of effects, overall the literature reviewed in this section finds that transportation infrastructure has positive effects on economic activity, in the form of increasing population and production in the areas benefiting from the infrastructure.

18.2 Roads and the distribution of population within cities

Baum-Snow (2006) find that one additional highway built within a central city reduced its population by 18%. This result is based on an analysis of different rates of suburbanisation within U.S. metropolitan areas compared to a measure of highway infrastructure (the number of highway rays originating in central cities).

The model estimates that between 1950 and 1990 the aggregate population of central cities declined by 17%. At the same time the population growth of the broader metropolitan areas was 72%. Population residing in central cities would have increased by 8%, without the level of highway infrastructure that took place. Highways are a significant explanation for the difference in population growth rates of aggregate central cities relative to broader metropolitan areas. Overall 1/3 of the decline in aggregate central city population, relative to the population in metropolitan areas, was the result of highway infrastructure.

By analysing commuting patterns, Baum-Snow (2007) determines that population decentralisation that took place between 1960 and 2000 in the United States was the result of new highways encouraging the population to reside in suburban areas instead of within central cities. Had the additional infrastructure not been built, the number of within-city commutes would have been twice the number recorded in the final year of analysis (2000). As a result of changing residential choices by the population, 45% or workers lived and worked in central cities in 1960, only 15% did in 2000, as a result there was significant variation in the nature of commutes. In particular, commuting within and across suburbs rose significantly at the expense of commuting which involved the central city. Similarly residential differences attributable to highway infrastructure were estimated. There was an 18% decline in the number of people who both resided and worked within the central city.

Population movements within China have been taking place at a rapid rate over the last 20 years. This has been particularly true for central city locations. Baum-Snow *et al* (2011) determine that the presence of ring roads and radial roads outside of the central city had a strong effect on reducing population within central cities. Ceteris paribus, each highway ray is estimated to have caused 6.3 to 7.1% of the central city population to relocate from the central city to suburban areas.

18.3 Roads and the distribution of population between cities

A complementary analysis to that presented in the above section of the distribution of population within cities, is an understanding of the distribution of population across cities. Duranton and Turner (2010) estimate that a 10% increase in the stock of interstate highways leads to a 1.5% increase in employment over 20 years.

This rate is slightly less than 2/3rds of the standard deviation of metropolitan areas employment growth rate over the period. Put simply, a one standard deviation increase in the stock of highway within a metropolitan area, leads to 2/3rds of a standard deviation in employment growth.

The stock of highways is a primary cause of the growth of employment within a metropolitan area. Additional highway infrastructure within metropolitan regions will create higher demand for employment relative to those metropolitan areas where no such growth in infrastructure took place. The result of this will be to shift the working population towards those metropolitan regions which experience higher rates of highway infrastructure growth and away from those that experienced relatively less growth.

By lowering the cost of transportation within a city highway infrastructure that makes a city more attractive relative to others, should be associated with population changes in the city benefitting from the infrastructure. Duranton and Turner (2008) analyse U.S. metropolitan areas between 1980 and 2000 in order to understand the relationship between population growth and highway infrastructure. Using historical transport infrastructures, they estimate that a 10% increase in the extent of the road networks in a given city, results in an increase of population in that metropolitan area of 1.3% over 10 years, rising to 2% over 20 years.

18.4 Roads and transportation costs

Transportation costs are an essential parameter in understanding the development of cities. By reducing the time taken for workers to travel, within and across metropolitan areas, alterations to road networks increase access to employment across a broader area. Duranton and Turner estimate the elasticity of unit transportation costs to road provision.

In Duranton and Turner (2009) the direct measurement of the elasticity is provided by estimating the metropolitan areas mean cost of driving (as measured by inverse speed) as a function of interstate lane kilometres. The derived estimate for elasticity of unit transportation costs to road provision is 0.06. This means that a 1% increase in road provision leads to a 0.06% decrease in transport costs.

In their structural model of urban growth and transportation Duranton and Turner (2011) provide a model, and associated transportation parameters, which reflects the relationship between transportation costs and city development. Using first order conditions for utility maximisation with respect to driving distance, Duranton and Turner (2011) estimate that the elasticity of unit transportation costs to road provision is between 0.05 and 0.10. While this was estimated using a less direct and less precise method, the measure of elasticity is comparable to those estimated by Duranton and Turner (2009).

18.5 Roads and productivity

A data set of firms, linked by geographical location to road transport infrastructure schemes established between 1998 and 2003, was analysed by Gibbons *et al* (2010) to estimate the productivity effects of rising employment accessibility resulting from road transport infrastructure schemes.

Estimates of total factor productivity arising from changes to employment accessibility were generally found to be statistically insignificant. These results suggest that those firms that experience an increase in employment accessibility as a result of the transportation schemes do not experience a productivity gain relative to other firms.

The results presented above are puzzling as economic theory suggests positive effects for productivity from agglomeration. This result is supported by other literature which has found that there are positive productivity impacts arising from agglomeration effects. Davis et al (2009) use a panel of U.S. cities estimates the relationship between wages, output prices, housing rents and structure of the work force, in order to assess the effect of agglomeration and variation in land rents to estimate the effect on local wages. The model estimates that doubling the density of economic activity, measured as output per unit of productive land, increases wages by 2%. This is a small but statistically significant effect. The larger impact is on the effect for land prices. Combining the wage outcome with the increases in land value associated with agglomeration effects finds that individual consumption grows by 10%.

Production within a city is subject to agglomeration effects; generally these effects are analysed in the literature as changes to individual wages. Duranton and Turner (2010) estimate that the elasticity of local productivity (as measured by wages) with respect to employment density (workers per sq.km) is about 0.03, suggesting that a doubling of employment density will lead to an increase in wages of about 3%. This is within the central range of other productivity estimates, including Davis et al (2009) which estimate a productivity value of 0.02 (outlined above) in the US and Glaeser and Resseger (2010) who suggest a value of 0.04 or less .

18.6 Rail and the distribution of population within cities

Additional rail infrastructure is positively and significantly related to population in the area that benefited from it. Specifically, Levinson (2007) found that a 10% increase in rail infrastructure results in a 2.2% increase in population density in the affected area.

In addition, an increase of surface rail density is positively associated with population density in the neighbouring region. That is, population density is weakly associated with population density in the next closest area (between the region of interest and the City of London), although these effects are small: a 10% increase in population density leads to 0.34% increase in the neighbouring region.

The model also finds that increasing rail infrastructure is negatively associated with population density in the centre of London. A 10% increase in rail results in a 3.8% fall in population in the City of London (although these results were not statistically significant).

Table 18.1: Rail and population elasticities

Elasticity	Periphery	Core
Rail (combined) on Population density	0.0023	-0.0038
Change in Population Density on Surface Rail Density	0.0023	-0.0065
Change in Population Density on Underground Rail Density	0.0027	-0.0041

Source: Levinson (2007)

In addition, Levinson finds significant feedback effects, a 10% increase in population density in the 10 years prior leads to a 2.3% increase in surface rail density, and a 2.7% increase in Underground rail density. These effects suggest that that rail and population density evolved together. Demand for rail infrastructure is not only driven by the increase in demand from existing residence but is also associated with an increase in demand for new residents, who moved into the area as a result of the infrastructure.

Baum-Snow et al (2011) analyse the role of transportation networks generally, and rail infrastructure specifically, on urban development. They find that radial railroad lines lead to a decline in central GDP of approximately 13% and 20% of central city industrial output. Overall, additional rail lines, together with ring roads, are positively associated with the decentralisation of production in Chinese cities towards suburban regions. Baum-Snow et al (2011) also find that while ring roads and radial roads are positively associated with population decentralisation, rail infrastructure is associated with decentralisation of production.

18.7 Rail and the distribution of population between cities

Duranton and Turner (2011) estimate the long term rate of population growth, between 1920 and 2000, as a function of 1898 rail routes and 1920 population. The elasticity of population growth of 1898 rail, holding physical geography factors constant, is 0.3. This indicates that a 10% increase in rail would result in a 3% increase in population over the time period 1920-2000.

18.8 Transport and house prices

Construction of new rail stations in London in the late 1990s, which reduced the distance to train stations for some homes while leaving others unchanged, means that Gibbons and Machin (2004) are able to analyse the relationship between house prices and rail infrastructure, without the biases inherent in valuation analysis. Gibbons and Machin find that house prices are affected by the distance to rail stations, suggesting that transport infrastructure has a positive relationship with housing.

House values which were affected by the rail infrastructure rose by 45% in real terms, while, over an equivalent time period, houses which were not affected by the rail infrastructure experienced price rises of only 37%. Overall it was found that house prices grew by 9.3% higher in areas affected by the rail infrastructure than otherwise. Regression estimates, which control for a range of property, neighbourhood and distance characteristics, indicate that for each additional kilometre in distance closer to the rail station, the value of housing rises by 1.5%. These results indicate that households place a premium on access to rail infrastructure and this premium is reflected in higher prices.

19 A worked example

Using the relationships identified from the literature review, this section steps through an example of the approach that could be used to link infrastructure investments to the CGE model and therefore determine the overall economic benefits of an infrastructure investment. In this case we have focussed on two projects, M4 and M5 east. Although a simplification, this will clearly show how the approach links infrastructure to the CGE model through results identified in the literature.

In terms of this modelling, the benefits identified relating to the M4 and M5 east are a reduction in travel times as average speeds increase, which both reduces freight transport costs and reduces congestion costs for commuters. Reducing congestion costs also makes Sydney a more appealing place to live and so, in the long run, helps to increase population growth.

The first set of benefits (related to congestion) are informed by transport modelling undertaken by Roads and Maritime Services. The scenarios were introduced in 2016 and modelling results were provided for the years 2021 and 2026 for both AM and PM peak. The transport model results covered vehicle kilometres and vehicle hours and were broken down by vehicle type (car and truck) and road type (freeway, arterial, sub-arterial and local). Some key model outputs are included in the table below.

Table 19.1: Estimated transport network effects from the M4 and M5

		Base		Policy		Change	
		Vehicle Kilometres	Vehicle Hours	Vehicle Kilometres	Vehicle Hours	Vehicle Kilometres	Vehicle Hours
2021	AM	10,291,467	332,440	10,286,030	321,601	-0.1%	-3.3%
	PM	10,801,218	335,645	10,797,074	325,817	0.0%	-2.9%
2026	AM	11,072,253	370,942	11,067,314	356,332	0.0%	-3.9%
	PM	12,205,313	392,042	12,199,726	378,194	0.0%	-3.5%

Source: Deloitte Access Economics based on data provided by Transport for NSW

These transport network benefits were then converted into travel cost benefits and transport cost benefits by applying a model which takes into account factors such as:

- the composition of road traffic (to break down car and truck travel into subgroups such as business/commuter and rigid/articulated);
- the value of travel time;
- morning and afternoon peak travel's share of total travel; and
- vehicle operating costs.

This model produced the following benefits:

Table 19.2: Estimated transport benefits ($m, net present value, 2016-2045)

Benefit	Value
Passenger Travel Time Savings	8,310
Freight Travel Time Savings	711
Vehicle Operating Cost Savings	447
Accident Cost Savings	126
Total	9,594

Source: Deloitte Access Economics based on data provided by Transport for NSW

Finally, the vehicle operating cost saving in the above table was used to gauge where Sydney was to be found in the range of vehicle operating cost savings identified in the literature. The literature suggested that a 1% increase in the stock of roads leads to between a 0.05% and 0.1% decrease in transport costs (Duranton and Turner 2009). The above analysis suggested that Sydney lies near the top end of this range. This implies that the construction of the M4 and M5 would result in a 2.68% decrease in road transport costs in Sydney.

The next angle of estimation is to analyse the relationship between infrastructure and population growth. Using the results from Duranton and Turner (2011) which relate provision of road infrastructure to population growth rates indicates that the M4 and M5 (being around a 27% increase in Sydney's stock of orbital roads) will likely result in the following increase in population in Sydney over the period to 2032:

Table 19.3: Estimated population effects from the M4 and M5

Year	Estimated increase in population (000s)
2017	6
2022	44
2027	148
2032	250

Source: Deloitte Access Economics

Based on this analysis, the inputs into the CGE modelling to represent to the M4 and M5 extensions are:

- the capital costs of the project;
- a decrease in transport costs of around -2.68% Sydney wide; and
- an increase of population of up to 250,000 people by 2032.

In addition to this we would calculate the value of the reduced travel time costs outside the CGE model, this calculation would be based on average hourly wages.

We have not specifically run the CGE model for this project but the CGE model outputs would focus on GDP and employment effects and would provide insight into the overall economic benefits that could be generated by the M4 and M5.

References

ABS. (2008). 3105.0.65.001 - Australian Historical Population Statistics, 2008. Retrieved February 6, 2012, from ABS: http://www.abs.gov.au/ausstats/abs@.nsf/mf/3105.0.65.001

ABS. (2011a). 3101.0 - Australian Demographic Statistics, Jun 2011. Retrieved February 6, 2012, from ABS: http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0

ABS. (2011b). 5220.0 - Australian National Accounts: State Accounts, 2010-11. Retrieved February 6, 2012, from ABS: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5220.02010-11?OpenDocument

ABS. (2011c). 5501.0.55.001 - Government Financial Estimates, Australia, 2011-12.

ABS. (2011d). NSW State and Regional Indicators, December 2010.

ABS (2012a). 1367.0 - State and Territory Statistical Indicators, 2012. Retrieved August 27, 2012, from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1367.0~2012~Main%20Features~Total%20Fertility%20Rate~2.2

ABS. (2012). 6202.0 - Labour Force Australia, Dec 2011. Retrieved February 6, 2012, from http://www.abs.gov.au/ausstats/abs@.nsf/mf/6202.0

ACMA. (2010, November). Australia in the digital economy. Retrieved February 7, 2012, from ACMA: http://www.acma.gov.au/webwr/_assets/main/lib310665/aust_in_digital_economy-consumer_engagement_with_e-commerce.pdf

AEMC, 2011, 'Review of Distribution Reliability Outcomes and Standards', http://www.aemc.gov.au/Media/docs/Issues%20paper-8f2e9b03-5b4d-434d-aef8-59d868ec01e1-0.PDF

AEMC, 2012, 'Fact sheet: NSW customer survey on electricity reliability', http://www.aemc.gov.au/Media/docs/Fact-sheet---NSW-customer-survey-603a433c-cfb4-4f90-b5d7-a439431fa234-0.pdf

AEMO. (2011). National Transmission Network Development Plan. AEMO.

AER, 2011, 'State of the Energy Market 2011', http://www.aer.gov.au/sites/www.aer.gov.au/files/State%20of%20the%20energy%20market%202011%20-%20complete%20report.pdf

Australian Government. (2010). The 2010 intergenerational report. Retrieved February 6, 2012, from The Treasury: http://www.treasury.gov.au/igr/igr2010/

Australian Government. (2011). Statement 4: Opportunities and Challenges of an Economy in Transition. Retrieved February 6, 2012, from Treasury: http://cache.treasury.gov.au/budget/2011-12/content/download/bp1_bst4.pdf

Avenell Services, 2011, Western Sydney Rail Proposals, A rail Operations Study for Parramatta City Council.

Baum-Snow 2010, ‘Changes in Transportation Infrastructure and Commuting Patterns in U.S. Metropolitan Areas, 1960-2000’, American Economic Review Papers and Proceedings, 2010, 100(2): 378-382.

Baum-Snow. D, Brandt. L, Henderson. V, Turner. M, Zhang, Q (2011) ‘Roads, Railways and Decentralisation of Chinese cities’, working paper Centre for Economic Policy Research. http://cepr.org.meets/wkcn/2/2434/papers/HendersonFinal.pdf

Black, S., Brassil, A., & Hack, M. (2010). The Impact of the Financial Crisis on the Bond Market.

Boarnet, M. G., & Chalermpong, S. 2001, ‘New highways, house prices, and urban development: A case study of toll roads in Orange County, CA’, Housing Policy Debate, 12(3), 575-605.

Cisco. (nd). VNI Forecast Highlights. Retrieved February 7, 2012, from Cisco: http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html#~Country

Deloitte Access Economics. (2011a). The True Value of Rail. Retrieved February 6, 2012, from Deloitte: http://www.deloitte.com/assets/Dcom-Australia/Local%20Assets/Documents/Industries/Government%20Services/Deloitte_the_true_value_rail.pdf

Deloitte Access Economics. (2011b). Next Generation Telework: A Literature Review.

Department of Planning. (2011). Draft interim review of NSW State and Regional Population Projections, 2006-2036. Sydney, NSW.

DRET. (2011a). Draft Energy White Paper. Canberra.

DRET. (2011b). Energy in Australia 2011. Canberra.

Duranton, G and Turner, MA 2011, ‘Urban growth and transportation’, University of Toronto.

Duranton, G. and Turner, M. A. (2009), “The Fundamental Law of Road Congestion: Evidence from US cities”.

EDRG (Economic Development Research Group) (2005),” The Cost of Congestion to the Economy of the Portland Region”. December 2005

Frost and Sullivan. (2010, July 20). A$12 Billion Australian Consumer eCommerce Market Underdeveloped and Lags US and UK by Three Years. Retrieved February 7, 2012, from http://www.frost.com/prod/servlet/press-release.pag?docid=207380860

Gibbons. S, and Lyytikainen. T, Overman. H, Sanchis-Guarner. R, and Laird. J 2010 ‘Evaluating the productivity impacts of road transport schemes: report on pilot study findings’. Department for Transport.

Hensher, D.A., Stopher, P.R., Bullock, P. and Ton, T, 2004, TRESIS (Transport and Environmental Strategy Impact Simulator): Application to a Case Study in NE Sydney, Transportation Research Record 1898, 114-123.

Hensher, D.A., 2008, Climate change, enhanced greenhouse gas emissions and passenger transport- what can we do to make a difference? Transportation Research, 13 (2), 95-111.

Hogan, L., & Morris, P. (2010). Agricultural and food policy choices in Australia. Sustainable agriculture and food policy in the 21st century: challenges and solutions. Brussels.

I&I (NSW Government Industry and Investment), 2010, "NSW Electricity Network and Prices Inquiry', http://www.dpc.nsw.gov.au/__data/assets/pdf_file/0005/118904/NSW_Electricity_Network_and_Prices_Inquiry_Report.pdf

Infrastructure Australia. (2011). Communicating the Imperative for Action.

Levinson, D 2007, 'Density and dispersion: the co-development of land use and rail in London', Journal of Economic Geography, 8: 55–57.

Martin, S. (2011). Reviewing the last decade of public transport infrastructure projects in Australasia. Australasian Transport Research Forum 2011 Proceedings. Adelaide.

Murray Darling Basin Authority. (2011). Proposed Basin Plan.

Nadiri, I., and Mamuneas, T.P. (1996), "Contribution of Highway Capital to Industry and National Productivity Growth". U.S. Department of Transportation, Federal Highway Administration, Office of Policy Development, Washington, D.C., September 1996

National Housing Supply Council. (2010). 2nd State of Supply Report. Retrieved February 6, 2012, from FAHCSIA: http://www.fahcsia.gov.au/sa/housing/pubs/housing/national_housing_supply/Documents/StateofSupplyReport_2010.pdf

NBN. (nd). Telework. Retrieved February 7, 2012, from NBN: http://www.nbn.gov.au/telework/

Neurath, A. (2006) "Traveling interstates is our sixth freedom", USA Today, http://www.usatoday.com/news/opinion/columnist/neuharth/2006-06-22-interstates_x.htm

NSW Government. (2010). Metropolitan Plan for Sydney. Sydney.

NSW Government. (2011). Sydney and New South Wales Financial Services. Retrieved February 6, 2012, from http://www.business.nsw.gov.au/__data/assets/pdf_file/0006/5685/nsw_financial_services_profile_20111221.pdf

NSW Treasury. (2011). NSW long-term fiscal pressures report. Retrieved February 6, 2012, from http://www.budget.nsw.gov.au/__data/assets/pdf_file/0018/20538/bp6_ltfp.pdf

OECD. (2011). OECD - FAO Agricultural Outlook 2011-2020. Retrieved February 6, 2012, from OECD: http://www.oecd.org/dataoecd/13/2/48186214.pdf

Ports Australia. (2011). Containerised Trade in TEU. Retrieved February 6, 2012, from http://www.portsaustralia.com.au/tradestats/?id=5&period=11

Quah, D. (2011, January). The Global Economy's Shifting Centre of Gravity. Global Policy, 2(1), 3-9.

Ramey, V. A., 2011, "Can Government Purchases Stimulate the Economy?" Prepared for The Journal of Economic Literature forum on "The Multiplier."

Roberts, M., Deichmann, U., Fingleton, B., Shi, T. and Kopp, A. (2009), Regional Economic Impacts of Highway Projects, http://siteresources.worldbank.org/DEC/Resources/84797-1257266550602/DeichmannU.pdf

Roberts, R., Mitchell, N., & Douglas, J. (2006). Water and Australia's future economic growth.

Stanley, J., 2007, Sustainability in land transport: the big picture, http://www.busvic.asn.au/database/files/JStanley-TheBigPicture.pdf

Transport NSW 2010, Infrastructure Australia, Updated submission by the NSW Government 2010, http://www.transport.nsw.gov.au/sites/default/files/publications/ia_submission_full_web.pdf

Treasury. (2008a). Australia's Low Pollution Future. Canberra.

Treasury. (2008b). Budget Statement 4: Boosting Australia's Productivity Capacity: The Role of Infrastructure and Skills. Canberra.

Treasury. (2011). Strong Growth, Low Pollution. Canberra.

World Health Organisation. (nd). Availability and changes in consumption of animal products. Retrieved February 6, 2012, from http://www.who.int/nutrition/topics/3_foodconsumption/en/index4.html

Appendix A: Analysis for the Sydney Metro area

The tables below provide a brief summary of the results outlined in section 6. The breakdown within Sydney is based on population location forecasts developed by the Bureau of Transports Statistics. These forecasts were adjusted based on more recent population statistics for the Sydney Metropolitan area. The geographic breakdown developed by the Bureau of Transport Statistics has been applied to the overall CGE modelling results for the Sydney Metropolitan area and potential GRP for each region has then been estimated based on existing income information. The sub-Sydney breakdown has not been modelled within the CGE framework.

Table A.1: Summary of forecasts and estiamted breakdown within Sydney (levels)

		Sydney (Central)*	Sydney (Greater)*	Sydney (Metro)	Regions	Total
Population	2010	1.3	3.3	4.6	2.6	7.2
	2032	1.7	4.4	6.1	3.1	9.2
	Growth rate	1.3%	1.3%	1.3%	0.7%	1.1%
Jobs	2010-11	1.0	1.3	2.3	1.3	3.6
	2031-32	1.2	1.6	2.8	1.5	4.4
	Growth rate	0.87%	1.05%	0.97%	0.86%	0.93%
GRP/GSP	2010-11	173.0	139.9	312.9	107.0	419.9
	2031-32	312.5	252.8	565.3	165.6	730.9

Note: * Sydney Central and Greater figures are estimated outside the CGE model

Table A.2: Summary of forecasts and estimated breakdown within Sydney (shares)

		Sydney (Central)*	Sydney (Greater)*	Sydney (Metro)	Regions	Total
Population	2010	17%	46%	63%	37%	100%
	2032	18%	48%	66%	34%	100%
Jobs	2010-11	28%	36%	64%	36%	100%
	2031-32	28%	37%	65%	35%	100%
GRP/GSP	2010-11	41%	34%	75%	25%	100%
	2031-32	43%	34%	77%	23%	100%

Note: * Sydney Central and Greater figures are estimated outside the CGE model

Source: Deloitte Access Economics estimates

Appendix B: Detailed modelling methodology

Background on the DAE CGE model

A Computable General Equilibrium (CGE) model is a stylised representation of the real world economy which allows for analysis of how the economy might react to changes in external factors such as policy, technology, environment and population.

CGE models are based on real world economic data. The fundamental building block is a database which reconciles how goods and services flow from one industry to another. For example, this database could show how much road transport is used by the food and beverage industry or how much output from agricultural industries is used in food manufacturing. This database covers the entire economy. From this real world data information on key variables such as GDP can be calculated.

The second main component of the model is an extensive set of information on the preferences of consumers and producers. These preferences cover details such as how consumption of an item changes as its price increases, how likely consumers are to switch their consumption between different goods and how producers are best able to produce their output.

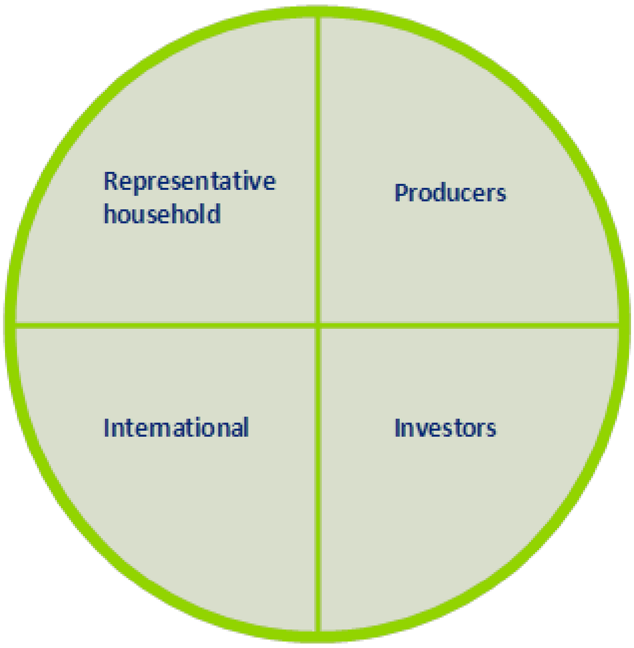
The model therefore represents a static picture of the economy (how goods and services are currently used) and a framework for measuring how changes to this picture will flow through the economy.

The Deloitte Access Economics – Regional General Equilibrium Model (DAE-RGEM) is a large scale, dynamic, multi-region, multi-commodity computable general equilibrium model of the world economy. The model allows policy analysis in a single, robust, integrated economic framework. This model projects changes in macroeconomic aggregates such as GDP, employment, export volumes, investment and private consumption. At the sectoral level, detailed results such as output, exports, imports and employment are also produced.

The model is based upon a set of key underlying relationships between the various components of the model, each which represent a different group of agents in the economy. These relationships are solved simultaneously, and so there is no logical start or end point for describing how the model actually works.

Figure A.1 shows the key components of the model for an individual region. The components include a representative household, producers, investors and international (or linkages with the other regions in the model, including other Australian States and foreign regions). Below is a description of each component of the model and key linkages between components. Some additional, somewhat technical, detail is also provided.

Figure B.1: Key components of DAE-RGEM



DAE-RGEM is based on a substantial body of accepted microeconomic theory. Key assumptions underpinning the model are:

- The model contains a 'regional consumer' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).
- Income is allocated across household consumption, government consumption and savings so as to maximise a Cobb-Douglas (C-D) utility function.
- Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In the Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a C-D utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.
- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES production function.
- Producers are cost minimisers, and in doing so, choose between domestic, imported and interstate intermediate inputs via a CRESH production function.
  - The model contains a more detailed treatment of the electricity sector that is based on the 'technology bundle' approach for general equilibrium modelling developed by ABARE (1996).
- The supply of labour is positively influenced by movements in the real wage rate governed by an elasticity of supply.

- Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return. Once the aggregate investment has been determined for Australia, aggregate investment in each Australian sub-region is determined by an Australian investor based on: Australian investment and rates of return in a given sub-region compared with the national rate of return.
- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.
- Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).
- For internationally-traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But, in relative terms, imported goods from different regions are treated as closer substitutes than domestically-produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes again.
- The model accounts for greenhouse gas emissions from fossil fuel combustion. Taxes can be applied to emissions, which are converted to good-specific sales taxes that impact on demand. Emission quotas can be set by region and these can be traded, at a value equal to the carbon tax avoided, where a region's emissions fall below or exceed their quota.

The representative household

Each region in the model has a so-called representative household that receives and spends all income. The representative household allocates income across three different expenditure areas: private household consumption; government consumption; and savings.

Going clockwise around Figure B, the representative household interacts with producers in two ways. First, in allocating expenditure across household and government consumption, this sustains demand for production. Second, the representative household owns and receives all income from factor payments (labour, capital, land and natural resources) as well as net taxes. Factors of production are used by producers as inputs into production along with intermediate inputs. The level of production, as well as supply of factors, determines the amount of income generated in each region.

The representative household's relationship with investors is through the supply of investable funds – savings. The relationship between the representative household and the international sector is twofold. First, importers compete with domestic producers in consumption markets. Second, other regions in the model can lend (borrow) money from each other.

Some detail:

- The representative household allocates income across three different expenditure areas – private household consumption; government consumption; and savings – to maximise a Cobb-Douglas utility function.
- Private household consumption on composite goods is determined by minimising a CDE (Constant Differences of Elasticities) expenditure function. Private household consumption on composite goods from different sources is determined is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption on composite goods, and composite goods from different sources, is determined by maximising a Cobb-Douglas utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of generating capital.

Producers

Apart from selling goods and services to households and government, producers sell products to each other (intermediate usage) and to investors. Intermediate usage is where one producer supplies inputs to another's production. For example, coal producers supply inputs to the electricity sector.

Capital is an input into production. Investors react to the conditions facing producers in a region to determine the amount of investment. Generally, increases in production are accompanied by increased investment. In addition, the production of machinery, construction of buildings and the like that forms the basis of a region's capital stock, is undertaken by producers. In other words, investment demand adds to household and government expenditure from the representative household, to determine the demand for goods and services in a region.

Producers interact with international markets in two main ways. First, they compete with producers in overseas regions for export markets, as well as in their own region. Second, they use inputs from overseas in their production.

Some detail:

- Sectoral output equals the amount demanded by consumers (households and government) and intermediate users (firms and investors) as well as exports.
- Intermediate inputs are assumed to be combined in fixed proportions at the composite level. As mentioned above, the exception to this is the electricity sector that is able to substitute different technologies (brown coal, black coal, oil, gas, hydropower and other renewables) using the 'technology bundle' approach developed by ABARE (1996).
- To minimise costs, producers substitute between domestic and imported intermediate inputs is governed by the Armington assumption as well as between primary factors of production (through a CES aggregator). Substitution between skilled and unskilled labour is also allowed (again via a CES function).
- The supply of labour is positively influenced by movements in the wage rate governed by an elasticity of supply is (assumed to be 0.2). This implies that changes influencing the demand for labour, positively or negatively, will impact both the level of employment and the wage rate. This is a typical labour market specification for a dynamic model such as DAE-RGEM. There are other labour market 'settings' that can be used. First, the labour market could take on long-run characteristics with aggregate employment being fixed and any changes to labour demand changes being absorbed through movements in the wage rate. Second, the labour market could take on short-run characteristics with fixed wages and flexible employment levels.

Investors

Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. The global investor ranks countries as investment destination based on two factors: current economic growth and rates of return in a given region compared with global rates of return.

Some detail

- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.

International

Each of the components outlined above operate, simultaneously, in each region of the model. That is, for any simulation the model forecasts changes to trade and investment flows within, and between, regions subject to optimising behaviour by producers, consumers and investors. Of course, this implies some global conditions must be met such as global exports and global imports are the same and that global debt repayments equals global debt receipts each year.

Discussion of CGE models

The strength of CGE models is that this combination of data and preferences represents the highly interlinked nature of the economy. For example, a policy which improves the efficiency of road transport will result in a cost saving to all businesses using road transport. In some markets this cost saving may be passed onto consumers, which frees up some of their money to be spent on other goods, which results in increased employment in other sectors. That is, a shock to one area of the economy propagates its way into all areas and a CGE model provides a structured way to trace through, record and gauge the final consequences of an initial change in economic conditions.

CGE models are also useful as they provide a realistic treatment of how economic resources are allocated. For example, a large capital project will necessarily lead to increased spending which will result in an increase in economic activity. However, this increase in economic activity comes at a cost, as resources must be shifted from other activities, for example construction of a new pipeline will require expenditure from the pipeline builder on labour, machinery (such as welding and excavation equipment) and land – this will all increase economic activity. However, the workers on the project are likely drawn from other jobs and, by purchasing equipment, this might push up costs for other businesses that also use welding and excavation equipment – this will work to reduce economic activity in these areas. On net, there is likely to be an increase in overall economic activity but not by as much as would be initially expected given the expenditure on the pipeline. A CGE model is able to track these relationships and account for these effects.

By tracking how the economy responds to changes, a CGE model can be used to assess the effects of policy on high level economic variables such as Gross Domestic Product (GDP), employment and trade balances as well as industry level information such as composition of economic activity by industry type. Without a CGE model it would be extremely difficult to gauge the effect that a certain policy would have on these aggregate variables.

A CGE model is, however, a stylised representation of the economy and abstracts from some of the real world elements of the economy which can be of importance. For example, although a CGE model represents geographically based units (such as countries and states) there is no geography in the model. Instead the effect of geography is represented through other variables – geography affects transport costs and transport costs can affect the decisions of businesses and individuals.

Similarly, infrastructure is not directly represented in a CGE model. A CGE model does not directly define the power lines connecting an electricity generator to electricity consumers, nor the road which allows trucks to transport goods from one area to another nor the rail line which moves commuters from their home to work. Instead this physical infrastructure enters the CGE model by how it affects the industries and consumers in the model. For electricity an interconnector between states will effectively reduce the costs of trade in electricity between the states, a better road will reduce the costs of road transport and a better rail line will give benefits to consumers in terms of leisure time.

That last benefit from infrastructure, more leisure time when congestion decreases, bears further discussion. A CGE model is focussed on replicating the measurements of GDP. That is, if something does not enter into the standard calculation of GDP it is unlikely to be well measured in a CGE model. The standard measure of GDP can be made by looking at all individual's final income, the total amount of value added in production or the total amount of expenditure made, these three approaches are conceptually equivalent. As increased leisure time does not directly contribute to these areas, it is not measured in GDP and so may not be well measured in a CGE model. In cases like this, where there are significant non-market benefits, that it is necessary to augment the results from a CGE model with other calculations.

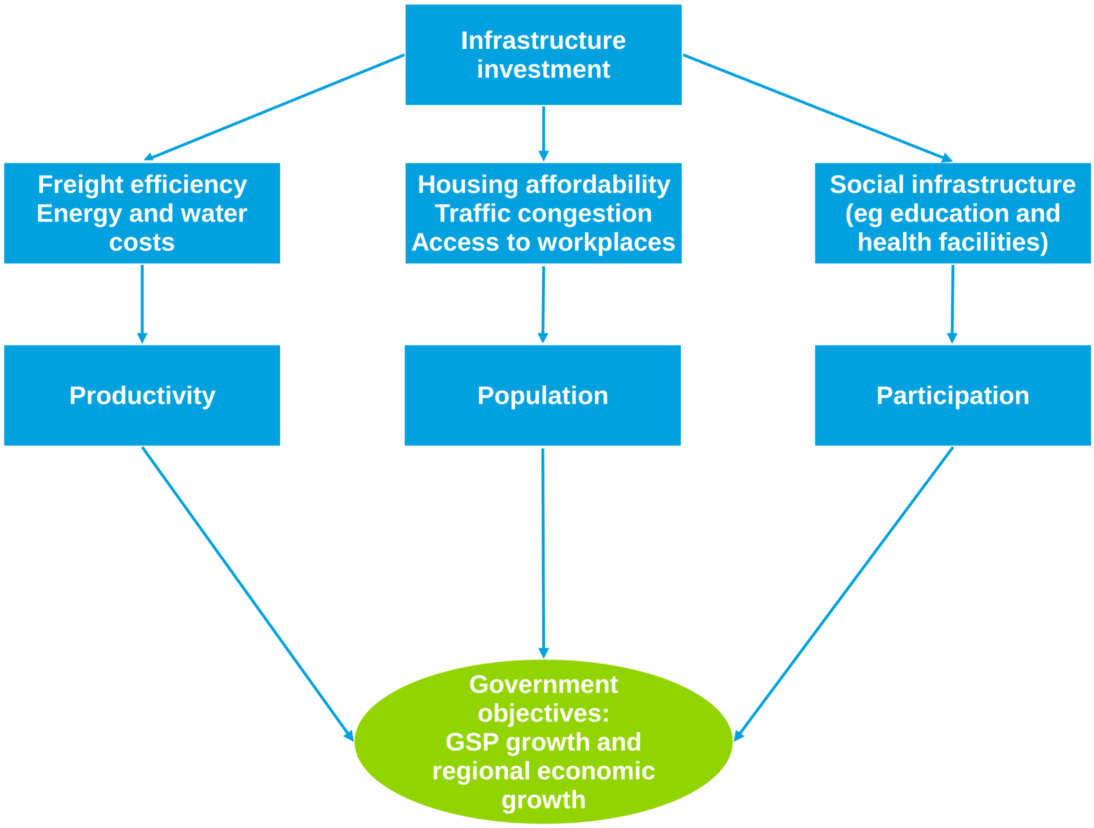
Infrastructure and CGE models

As noted above, CGE models are an essential tool in assessing how policy decisions affect overall economic activity but they do not directly incorporate physical infrastructure – we cannot simply add a new piece of infrastructure into the model. For CGE modelling to help articulate the link between infrastructure an economic activity (such as GSP growth, regional economic growth, employment and industry structure) we must build a bridge between infrastructure projects and how they influence variables which are included in the CGE model.

The conceptual link

A useful way of understanding how infrastructure projects will affect long-term economic growth in NSW is via the three "Ps": population, participation and productivity. This conceptual relationship is shown in the figure below.

Figure B.2: The conceptual relationship between infrastructure and the economy



For example, if the infrastructure investment package includes

- roads to allow goods to be transported from Sydney's ports more efficiently as well as making it easier to travel from home to work;
- electricity network upgrades to increase the security of supply; and

- funding of new schools and hospitals.

Then the above framework would suggest that the new road and the electricity network upgrades will reduce costs for businesses which use road transport and electricity – this is almost all businesses in Sydney. This is the productivity bridge between infrastructure and the economy. The benefits of investment in the road do not stop there though; looking at the population bridge, by reducing congestion and making it easier to get to work the new road will increase the desirability of NSW as a place to live and so population will grow over time. More people will lead to more jobs, more ideas and more demand for goods all of which enhance economic activity. Turning to the schools and hospitals, a healthier and better education populace is more likely to participate in the workforce again improving economic outcomes.

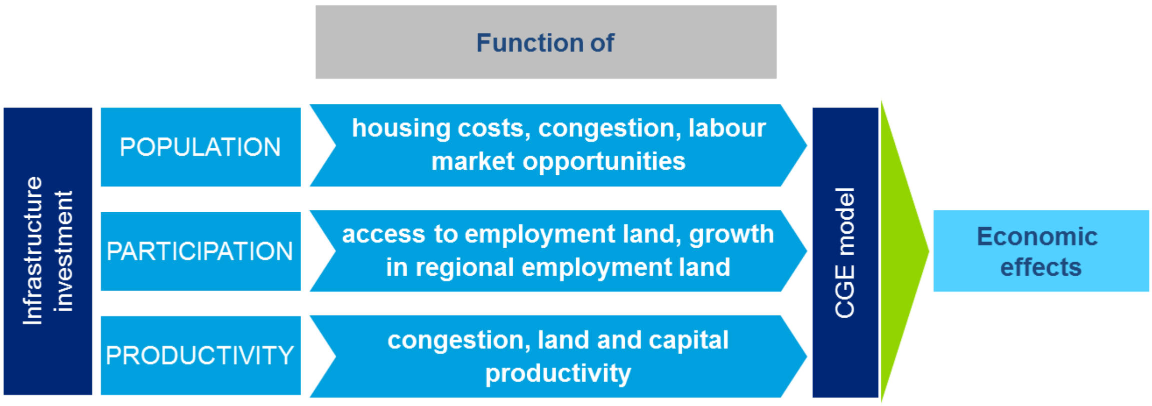
Put succinctly: growth in the number of people employed and growth in productivity ultimately determine the rate at which the NSW economy will grow in the future and infrastructure can play a key role in influencing all of these factors.

Modelling the link

Having established this conceptual bridge between infrastructure and the economy, the next step involves identification and quantification of the relationship between infrastructure projects and economic activity through the pathways of population, participation and productivity. By clearly defining and quantifying these relationships we are able to convert an infrastructure project into a set of effects which can be used in a CGE model.

The diagram below illustrates the key links through which we expect infrastructure policy to influence the growth path of population, participation and productivity:

Figure B.3: Modelling the relationship between infrastructure and the economy



The nature of this relationship can be best understood with an example. A transport infrastructure project would likely affect economic activity via the three Ps in the following way:

- **Productivity**, by:
  - Reducing freight costs:
    - Improved roads will reduce congestion costs for freight vehicles; this will flow through as reduced costs to industries that rely on freight.
    - Reducing land and capital costs:
      - Better access to alternative employment lands will give businesses the opportunity to reduce their capital costs by lowering rents.

- **Participation** in the labour force, by:
  - Improving access to employment land:
    - Participation is likely to increase as more employment land will be within reasonable commuting times.
  - Increasing the amount of employment land:
    - Better transport connections will lead to development of housing and relocation of businesses into new areas, increasing and diversifying employment land.
- **Population** and demographic characteristics, by:
  - Reducing housing costs:
    - Population will migrate from higher cost to lower cost areas, which have been made more accessible by improved transport connections.
    - A small amount of inter-state migration will result from improved housing affordability in Sydney.
    - Working age population will migrate closer to labour market if relatively more cheaper to live there with policy change
  - Reducing congestion:
    - A reduction in the time taken to travel around the city will increase the relative attractiveness of Sydney as a place to live.
  - Improving labour market opportunities:
    - Better access to jobs will make Sydney a more appealing place to live.

Each type of infrastructure project will have a different mechanism for how the conceptual bridges of population, participation and productivity are affected and so, in quantifying these relationships we need to consider each type of infrastructure investment, its pathway through the three conceptual bridges and how each of the pathways can be quantified.

The following section outlines ways to quantify the conceptual bridges of productivity and population. The participation bridge is not quantified. The participation bridge is most strongly influenced by social infrastructure investments such as schools, hospitals, childcare and aged care facilities. These investments do have important economic consequences (their effect on participation) but their economic consequences are likely to be only one component of a much broader assessment of why these projects are needed and where investment should be focussed. For this reason our analysis does not seek to include social infrastructure and the participation bridge into an overall assessment of the economic consequences of infrastructure investment.

Quantifying the link

Looking at the range of infrastructure investments possible in NSW, there are seven broad categories of investment which lend themselves to quantification via the productivity and population bridges: urban roads; regional roads; commuter rail; urban freight rail; regional freight rail; other transport (busses, light rail, etc) and energy.

Each of these categories of infrastructure investment will have slightly different approaches to quantifying its effect on economic activity. The approach that has been used in the analysis is set out in the table below.

Table B.3: Summary of the link between infrastructure and the economy

Infrastructure investment category	Conceptual link: Productivity	Conceptual link: Population	Quantification: Productivity	Quantification: Population
Urban roads	Congestion: Better roads reduce congestion which reduces transport costs Capital costs: Better roads give businesses access to lower cost land.	Congestion: Better roads reduce congestion which makes the city a more appealing place to live. Housing costs: Better roads open up new housing areas, increasing supply and reducing costs, making the city a more appealing place to live	Modelling of Sydney transport network to determine decrease in costs of road transport Duranton and Turner (2009 and 2011) indicate that a 1% increase in road provision leads to between a 0.05% and 0.1% decrease in transport costs Gibbons et al (2010) find no statistically significant effect on productivity from rising employment accessibility resulting from road transport infrastructure schemes	Modelling of Sydney transport network to determine decrease in congestion costs Baum-Snow (2006 and 2011) find that an additional radial road leads to central city populations decreasing by between 6-18% compared to the case where no road is provided. Duranton and Turner (2010) estimate that a 10% increase in the stock of interstate highways leads to a 1.5% increase in employment over 20 years Boarnet and Chalermpong (2003) find that construction of roads increases house prices for those nearby the road.

Infrastructure investment category	Conceptual link		Quantification	
	Productivity	Population	Productivity	Population
Regional Roads	Congestion: Better roads reduce congestion which reduces transport costs Capital costs: Better roads give businesses access to lower cost land.	Congestion: Better roads reduce congestion which makes the city a more appealing place to live. Housing costs: Better roads open up new housing areas, increasing supply and reducing costs, making the city a more appealing place to live	Duranton and Turner (2009 and 2011) indicate that a 1% increase in road provision leads to around a 0.06% decrease in transport costs	Duranton and Turner (2010) estimate that a 10% increase in the stock of interstate highways leads to a 1.5% increase in employment over 20 years Boarnet and Chalermpong (2003) find that construction of roads increases house prices for those nearby the road.

Infrastructure investment category	Conceptual link		Quantification	
	Productivity	Population	Productivity	Population
Commuter Rail	Congestion: Better rail reduces road commuting which reduces transport costs	Congestion: Better rails reduces congestion which makes the city a more appealing place to live. Housing costs: Better roads open up new housing areas, increasing supply and reducing costs, making the city a more appealing place to live	Modelling of Sydney transport network to determine decrease in costs of road transport	Modelling of Sydney transport network to determine decrease in congestion costs Duranton and Turner (2011) find that a 10% increase in rail infrastructure results in a 3% increase in population over 80 years. Levinson (2007) found that a 10% increase in rail infrastructure results in a 2.2% increase in population density in the affected area Gibbons and Machin (2004) find that that house prices increase by 9.3% more in areas affected by rail infrastructure than they otherwise would have.

	Conceptual link		Quantification	
Infrastructure investment category	**Productivity**	**Population**	**Productivity**	**Population**
Urban Freight Rail	Mode shift: Better rail causes business to switch between road transport and rail transport Congestion: Better rail reduces road transport which reduces transport costs	Congestion: Better rails reduces congestion which makes the city a more appealing place to live.	Modelling of relationship of transport costs on road and rail and how this varies with overall rail volumes Modelling of Sydney transport network to determine decrease in costs of road transport when road journeys decrease.	Modelling of Sydney transport network to determine decrease in congestion costs when road journeys decrease.
Regional Freight Rail	Mode shift: Better rail causes business to switch between road transport and rail transport Congestion: Better rail reduces road transport which reduces transport costs Capacity constraints: Better rail allows for export of more goods than would be possible without it		Modelling of relationship of transport costs on road and rail and how this varies with overall rail volumes Estimation of exports enabled by overcoming capacity constraints	Modelling of Sydney transport network to determine decrease in congestion costs when road journeys decrease.

Infrastructure investment category	Conceptual link		Quantification	
	Productivity	Population	Productivity	Population
Other Transport	Congestion: Better transport options reduce congestion which reduces transport costs	Congestion: Better transport options reduce congestion which reduces transport costs	Modelling of Sydney transport network to determine decrease in costs of road transport	Modelling of Sydney transport network to determine decrease in congestion costs
Energy	Reliability: Electricity outages affect business productivity, reducing outages will reduce overall business costs Congestion: Congestion on electricity networks increases prices in NSW. Better electricity infrastructure can reduce the cost of electricity in NSW, decreasing the cost doing business	Congestion: Congestion on electricity networks increases prices in NSW. Better electricity infrastructure can reduce the cost of electricity in NSW, making the state a more appealing place to live	Estimation of the costs of electricity outages and how these can be reduced. Estimation of the cost of electricity imports affected by congestion and how these could be reduced	Estimation of the cost of electricity imports affected by congestion and how these could be reduced

The set of approaches outlined in the above table allows us to quantify the effect of infrastructure investment in a way which can be inputted in a CGE model to provide an overall. An important aspect of the above approach is that is can be aggregated over any number of infrastructure projects. For example, the relationship between investment in road and rail and population allows for cumulative total impacts of road and rail investment on population growth to be estimated.

Aggregation is also possible in the approach for estimating reductions in congestion costs and overall transport costs relies on modelling of the entire transport network and looking at aggregate statistics (such as total travel time costs and vehicle operating costs). The overall modelling of the transport could make use of a number of standard transport models maintained by the NSW government.

The following section of the appendix sets out an example of how this approach can be used to link an infrastructure investment to the CGE model and provide an overall estimation of the economic benefits of an infrastructure investment.

Our approach in action

This section steps through an example of the approach that has been used to link infrastructure investments to the CGE model and therefore determine the overall economic benefits of an infrastructure investment. In this case we have focussed on two projects, M4 and M5 east, instead of looking at the overall impact of the investment associated with the State Infrastructure Strategy. Although a simplification, this will clearly show the approach that has been used.

In terms of this modelling, the benefits identified relating to the M4 and M5 east are a reduction in travel times as average speeds increase, which both reduces freight transport costs and reduces congestion costs for commuters. Reducing congestion costs also makes Sydney a more appealing place to live and so, in the long run, helps to increase population growth.

The first set of benefits (related to congestion) are informed by transport modelling undertaken by Roads and Maritime Services. The scenarios were introduced in 2016 and modelling results were provided for the years 2021 and 2026 for both AM and PM peak. The transport model results covered vehicle kilometres and vehicle hours and were broken down by vehicle type (car and truck) and road type (freeway, arterial, sub-arterial and local). Some key model outputs are included in the table below.

Table B.4: Estimated transport network effects from the M4 and M5

		Base		Policy		Change	
		Vehicle Kilometres	Vehicle Hours	Vehicle Kilometres	Vehicle Hours	Vehicle Kilometres	Vehicle Hours
2021	AM	10,291,467	332,440	10,286,030	321,601	-0.1%	-3.3%
	PM	10,801,218	335,645	10,797,074	325,817	0.0%	-2.9%
2026	AM	11,072,253	370,942	11,067,314	356,332	0.0%	-3.9%
	PM	12,205,313	392,042	12,199,726	378,194	0.0%	-3.5%

Source: Deloitte Access Economics based on data provided by Transport for NSW

These transport network benefits were then converted into travel cost benefits and transport cost benefits by applying a model which takes into account factors such as: the composition of road traffic (to break down car and truck travel into subgroups such as business/commuter and rigid/articulated); the value of travel time; morning and afternoon peak travel's share of total travel; and vehicle operating costs.

This model produced the following benefits:

Table B.5: Estimated transport benefits ($m, net present value, 2016-2045)

Benefit	Value
Passenger Travel Time Savings	8,310
Freight Travel Time Savings	711
Vehicle Operating Cost Savings	447
Accident Cost Savings	126
Total	9,594

Source: Deloitte Access Economics based on data provided by Transport for NSW

Finally, the vehicle operating cost saving in the above table was used to gauge where Sydney was to be found in the range of vehicle operating cost savings identified in the literature. The literature suggested that a 1% increase in the stock of roads leads to between a 0.05% and 0.1% decrease in transport costs. The above analysis suggested that Sydney lies near the top end of this range. This implies that the construction of the M4 and M5 would result in a 2.68% decrease in road transport costs in Sydney.

The next angle of estimation is to analyse the relationship between infrastructure and population growth. Using the results from Duranton and Turner (2011) which relate provision of road infrastructure to population growth rates indicates that the M4 and M5 (being around a 27% increase in Sydney's stock of orbital roads) will likely result in the following increase in population in Sydney over the period to 2032:

Table B.6: Estimated population effects from the M4 and M5

Year	Estimated increase in population (000s)
2017	6
2022	44
2027	148
2032	250

Source: Deloitte Access Economics

Based on this analysis, the inputs into the CGE modelling to represent to the M4 and M5 extensions are:

- the capital costs of the project;
- a decrease in transport costs of around -2.68% Sydney wide; and
- an increase of population of up to 250,000 people by 2032.

In addition to this we would calculate the value of the reduced travel time costs outside the CGE model, this calculation would be based on average hourly wages.

We have not specifically run the CGE model for this project but the CGE model outputs would focus on GDP and employment effects and would provide insight into the overall economic benefits that could be generated by the M4 and M5.

In the full analysis for the SIS, we have used a similar approach where we relate infrastructure to economic outcomes via the pathways described in this appendix. The only change between the treatment of a single project and the full SIS is the inputs into the transport modelling and an extension of the population effects.

Appendix C: Detailed literature review

Baum-Snow (2010) Changes in Transportation Infrastructure and Commuting Patterns in U.S. Metropolitan Areas, 1960-2000

The importance of U.S. cities as places of home and business has declined relative to the suburbs. There are implications of this trend on firm productivity, previously agglomeration benefits and their associated productivity impacts, were one of the primary reasons for central regions of business. Likewise, there are implications of this trend for residential decentralisation, and in particular has worker commutes, both in time and method (within central-city or within-suburb). While there is wide acceptance that highway infrastructure contributed to this decentralisation, little evidence exists on the outcome on employment locations and commuting patterns. This paper aims to fill that gap.

Data which tracks the number of commutes between central city and various other locations was collected from the 1960 and 2000 censuses. Adjustment to take account of regional classification by area was made to ensure comparability over time. Using portions of the interstate highway as an exogenous variation, changes in employment and residential spatial allocations over time were estimated.

The paper finds that, as both residential and employment decentralisation took place simultaneously, the relative spatial concentrations remained unchanged. One of the primary changes that did take place was the nature of commutes. Many commuters no longer travel through central cities; by 2000 central cities were the origin and/or destination of only 38% of commutes, down from 66% in 1960. Baum-Snow found that each highway ray caused an 18% decline in the number of people who both lived, and worked in central cities, and a 10% decline in reverse commutes. Overall these results indicate a 16% decline in central city working residents caused by each additional radial highway. As a result of the increase of within-suburb commuting, each highway ray resulted in an estimated 25% increase in the number suburban commutes (both within and across suburbs).

The paper found that the reduction of suburb-city commuters was equally offset by an increase in suburban commuters. Highway infrastructure allowed commuters to spread out, at the same time that firms were able to obtain productivity affects at further distances from the central city.

Overall, the paper found that highways played a crucial role not just in the increase in suburban residents, but also suburban employment.

Baum-Snow 2010, ‘Changes in Transportation Infrastructure and Commuting Patterns in U.S. Metropolitan Areas, 1960-2000’, American Economic Review Papers and Proceedings, 2010, 100(2): 378-382.

Duranton and Turner (2011), Urban Growth and Transportation

Government spending in the United States on transport generally, and infrastructure particularly, amounts to $200 billion annually. Given the magnitude of expenditure it is important that the impacts for economic growth be thoroughly assessed. More broadly, as transport is a key input into theoretical models of cities it is an important this variable is determined accurately. In this context this paper attempts to provide a basis for sound economic policy to guide governments and city planners.

The authors estimate a structural model of urban growth and transportation using instrumental variables estimation. The analysis proceeds in three sections. Firstly the authors constructed a simple structural model demonstrating the related evolution of highways and employment. As estimates of the initial stock of roads is unlikely to be uncorrelated with unobserved determinants of change, the authors then go onto estimate two structural equations which estimate changes to employment and roads, holding the initial stock of roads as endogenous. To do this, the authors employ the use of instrumental variables (IV) estimation. The authors construct IV estimates for 1983 highways using a1947 plan of the interstate highways system, an 1898 may of railroads, and maps of the early explorations of the US. Finally, the authors use the parameters from the second stage of the model to assess a number of alternative transportation policy experiments.

The estimates from the main IV model indicate that city employment is positively related to highway growth. The report estimates that a 10% increase in a city's existing stock of highways, at the beginning of the period of interest, results in a 1.5% increase in its employment over the following 20 years (these results were broadly consistent across a number of model specifications). The model also estimates that 10% more interstate highway at the beginning of the period leads to 2.7% less growth in roads in the subsequent 20 years. The authors also found that an additional kilometre of highway allocated to a city at random, rather than as a result of the political process, resulted in a larger increase in employment or population. The IV models estimate that roads are allocated to slow growing cities. Overall the authors found that highway growth was partly in response to negative population shocks, and that highways were used in place of other forms of social assistance.

Duranton, G and Turner, MA 2011, 'Urban growth and transportation', University of Toronto.

Levinson (2007), Density and Dispersion: The Co-Development of Land use and Rail in London

Infrastructure expansion generally happens simultaneously with economic development. Understanding the casual linkages, or untangling the chicken and the egg story of rail network and land development, is the primary concern of this paper. Largely as a result of paucity of data of the rail and population network elements, analysis thus far tends to examine aggregate and macro factors. This paper attempts to fill this gap by examining the relationship between infrastructure and development and in particular whether the development of rail is centralising or decentralising. The results will have implications for understanding city development.

Panel data representing 33 boroughs of London over each decade (21 points in time), from 1871 to 2001, was obtained for population estimates. Three models predict: population density; surface rail station density; and Underground station density. Separate models are estimated for the 'core' (centre of London) and the periphery (the suburbs). The models predict the population density of an area. Because density changes slowly in infrastructure and housing, density at any time can largely be explained by the density in the previous time period. The lagged dependent variable reduce autocorrelation in the model, as it helps test cause and effect in a way that simultaneous estimation could not.

Additional rail infrastructure is positively and significantly related to rising population in the area. A 10% increase in rail infrastructure, measured at the typical value of 0.3 surface and Underground stations per km², results in a 2.2% increase in population density. The model estimates spatial effects of rail infrastructure. An increase of surface rail density is positively associated with population density in the neighbouring region. The model also finds that increasing rail infrastructure is negatively associated with population density in the centre of London. A 10% increase in rail results in a 3.8% fall in population (although these results were not statistically significant). Overall, the paper finds that there are positive feedback effects between rail infrastructure and population growth, with both developing concurrently over the time.

Table C.1: Elasticities

Elasticity	Periphery	Core
Rail (combined) on Population density	0.0023	-0.0038
Change in Population Density on Surface Rail Density	0.0023	-0.0065
Change in Population Density on Underground Rail Density	0.0027	-0.0041

Source: Levinson (2007)

Levinson, D 2007, 'Density and dispersion: the co-development of land use and rail in London', Journal of Economic Geography, 8: 55–57.

Baum-Snow (2011), Roads, Railways and Decentralisation of Chinese Cities

Chinese cities have struggled to accommodate the recent rapid migration of the rural population into cities. At the same time, expenditure on infrastructure in China has increased significantly. Understanding the structure of Chinese road, rail and transport infrastructure and the effect of population movements is therefore of great importance for Chinese policy makers. In particular, policy makers are interested in the optimal allocation of expenditure on radial highways, ring roads, rail lines and public transport. In light of these aims this paper seeks to gain an understanding of the role of transportation in determining the distribution of population between central cities and suburban regions.

As noted in the papers above, changing residential decisions and economic growth may increase the level of investment in transport infrastructure. To control for endogeneity, instrumental variable analysis was used to determine the casual effects of infrastructure on decentralisation. Following work by Duranton and Turner (2011) the model analyses exogenous variation in historical transport networks, that took place prior to China's conversion towards a market based economy, from 1980, 1962, 1924 and 1700, to predict future transport infrastructure networks.

The model concludes that radial roads reduce population density and ring roads outside of cities additionally reduce central city population. Estimates of the IV model indicate a positive relationship between highways and change in central city population. Each highway ray is estimated to cause a 6.3 to 7.1% decline in central city population. The results are higher for the period 1990-2000, suggesting that roads built earlier have a greater impact than those built latter.

Overall, while it was found that more rapidly growing Chinese cities received more transport infrastructure than other types of cities, the highways positively contributed to population decentralisation in central city areas.

However, it should be noted that the growth in infrastructure arising from economic growth far exceeds the growth in infrastructure arising from population decentralisation. Rail infrastructure is positively associated with the decentralisation of production in the central city, each additional railway ray is associated with a 13% decline in central city GDP. Overall the authors find that road infrastructure is positively associated with population decentralisation, while rail infrastructure is positively associated with production decentralisation.

Baum-Snow. D, Brandt. L, Henderson. V, Turner. M, Zhang, Q (2011) 'Roads, Railways and Decentralisation of Chinese cities', working paper Centre for Economic Policy Research. http://cepr.org.meets/wkcn/2/2434/papers/HendersonFinal.pdf

Gibbons (2010), Evaluating the productivity Impacts of Road Transport Schemes. Report on pilot study findings

An initial scoping study tested the effects of changing employment accessibility, which arises from additional transport infrastructure, on firm productivity. This paper was intended to test the methodological approach established in the initial scoping study. The direct benefits of transport infrastructure, such as reduced travel time which lowers transportation costs, are well established in the literature. This report intended to contribute to the literature which evaluates the 'wider benefits' of transport infrastructure, the benefits which go beyond the usual direct benefits.

A micro longitudinal data set of firms, which are linked by geographical location to road transport infrastructure schemes that were established between 1998 and 2003, was analysed. The analysis proceeded in two stages. Firstly the model estimated whether transport schemes were associated with changes to employment accessibility (where transport schemes increase available workers by bringing firms closer to workers and other firms). Secondly, the model then estimated whether the productivity outcomes of firms which benefited from a significant increase in employment accessibility was notably different from those firms which received relatively minor changes to employment accessibility.

The report does not find that there are positive total factor productivity impacts arising from changes to employment accessibility. While the report found there was some increase in the number of firms in areas which were close to transport schemes, there was minimal impact on employment growth, with variability across transport schemes. The change to employment accessibility arising from the transport scheme varies from a very small 0.31% (within 10km of the scheme) to an increase in accessibility of 2.5% (also within 10km of the scheme). There was also noticeable variation across industries. For the M11/M25 transport scheme, the mean change in accessibility within 10km of the scheme is 0.35%, which results in an increase in productivity of around 2.3%. Total factor productivity arising from changes to employment accessibility for the M60/M61 scheme were negative, and weakly significant.

Gibbons. S, and Lyytikainen. T, Overman. H, Sanchis-Guarner. R, and Laird. J 2010 'Evaluating the productivity impacts of road transport schemes: report on pilot study findings'. Department for Transport.

Boarnet and Chalermpong (2003) New Highways, house prices, and urban development; A case study of toll roads in Orange County, CA

Economic theory suggests that land value, and housing prices, will be higher in locations which are more accessible to employment and other amenities. This paper aims to contribute to the debate on the link between highways and its effects on urban development, by testing whether the economic theory holds true in application. In particular, it aims to assist with planning and urban policy issues.

Two models are estimated to determine the impact of the construction of toll roads in Orange County, California, hedonic price regression analysis and multiple sales techniques, on house prices. Analysis considers prices before and after the construction to determine the impact of the infrastructure.

For one of the toll roads, linear specifications found that, house prices within the specified corridor, decrease ceteris paribus (factors which were controlled for include, distance from coast line, proximity to schools, crime rates in the areas, size of homes, and time factors) by approximately $0.88 per foot. This is equivalent to approximately $4,600 less in price for each mile the house is located from the toll road. While for the other toll road home prices decrease, all else constant, by approximately $4.49 per foot, equivalent to almost $24,000 per mile from the toll road.

The analysis presented in this report suggests that the toll roads created an 'accessibility premium' in that home buyers are willing to pay for the increased access created by the new roads. This increased willingness to pay is associated with development patterns, and (potentially) induced travel (that is the travel that is associated with new highways capacity, which increases vehicle miles of travel).

Boarnet, M. G., & Chalermpong, S. 2001, 'New highways, house prices, and urban development: A case study of toll roads in Orange County, CA', Housing Policy Debate, 12(3), 575-605.

Limitation of our work

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