

Sustainable Urban Mobility: Economic Perspectives

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Contents

1. Sustainable urban mobility

1.1 Elusive definitions

As a precursor to exploring economic perspectives on sustainable urban mobility, there is value in seeking some clarity around the meaning of the subject matter: *sustainable urban mobility*. Any rudimentary Google, or similar, search will find many references to sustainable mobility and sustainable transport. Bakker et al. (2014) have listed 12 definitions of sustainable transport, but a widely agreed definition of sustainable urban mobility, or of sustainable urban transport, remains somewhat elusive. With respect to the concept of sustainable mobility, most articles on the subject talk about various qualities that the authors conclude will enhance the sustainability of (urban) mobility systems but it is unusual to see any reference to the characteristics of a sustainable end-state system. By implication, it might be possible to say that one urban mobility system is more sustainable than another but neither might actually be 'sustainable' in any fundamental long-term sense.

To illustrate this situation, Banister (2008) is perhaps regarded as the classic article on sustainable mobility, yet his paper includes no definition of the concept. Similarly, Gärling et al. (2014), in their recent *Handbook of Sustainable Travel,* to which one of us was a contributing author, refer to several articles that proposed 'various elaborate schemes' for defining sustainability of travel, without ever defining the concept themselves.

Most efforts at defining sustainable mobility (or similar concepts, like sustainable transport or travel) owe their origins to the work of the landmark Brundtland Commission, which set out its much-quoted definition for *sustainable development* almost two decades ago (WCED 1987, p. 8):

> 'Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.'

While this definition reads as somewhat anthropocentric, the Commission also noted (for example) '… moral, ethical, cultural, aesthetic, and purely scientific reasons for conserving wild beings' (WCED 1987, p.13). 'Human needs' are notoriously difficult to define and measure but the familiar triple bottom line evaluative dimensions (economic, social and environmental, or sometimes expressed as productivity, people and planet), as indicators of capacity for people to meet needs and to do so over a prolonged period, were embedded in thinking about sustainability in this work and in discussion thereof.

In commentary on Brundtland, pioneering environmental economist Professor David Pearce argued that '… sustainable development is readily interpretable as non-declining human welfare over time' (Pearce 1991, p.1). Pearce argued that the conditions for achieving sustainable development include compensating future generations for damage done by current generations and that this is best achieved by ensuring future generations have a stock of man-made and natural capital that is no less than the current stock. He went on to argue that the precautionary principle implies a bias towards conserving natural capital, rather than being able to trade it off against man-made capital assets without limit. This discussion is particularly relevant in a transport setting in terms of how one approaches climate change associated with greenhouse gas emissions, where the transport sector is a major, and increasing, contributor.

In this general vein, in 2001 European Ministers of Transport defined sustainable transport as transport that:[1]

- allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations,
- is affordable, operates fairly and efficiently, offers a choice of transport mode and supports a competitive economy, as well as balanced regional development and
- limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.

This definition incorporates high-level triple bottom line sustainability elements and adds a transport lens to those elements, including the incorporation of end-state conditions in relation to the environment, which reflects Pearce's approach.[2] In our view, and partly reflecting our value judgments about sustainability (elaborated further as the paper develops), this is a comprehensive and effective definition.

Holden et al. (2013) have developed a framework that works from the idea of sustainable development to principles for sustainable passenger transport, with target outcome performance indicators. Working from four high-level sustainability (outcome-based) dimensions, they go on to set one performance indicator per dimension for passenger transport (four in total), with associated targets, arguing that all the targets need to be met to align with their notion of 'sustainable'. This is in line with the idea of defining a set of desirable end-state conditions for sustainability but goes further than the European Ministers' definition by including end-state targets for all four sustainability dimensions they identify, not just for the environmental dimension. Trade-offs between targets are ruled out by Holden et al. (2013) in seeking to define the domain of sustainable passenger transport. Table 1.1 summarizes their sustainability dimensions and indicators and contributory passenger transport sustainability dimensions and performance indicators.

Obtaining single performance dimensions/indicators at the passenger transport level that closely reflect top level sustainable development dimensions/indicators, which are themselves contestable, is inevitably fraught with difficulty and danger, as illustrated in section 1.2, but the idea has much to commend it in terms of forcing a search for what really matters in terms of end-state outcomes.

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[1] http://corporate.skynet.be/sustainablefreight/trans-counci-conclusion-05-04-01.htm
[2] David Pearce was a frequent adviser to the OECD and European Ministers.

Table 1.1: Sustainable urban passenger transport

Sustainable development		Sustainable passenger transport	
Dimension	**Indicator**	**Dimension**	**Indicator**
1. Safeguarding long-term ecological sustainability	*Yearly per capita ecological footprint*	1. Impacts of transport activities must not threaten long-term ecological sustainability	*Daily per capita energy consumption for passenger transport*
2. Satisfying basic human needs	*Yearly per capita GDP*	2. Satisfying basic transport needs	*Daily per capita travel distance by motorised transport*
3. Promoting intragenerational equity	*Gini coefficient*	3. Promoting intragenerational equity	*Public Transport Accessibility Index (PTAL)*
4. Promoting intergenerational equity	*Amount of renewable to total energy in primary energy production*	4. Promoting intergenerational equity	*Amount of renewable to total energy used in transport*

Source: Based on Holden, E., K Linnerud and D Banister (2013). 'Sustainable passenger transport: back to Brundtland', *Transportation Research Part A* 54, 67-77, Table 1.

The most common approach to defining sustainable mobility or sustainable transport, however, works only with various sustainability dimensions, not seeking to specify target sustainable end-states on those dimensions. May et al. (2001), for example, align sustainable transport with six overarching goals: economic efficiency; livable streets and neighbourhoods; protection of the environment; equity and social inclusion; health and safety; and, contribution to economic growth. Stanley and Barrett (2010) have taken a similar approach in an Australian setting but did not include 'liveable streets and neighbourhoods', where measurement problems abound. The EU 2011 Transport White Paper identifies similar dimensions, with a particular emphasis on meeting mobility needs for people and freight, while complying with European GHG emission targets and enhancing competition.[3] It highlights the importance of wide stakeholder engagement and of integrated planning and policy-making approaches, useful process additions to the concept of sustainability. If the process elements are met, the outcome elements are more likely to be achievable.

This report sits between the two major approaches in terms of its conception of sustainable urban mobility/transport. It pursues the idea of sustainable urban mobility by identifying those qualities or impact dimensions of urban transport systems/services that are most likely to support achievement of the Brundtland conception of sustainable development. However, it also sees merit in trying to specify some absolute end-state targets that are likely to be indicative of a long term sustainable urban mobility/transport outcome, as Holden et al (2013) have done. The particular end-state conditions apply to the social and environmental dimensions, such that our conception of a sustainable urban mobility/transport is one of

[3] http://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=W68xJS0GL2NGLyT8nVwwgh7lkLbxKpvJdtm082FldXsYGsvT8pGJ!-725734022?uri=CELEX:52011DC0144. Viewed 18th December, 2014.

constrained maximization: maximising economic values/opportunities that are affected by urban mobility/transport (essentially open-ended), subject to meeting social and environmental constraints (end-state conditions). This is explored further below.

We believe that a city whose transport and land use systems support the following outcomes is likely to be sustainable long term.

1. **Increasing economic productivity**. This will increase Gross Domestic Product per capita, an imperfect indicator of human needs but one that is nonetheless widely used. The research we outline in section 2 of this report suggests that the European approach does not give sufficient importance to the role of urban transport systems in enhancing urban productivity through enhanced accessibility, supporting the economic leg of a triple bottom line approach to sustainability.
2. **Reducing ecological footprint** – in terms of the concept of passing on a stock of natural assets that will assist future generations to meet their own needs, however conceived at the time, and in accord with the Pearce (1991), Holden et al. (2013) and European Transport Ministers approaches, we see strong arguments for taking a hard line when it comes to urban transport greenhouse gas emissions, with a target set for end-state transport GHG emissions for 2050. Section 3.3 provides supporting discussion and proposes a target for Australian application.
3. **Increasing social inclusion and reducing inequality** – this is about ensuring that all residents have the opportunity to benefit from living in urban areas.[4] A trip or activity rate target can provide a feasible threshold indicator, as might a minimum transport service level that supports trip making and inclusion, as proposed in section 3.5. Recent OECD research is showing that economic productivity is assisted by more equal income distributions, connecting goals 1 and 3 (OECD 2014a).
4. **Improving health and safety outcomes.** The health dimension is dealt with in a companion report to ACOLA so is not dealt with in any detail in this paper. Safety refers primarily to accidents associated with travel. This is an area where more/less comparisons will be the norm, rather than the specification of a desired end-state (other than the aspirational target of zero accidents).
5. **Promoting intergenerational equity** – this goal is likely to be achieved if the preceding goals are met, since they are likely to support pursuit of the conditions noted by Pearce (1991) above.
6. **Engaging its communities widely** in development and delivery of land use/transport plans and policies. We see engagement as an essential ingredient in social sustainability and a matter of rights.
7. **Pursuing integrated land use/transport plans/policies** in the widest sense (e.g. across sectors, levels of government, modes, etc). This is primarily about the means of pursuing goals 1 to 5. It is included as a sustainability dimension in its own right simply because it is so fundamental to achievement.

[4] Visitor benefits are also implied but lower-order in our view.

Items 1 to 5 in this list relate to *outcome goals*, while 6 and 7 relate to *process goals* for sustainability, picking up on two areas highlighted in the EU White Paper (EU 2011).

With respect to the outcome goals, Professor Robert Cervero's view, with which we strongly agree, is that vehicle kilometres of motor vehicle travel (or VKT) is the single most powerful indicator of whether an urban land transport system is becoming more or less sustainable long term (Cervero 2014). Black (2010) expresses a similar view. VKT is a key performance indicator for some elements of the economic effectiveness of urban transport systems (e.g. congestion), environmental outcomes (e.g. greenhouse gas emissions[5] and air pollution), safety exposure (accidents), health (incidental exercise) and for energy security outcomes from land transport. It is probably least relevant as a performance indicator with respect to the social inclusion outcome goal, is only partially helpful for informing whether land use/transport systems support urban productivity (a key focus of the present paper) and says nothing about process, supporting the importance of additional sustainability performance indicators. For a quick snapshot on outcome goals, however, it is hard to beat!

1.2 Mobility, accessibility or a bit of each?

The Holden et al. (2013) paper prompts us to ask the question whether sustainable urban mobility is the best concept through which to focus attention on sustainability in urban transport or whether the focus should be more closely on accessibility? *Accessibility* is generally regarded as the ease of reaching opportunities and *mobility* as the ability to travel. Going around in circles, for example, demonstrates mobility but not accessibility! Accessibility involves both land use and transport perspectives.

A serious problem with the work of Holden et al is that, to assess performance on 'satisfying basic needs', they use the indicator of *Daily per capita travel distance by motorised transport* (with a target of 9.2 kilometres). Setting a minimum distance target is likely to clash head-on in many urban settings with the idea of increasing sustainability by reducing vehicle trip lengths, particularly via means such as developing more compact settlement patterns (e.g., as in Vancouver). More compact development can enhance accessibility (access to urban opportunities), while reducing the mobility requirement for achievement. In this regard, a compelling paper by Levine et al. (2012) supports relative priority being attached to accessibility over mobility as a transport system performance objective. They show that density is more important than speed for accessibility, whereas traditional transport planning methods have pursued speed (an indicator of mobility) as the primary measure of success. Levine et al. find that denser metropolitan areas have slower travel speeds but greater origin-destination proximity. The proximity affect dominates, such that denser areas are more accessible.

In similar vein, research on travel time budgets supports the importance of accessibility over mobility. The idea of travel time budgets dates back to Zahavi (1979) and has been further developed by Marchetti (1994). Professor Peter Stopher at the Institute of Transport and

[5] Although technological changes to reduce the carbon intensity of motorised transport are probably the single most significant requirement for lower land transport greenhouse gas emissions

Logistics Studies, University of Sydney, has recently been undertaking work on this subject in Sydney. Travel time budget research suggests that, across countries and cultures, people tend to have a certain amount of time they are willing to spend in travel. If travel speeds are improved, such as by the construction of a new road, people tend to travel further, converting savings in travel time into greater travel distances, maintaining their travel time budgets. Urban sprawl is sometimes the outcome. Partly reflecting this behavioural response, research by Duranton and Taylor (2009) shows that major urban road improvements tend to generate additional traffic almost in the same proportion as the relative expansion in the asset base – it is no surprise, then, that new or expanded freeways fill rather quickly.

A serious vulnerability with accessibility as the primary goal or purpose of urban travel policy and planning, however, is that it invites people ('experts') to specify those activities to which people should have access, as has happened in the UK accessibility planning approach. Perhaps such thinking is the reason why the EU Transport White Paper emphasizes mobility rather than accessibility (EU 2011). Stanley et al. (2010) have shown that a focus on accessibility planning may lead to neglect of social capital building activities that are important for well-being, activities that are supported by the capacity to be mobile and to make, and act on, your own travel/access decisions. Mobility is, therefore, also directly important, for what it can contribute to wellbeing.

The paper by Stone et al. (2014), as part of the ACOLA project, leans towards accessibility, as a better guide to sustainable urban transport systems/services than mobility, and so do we: while urban mobility is important, urban accessibility is somewhat more so in a sustainability setting. The pursuit of improved urban accessibility, however, should be undertaken with the clear intention to improve accessibility to a wide range of urban opportunities and with better enabling all people to engage in those opportunities that best enhance their wellbeing, implying an element of choice. This is where mobility comes in: opening up choices. In enhancing urban accessibility, care should be taken to avoid the 'tragedy of the commons': unwittingly adding to urban travel problems through supply-side initiatives that generate additional travel demand and, in so doing, frustrate achievement of what was initially intended.

1.3 Report structure

There are both macro and micro economic challenges to be confronted to improve the sustainability of Australia's urban transport systems and, more particularly, to enhance the sustainability of the cities that these systems serve. The macro challenges are primarily about responding to declining rates of urban productivity growth and the differential productivity performance between different parts of our cities, with associated equity implications. Also, there are links between urban productivity growth, transport/other community infrastructure investment and housing affordability. Section 2 of this paper explores these matters. It does so primarily by drawing on new, path-breaking research undertaken by NIEIR for Melbourne, Sydney and Brisbane, as part of the current strategic land use transport planning being done for those cities[6]. The research suggests ways to enhance urban productivity and how the benefits

[6] Dr Peter Brain is Executive Director of NIEIR and principal researcher in this work.

of this productivity growth can be shared more widely across our cities. We are not aware of any similar research having been undertaken internationally.

Section 3 presents a micro-economic focus. This is more traditional, drawing partly on a recent transport policy textbook co-written by one of us (Stopher and Stanley 2014) to highlight the wide range of market failures associated with urban transport. These market failures include the positive externalities associated with urban productivity growth, most commonly associated with the discussion of wider economic benefits, which were a contentious aspect of the debate about Melbourne's proposed East-West road link. The macro section of the report (section 2) deals with the positive productivity externality. Section 3 focuses on some of the wide range of negative external impacts commonly associated with urban transport, particularly motorized transport: congestion; greenhouse gas emissions and air pollution. Other significant negative external impacts include and noise, accidents, health, energy security, external effects of transport construction activity and pollution run-off from transport infrastructure into waterways but space constraints preclude consideration of these matters, other than via reference to comprehensive road pricing reform. We also consider some economic aspects of social inclusion as it relates to urban transport, an issue that has externality components but also reflects market failures arising from the absence of traded market values and has distributional implications (Stopher and Stanley 2014). Section 4 draws out implications for Australian cities from the preceding chapters

2. Macro-economic perspectives

2.1 Some urban economic challenges

Productivity growth

Sluggish productivity growth (OECD 2014b) is a major concern for many developed countries. Table 2.1, for example, shows how growth in multi-factor productivity has slowed in Australia, Canada, the UK and the US over the past two decades. While the global financial crisis contributed to the poor results over 2007-2012, multi-factor productivity growth rates were declining in all four countries shown before the GFC hit. It is beyond the scope of the present paper to explore reasons why productivity growth has slowed but it remains ironic that this has happened at the same time that the relative significance of knowledge economy-based sectors and occupations is widely regarded as more important than ever before.

Table 2.1: Average annual growth in multi-factor productivity: 1995-2012 (% p.a.).

Period	Australia	Canada	UK	US
1995-2000	1.70	1.13	1.63	1.22
2001-2006	0.77	0.62	1.48	1.47
2007-2012	0.03	-0.52	-0.5*	0.83

Note: UK data for this period is for 2007 to 2011.
Source: Derived from data in OECD StatExtracts (2014a). http://stats.oecd.org/Index.aspx?DataSetCode=PDB_LV. Viewed 27th November 2014.

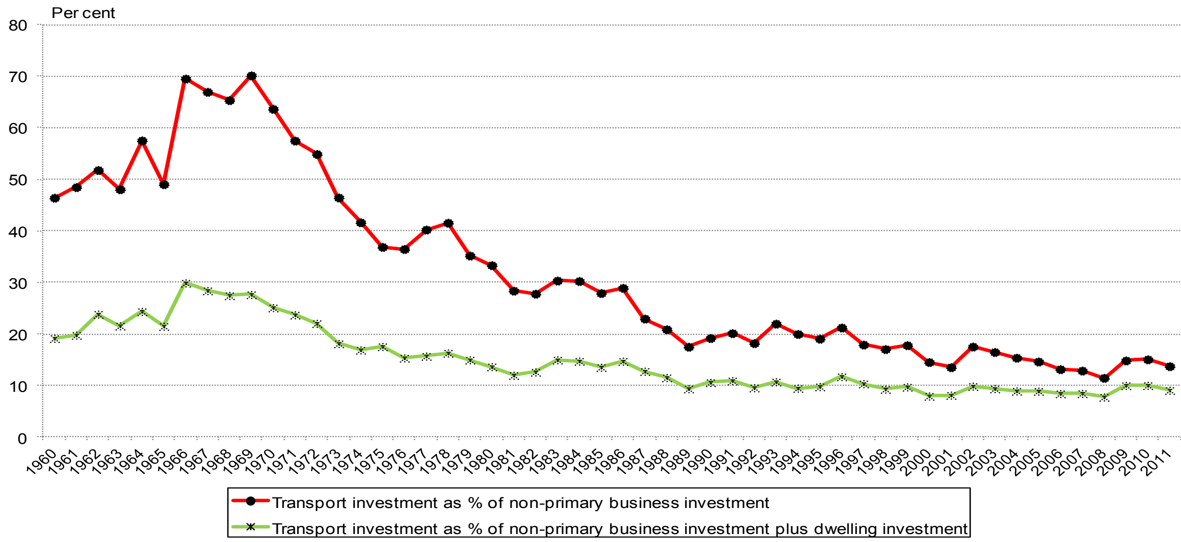
Deteriorating infrastructure condition is often noted as one possible contributory factor for a slowing in productivity growth rates, frequently linked to a declining infrastructure spending share within Gross Domestic Product. Figure 2.1 (for example) shows that, while Australian transport infrastructure spending has increased in relative terms in recent years, compared to spending on non-primary business investment and to that on non-primary business investment plus dwelling investment, it has declined substantially in relative terms over the past forty years, a time period which is reflective of the asset life of many transport assets built up over this period.

There is now an extensive body of literature that explores links between infrastructure investment and economic output (productivity). That literature generally assumes that output of the *i*th firm in the *j*th location (*Yij*) is some function of inputs of labour (*Lij*), capital (*Kij*) and inputs of other factors (*Gij*), where infrastructure (of particular types if required) can be included as one such specific input.

$$Y_{ij} = f(L_{ij}, K_{ij}, G_{ij}) \qquad (5.1)$$

Eberts (1986), for example, estimated an elasticity of output with respect to public capital stock of 0.03, suggesting that a 1 per cent increase in public capital stock will increase productivity by 0.03 per cent. Aschauer (1989) found slightly higher elasticities, as did Eberts (1990). Munnell (1990) noted that US states that invested more in infrastructure tended to have higher GDP, more positive investment and more employment growth. The issue of whether increased infrastructure causes increases in these indicator variables, or whether increases in those variables brings on a need for increased infrastructure investment, she answered by suggesting that increased public investment comes before a pick-up in economic activity.

Fig. 2.1: Transport infrastructure investment: per cent of other Australian investment (Source: NIEIR)



Conference Board of Canada (2013) has concluded that there is a robust link between the stock of infrastructure in an economy and its level of income, with a high degree of interdependence between the quality and quantity of public infrastructure and the performance (productivity) of an economy's business sector. Daley (2012) estimated that a 10 per cent increase in Australia's stock of infrastructure increases GDP by 1 per cent.

Reviewing this literature to 2009, Gwee (2010) concluded that studies generally suggest that a 1 per cent increase in public capital investment is associated with a 0.03 to 0.56 per cent increase in economic productivity (i.e., an output elasticity of 0.03 to 0.56), although some (fewer) studies suggest a weaker relationship and a few suggest higher responsiveness. It is no surprise, then, that many countries are now looking to infrastructure investment, particularly transport infrastructure, as one way to stimulate stronger productivity growth. Section 2.2 below examines how increased transport infrastructure spending in Australia might be used to drive GDP gains. Section 2.3 considers how targeting this investment within a city can be used to both support productivity growth and also to help share the benefits of this growth across a city.

Sharing the benefits of growth

Analysts such as Stiglitz (2012), Wilkinson and Pickett (2009), Picketty (2014) and OECD (2014b) have drawn attention to the problem of widening disparities in income levels within some countries, particularly the US. Wilkinson and Pickett (2009), for example, point out how the income gap between the richest and poorest 10 per cent in both the US and UK widened by about 40 per cent between the mid 70s and mid 90s. Stiglitz (2012) demonstrates that:

> 'The simple story of America is this: the rich are getting richer, the richest of the rich are getting still richer, the poor are becoming poorer and more numerous, and the middle class is being hollowed out. The incomes of the middle class are stagnating or falling, and the difference between them and the truly rich is increasing.' (Stiglitz 2012, p. 7).

Picketty (2014) shows that the top decile's share in US national income increased by over ten percentage points between the late 70s and early this century. Wilkinson and Pickett (2009) go on to suggest that reducing inequality tends to produce improved outcomes across a range of indicators, such as levels of trust, life expectancy, obesity, maths and literacy scores and homicide rates. OECD (2014b) suggests that rising inequality in the OECD over 25 years resulted in a cumulative loss of GDP at the end of the period of 8.5 per cent. With substantial proportions of national populations now living in cities, elements of the economic productivity and equity challenges summarized above can be seen at city level, as illustrated later in section 2.

2.2 Lifting Australia's rate of urban infrastructure spending

In opening the 2014 ADC Forum Infrastructure and Cities Summit, the then Secretary of the Department of Prime Minister and Cabinet, Dr. Ian Watt, suggested that $100b was an order of magnitude estimate for Australia's current infrastructure shortfall or gap (Watt 2014). Brain et al. (2014) explored the question of the size of this gap in some detail, together with the prospective productivity implications of reducing or removing it. For Australia, private capital investment appears to be pulling its weight, while public infrastructure investment has lagged, to be the fourth lowest in OECD countries in 2008.

Brain et al. (2014) used a range of approaches to assessing Australia's infrastructure needs (e.g., bottom up; top down; regional and international best practice comparisons), their analysis suggesting that:

- the stock of Australian installed infrastructure assets in 2013 was $785 billion (2012 prices), compared to $219 billion in 1971 (if water and sewerage assets are included, the 2013 stock became $888 billion)
- in 2013, a quarter of the infrastructure assets were in social capital, a quarter in community capital, 13 per cent in communications infrastructure and 36 per cent in transport
- the transport infrastructure capital stock, as a share of the total, had fallen significantly since the late 1970s , with a very large fall in the ratio of transport infrastructure to non-mining business capital stock (shown in Figure 2.1 above). At the national level the ratio was 26 per cent for the 1971-1988 period but only 18 per cent in 2013. Across the States, they concluded that the fall was greatest in Victoria.

Using a production function-based approach, Brain et al (2014) found that a 10 per cent increase in infrastructure capital stock leads to a 1 per cent per annum increase in GDP. However, if the increase is concentrated in transport infrastructure, where the data suggests a significant backlog has developed, then the increase in GDP is twice as large. For the major states, the marginal productivity of transport infrastructure spending was estimated to be higher than that from investment to grow the business capital stock, because of the accumulated transport infrastructure backlog.

Regional infrastructure shortfalls were estimated by Brain et al. (2014), based on a comparison with the investment performance of the two regions they rated as 'best practice'. For urban areas, that analysis suggested an infrastructure shortfall of over $50b in each of Sydney and Melbourne, with a small shortfall in Brisbane and Adelaide, relative to best practice. The national gap was estimated at $145b by this approach. Strong growth in Gross Regional Product was estimated from the removal of the gap (Table 2.2). It should be noted that rating Perth as a best practice benchmark does not mean that this city does not also have transport infrastructure backlogs, which would increase the estimated investment requirements from Table 2.2.

If international (rather than domestic) benchmarks are used to estimate Australia's infrastructure shortfall, the shortfall in Australian general government capital stock was again estimated by Brain et al. at around $150b. Over the period during which an infrastructure gap might be removed, additional infrastructure requirements will arise, Brain et al. estimating the economic impact of removing an Australian infrastructure backlog of about $150b, and also of preventing the development of a further backlog to 2025. This was estimated to require, in total, an additional $346b infrastructure spend over the period to 2025. This spending was forecast to lead to a continuing $75b annual gain in non-mining, non-community services gross product (NMNCGP) at factor cost.

An additional ~$350b infrastructure investment effort over the next 12 years amounts to an additional average annual investment spend of around $28 billion, or approximately $22 billion in local content. Brain et al. estimated that this additional investment effort would be sufficient to both neutralize the GDP effect of the decline in mining investment, adjusted for local content, and also of foreshadowed manufacturing output losses. A strong conclusion of their analysis was that, if additional infrastructure investment is allocated on the basis of tackling existing regional shortfalls, then the marginal product is likely to mean that the requisite financing would be self-funding, in terms of repaying all financing costs as well as maintaining the assets over relevant economic lives. This would only be the case, in practice, if the Federal Government returned all tax revenue generated from state or local government expenditures to the spending authority (a form of Tax Increment Financing). The current historically low interest rates on ten-year government bonds suggest that now is a good time to be investing in well chosen infrastructure initiatives.

Table 2.2 Regional analysis: Infrastructure shortfall ($2012b)

	Total shortfall 2012	Indicative increase in GRP 2012
Sydney	54.4	27.2
NSW non-metropolitan	6.6	3.3
Melbourne	52.9	26.5
VIC non-metropolitan	8.5	4.2
South East Queensland	3.1	1.6
Rest of Queensland	0.0	0.0
Adelaide	2.8	1.4
SA non-metropolitan	6.9	3.4
Perth	0.0	0.0
WA non-metropolitan	1.6	0.8
TAS	2.9	1.4
NT	0.0	0.0
ACT	5.1	2.6
Total	**144.8**	**72.4**

Source: NIEIR

2.3 Using urban transport investment to support productive structural economic trends and share the benefits of productivity growth

The analysis reported in section 2.2 is encouraging. It shows that tackling Australia's infrastructure backlog has the potential to deliver significant productivity benefits, increasing GDP growth by about 0.3 per cent p.a. if undertaken at the appropriate scale and with well chosen projects. It further shows that the revenue gains to government from a carefully managed infrastructure stimulus are potentially capable of funding, over the long term, the relevant infrastructure expansion. Governments may still, of course, prefer to use 'beneficiary pays' approaches, particularly user charges and value capture, to fund all or part of the relevant infrastructure expansion, a position that many (ourselves included) would regard as fair.

To help ensure such productivity and associated funding outcomes are achieved, it is necessary to understand (inter alia) how a city/region can best invest in its infrastructure base to capture the potential benefits. This is about project selection. In this regard, important research by Dr Peter Brain and colleagues at NIEIR, summarized below for Sydney and Melbourne, is showing how understanding of the way structural economic changes are affecting urban development patterns can be used to inform project selection to support economically desired structural changes. This interest has particularly concentrated on land use transport policy and planning implications of growth in the knowledge (high-tech) economy (defined in Appendix A1). The findings can contribute to outcome achievement on two of the components of the triple bottom line, by respectively boosting productivity growth and enabling the sharing of benefits of this productivity growth more broadly amongst urban residents.

The following economic and social performance indicators are suggested for assessing urban land use transport policies and plans in terms of their macro-economic impacts:

Economic

(i) The overall level of economic activity as measured by gross regional product per working age resident

(ii) The overall level of economic activity as measured by gross regional product per hour worked

Social

(iii) Convergence in the level of hours worked per working age population across the city

(iv) Convergence in dollars earned per hour worked by residents across the city.

Appendix A briefly describes the data used in the NIEIR analysis reported below and the treatment of LGA catchments. Table 2.3 sets out the 12 'rules of regional economic development' that have emerged from detailed analysis of structural economic change in Melbourne and Sydney, which have been corroborated by subsequent work in Brisbane (not reported below), together with supporting evidence in graphical format.

Table 2.3 The 'rules of economic development' in Melbourne and Sydney		
MACRO RULES	**Empirical tests**	**Context**
1. There is increasing inequity in regional economic performance, with fringe areas at an increasing disadvantage. That is, without strong policy intervention increasing inequality is expected, with the general rule being the greater the distance a sub-region is from the central LGA (of the City of Melbourne or Sydney), the greater the increase in inequality.	Assessment of the changes in resident gross regional product per capita and access to hours of employment and productivity in terms of $/hour of gross product. Figures 2.2(a)(b) show that the greater the distance from the central LGA the less the growth in per capita household real incomes and, therefore, declining access to high productivity employment and, in some cases, declining access to hours of work. Figs 2.3(a)(b) show that the productivity gap has been widening between inner and outer areas over the last 20 years.	The empirical validity of this rule is essential to justify the regional development policies. If this rule was not empirically valid, overall planning outcomes would be independent of where resources were distributed across the regions. For example, this would be the case if residents of all regions could reach all others within a reasonable travel time budget.

Figure 2.2(a): Sydney: Local GRP (residents) at factor cost per working age population, deviation in per cent of mean from 1992 to 2012

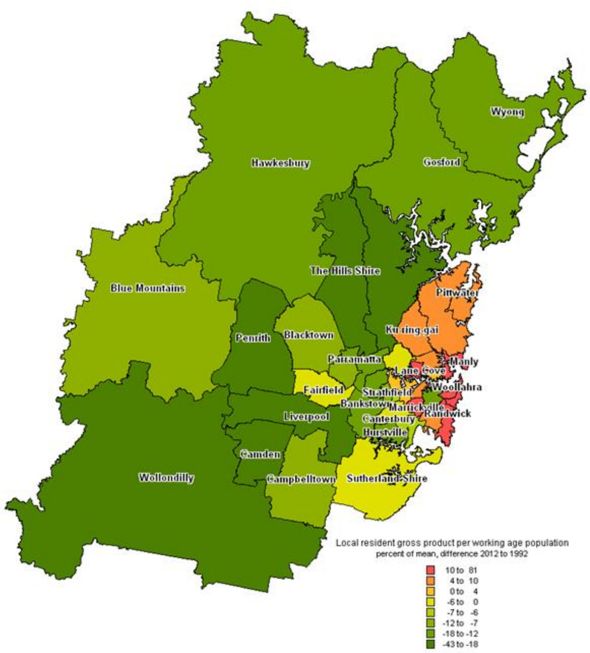


Figure 2.2(b): Melbourne: Local GRP (residents) at factor cost per working age population, deviation in per cent of mean from 1992 to 2012.

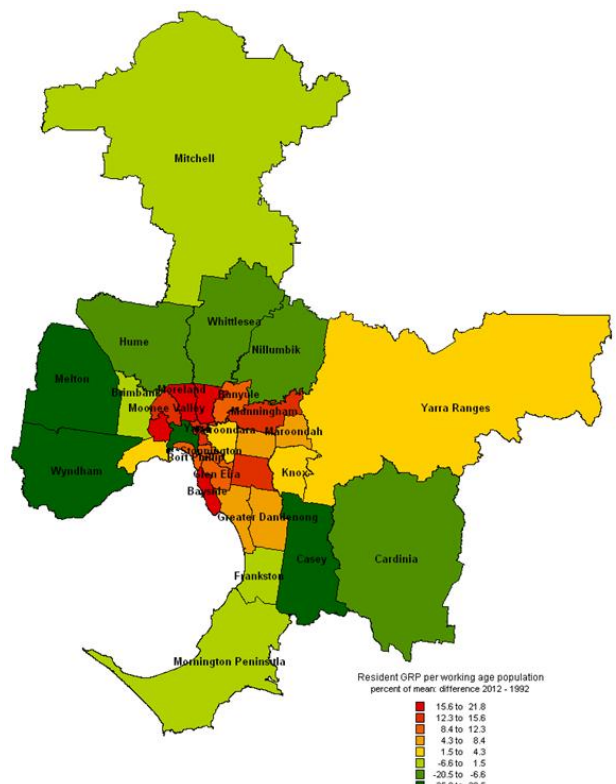


Figure 2.3(a): Sydney: Change in deviation about the mean 1992 to 2012 for headline GRP per hour worked

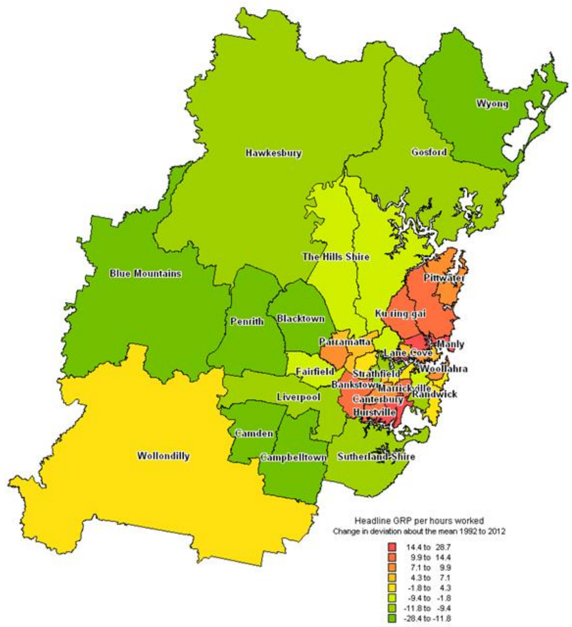
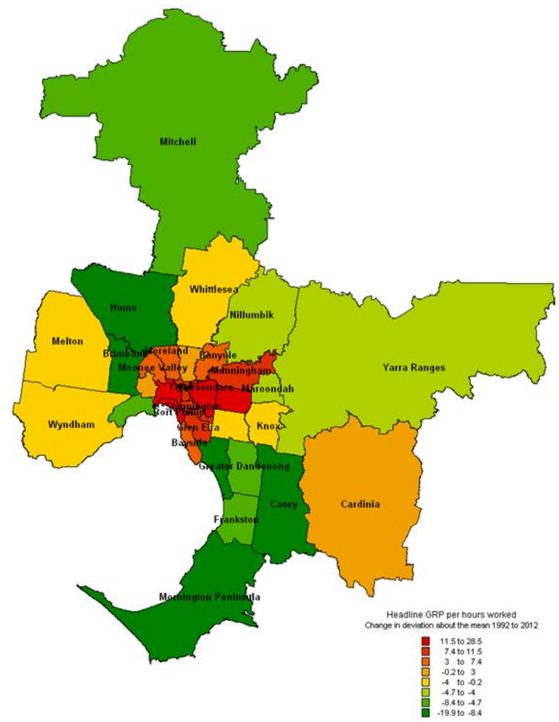


Figure 2.3(b): Melbourne: Change in deviation about the mean 1992 to 2012 for headline GRP per hour worked



2. The greater the level of economic activity located within a region's catchment, the greater the economic benefit to residents within the catchment. That is, the level of income received by a region's households from work is determined by the level of economic activity generated in the region's catchment, as determined by acceptable travel times.	The relationship between industry economic activity and resident economic activity. If the two are highly correlated the rule is validated. Figures 2.4 show the correlation holds.	If this rule is not empirically valid, there would be no point in attempting to allocate investment to specific regions since this would be ineffective in stimulating economic activity in the targeted regions. If resident employment is deficient in a given sub-region, then the solution is to either increase employment opportunities within the catchment of the LGA or alternatively widen the catchment size by reducing travel time.

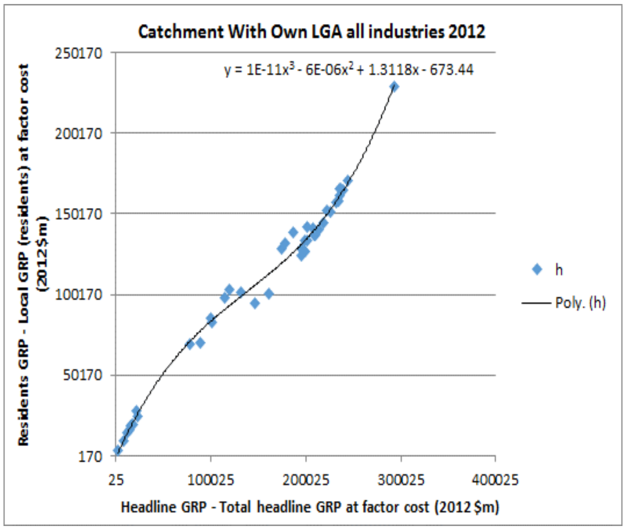
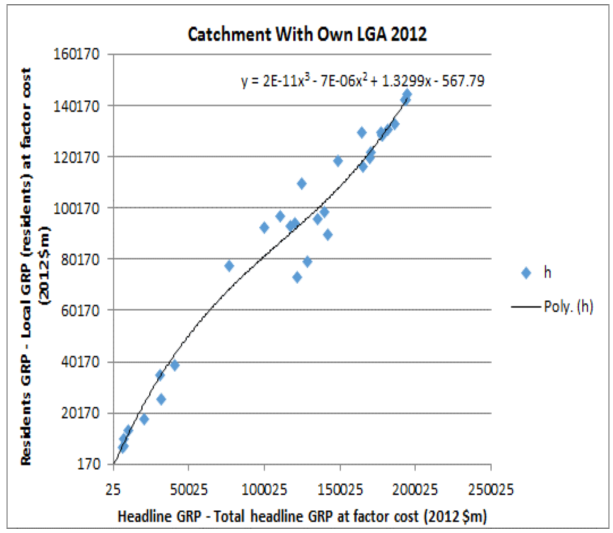
<table>
<tr><td colspan="2">Figure 2.4(a): Sydney: Headline GRP versus resident GRP – Catchment analysis</td><td>Figure 2.4(b): Melbourne: Headline GRP versus resident GRP – Catchment analysis</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td>3. Cumulative regional investment, that is, the capital stock per capita installed in a region, is a core fundamental factor that determines the level of economic activity.</td><td>Calculate the correlation between regional capital stock installed and regional economic activity.
Figures 2.5 clearly show the strong relationship between construction capital stock installed in a catchment and the catchment level of economic activity. The relationship approach is a one-to-one relationship. That is, a dollar increase in capital stock generates a similar annual increase in economic activity. The incremental output-capital ratio would fall to between 0.6 and 0.8 if equipment capital stock is allowed for.</td><td>The empirical validity of this rule indicates the high effectiveness of planning instruments and, therefore, planning. An important planning instrument is to allocate public sector capital directly to regions, using this to influence private sector investment decisions.</td></tr>
</table>

Figure 2.5(a): Sydney: Capital stock versus economic activity – 2012
Catchment outcomes on both axes

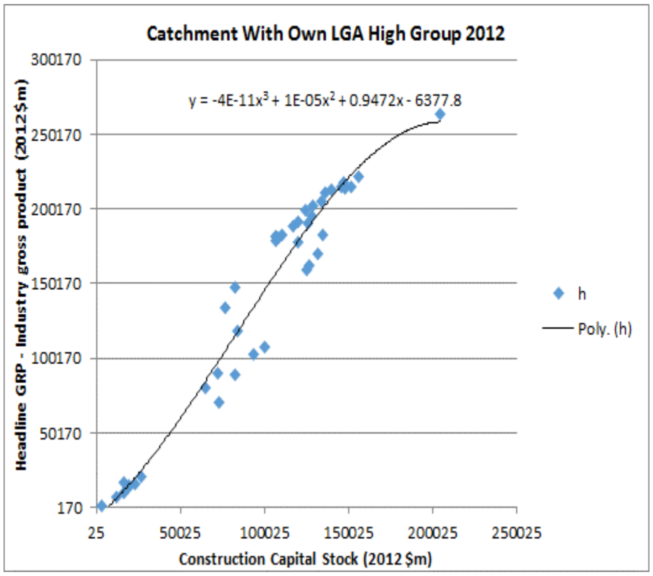
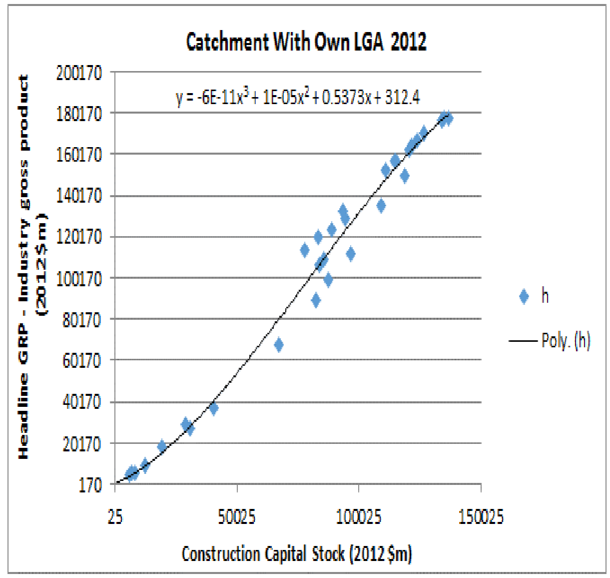
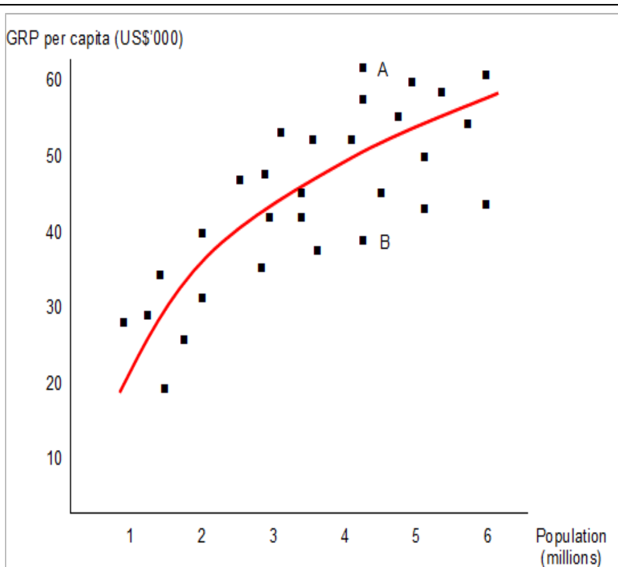


Figure 2.5(b): Melbourne: Headline GRP versus resident GRP – Catchment analysis



4. Increased scale of the Metropolitan Area will increase the opportunities to increase overall productivity.	The empirical relationship between metropolitan-wide productivity and scale compared to other cities, shown in Figure 2.6 for international cities and Figure 2.7 for Australian cities, indicates a strong relationship. That is, economies of scale and scope are strong as city size increases.	This rule is for reference as a reminder that, once economic activity is established, it will only be sustained if the competitiveness of the region, compared to the rest of the world, is sustained.

Figure 2.6: The relationship between city scale and productivity



Source: Adopted from Figure A.3.1 in OECD "*Competitive Cities in the Global Economy*", 2007, p. 277 using the cluster of the Developed Country Cities.

Figure 2.7: The relationship between region size and productivity is as relevant for Australia as it is for the world for non-resource based cities

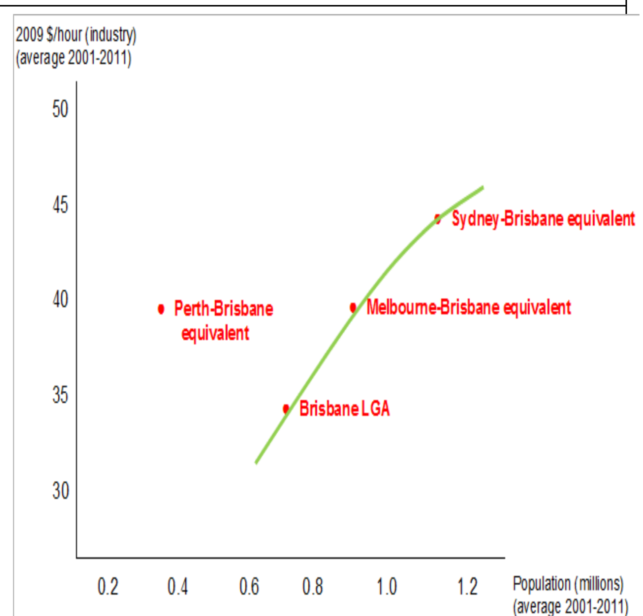


Table 2.3 The ‘rules of economic development’ in Melbourne and Sydney (continued)		
MACRO RULES	**Empirical tests**	**Context**
5. If the metropolitan area of a major city is to maximise the increase in its productivity, the scale of the central region will have to increase, at the very least proportionally to the overall increase in Metropolitan scale.	From Figure sets 2.8 and 2.9 the Central City LGAs have the highest productivity, as generally do the LGAs closer to the Central City LGA. Also, the Central City region in both cities is by far the most important in generating export activity, the core proximate driver of growth.	The importance of this rule is for plan design. If the rule is valid, mechanisms in the plan design to allocate economic activity closer to the fringe regions must not undermine the growth in the central region. This is necessary if the metropolitan area as a whole is to maximise its economic performance. The impact of this on plan design would be via the establishment of a minimum threshold level of central region contribution to metropolitan activity. Above this threshold level any further increases in the central region’s share may well be at the cost of metropolis-wide economic performance.

Figure 2.8(a): Sydney: Productivity versus travel time to Central Sydney in minutes – Individual LGA – 2012

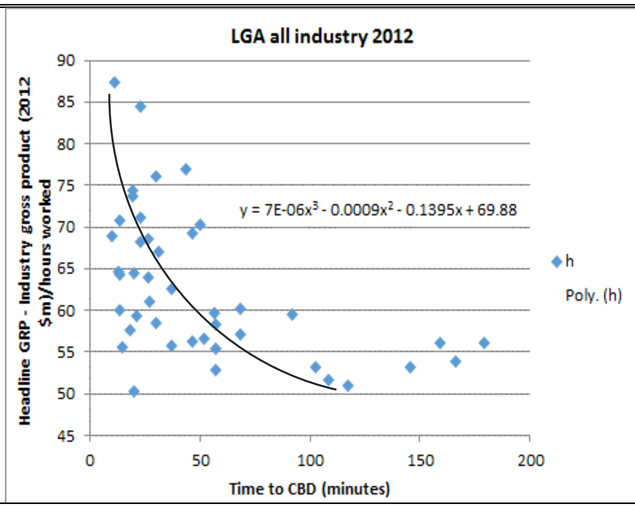


Figure 2.8(b): Melbourne: Productivity versus travel time to Central Melbourne in minutes – Individual LGA –

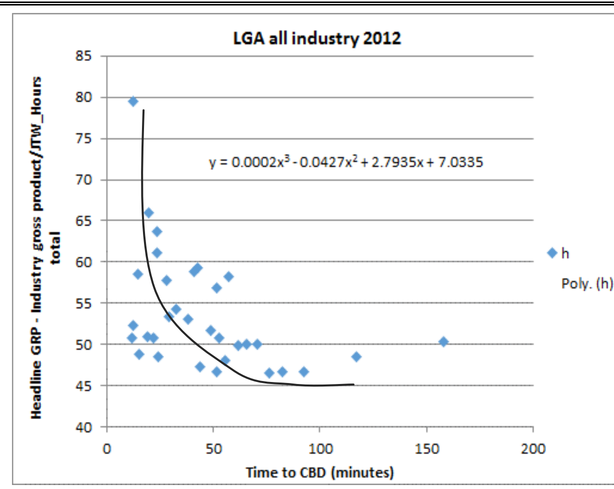


Figure 2.9(a): Sydney: High technology productivity versus travel time to Central Sydney in minutes – Individual LGA – 2012

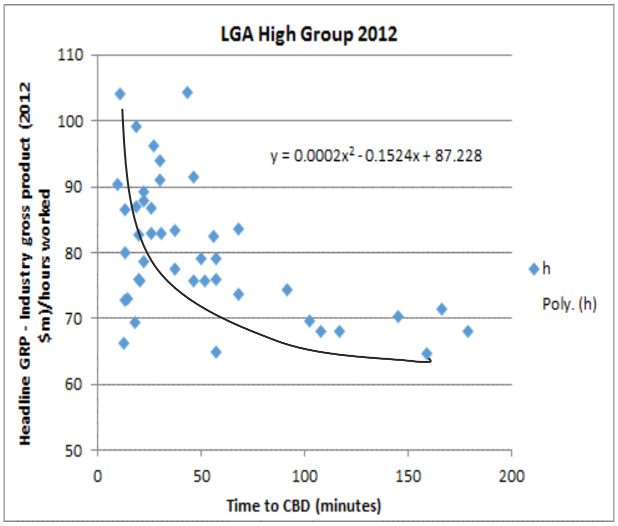
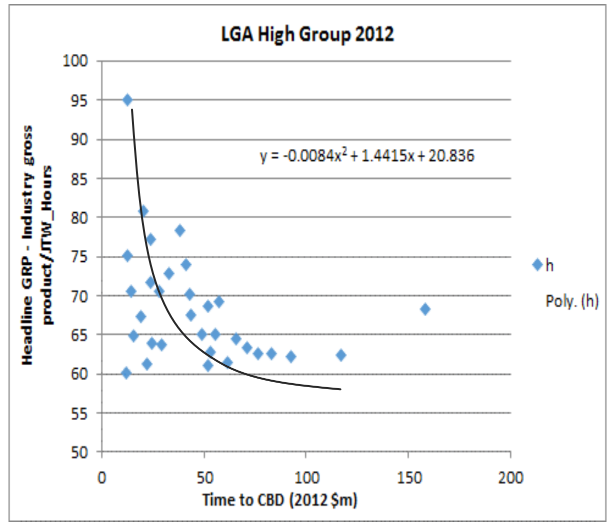


Figure 2.9(b): Melbourne: High technology productivity versus travel time to Central Melbourne in minutes – Individual LGA – 2012



6. The capacity to export out of a region is the core proximate driver of economic activity.	The correlation between exports and economic activity. This is clearly demonstrated by Figure sets 2.10. The strong relationship also holds even when the Central City regions are excluded (chart not included).	The validity of this rule is important to the legitimacy of the planning philosophy. If it was not valid, then local demand formation, not planning strategies, would be the main mechanism of determining regional development.

Figure 2.10(a): Sydney: Region's export share versus gross product share (per cent) – 2012

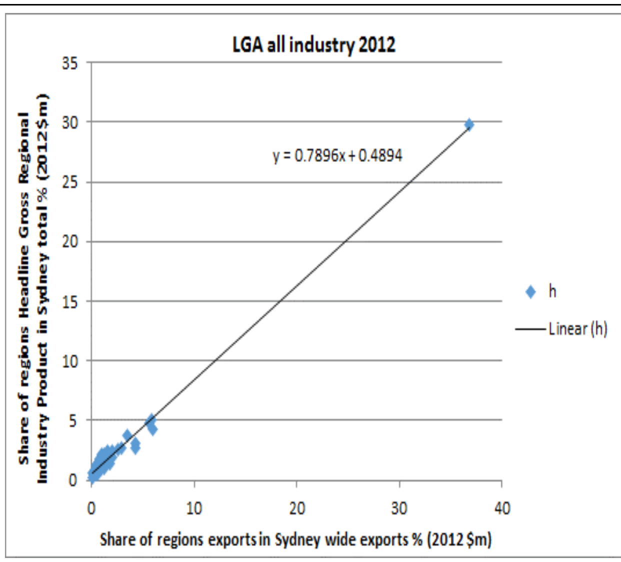
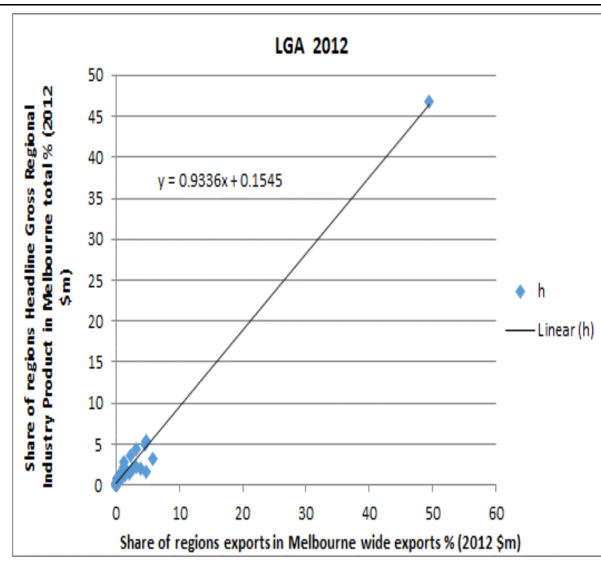


Figure 2.10(b): Melbourne: Region's export share versus gross product share (per cent) – 2012



7. The skills of households within each region's catchment is a core driver of the region's economic performance.	The relationship between the regional concentration of high skilled households and economic performance. As Figures 2.11 demonstrate, compared to Figures 2.12, the relationship is particularly strong for high technology industry activity.	Improving economic outcomes for residents in part requires increasing the skilled household share. If this rule was not valid, then, like Rule 1, the strategy could be relatively ineffective in channelling enhanced economic activity in each region into resident benefits. More importantly, if skilled residents are not willing to move into the labour market catchments of developing high technology clusters it will be difficult to exploit economies of scale and scope to improve living standards.

Figure 2.11(a): Sydney: Regional resident economic performance and skills within catchment

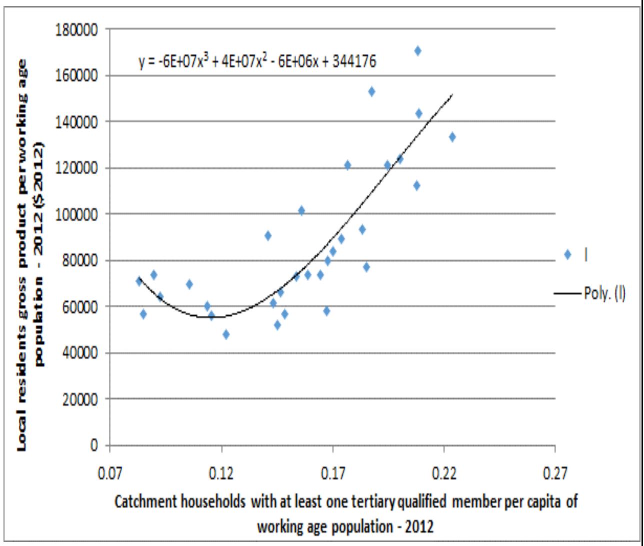


Figure 2.11(b): Melbourne: Regional resident economic performance and skills within catchment

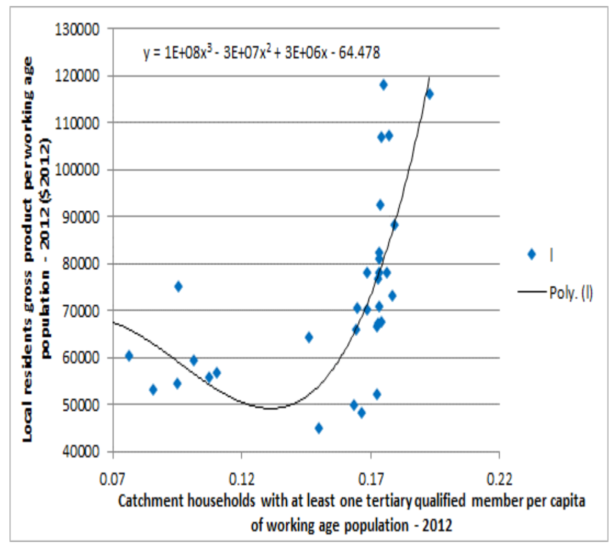


Figure 2.12(a): Sydney: Catchment skilled household availability versus high technology industry activity

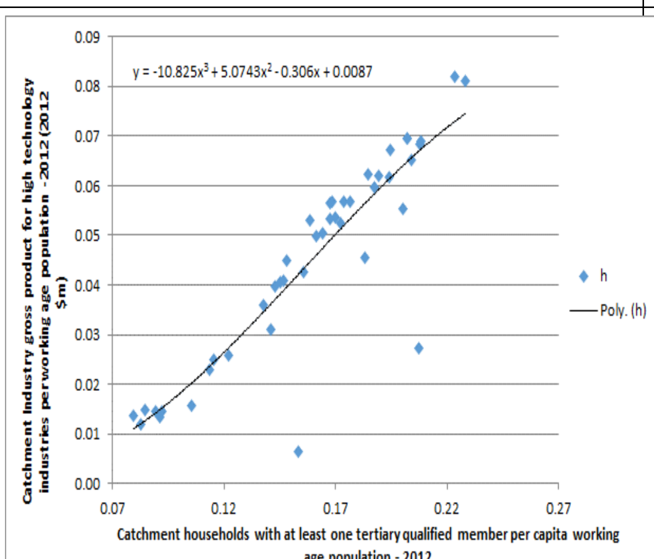
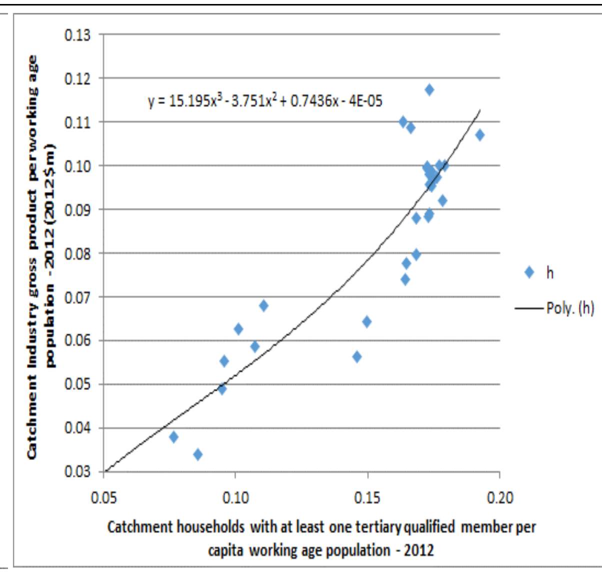


Figure 2.12(b): Melbourne: Catchment skilled household availability versus high technology industry activity



8. Different industry types have different multipliers (or flow-on impacts) for expansion. Here the rule is that high-technology industries have the largest multipliers and, therefore, the greater the concentration of high-technology industry in a region the better the relative economic performance.	The relationship between the economic performance of a region and high-technology industry concentration. Figures 2.13 show that, if high income employment is to be accessed, residents must have good access to high technology industry employment. Over the 1992 to 2012 period, there is a reasonably strong relationship between the high technology industry employment share in the change in hours of work (chart not shown).	If high-technology industry concentration was not associated with superior regional economic performance there would be no point in targeting high-technology industry to improve economic performance.

Figure 2.13(a): Sydney: Local gross resident product versus high technology employment share – 2012

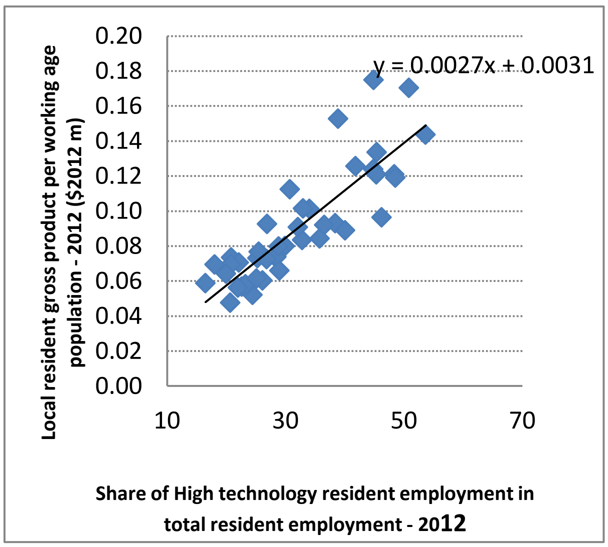
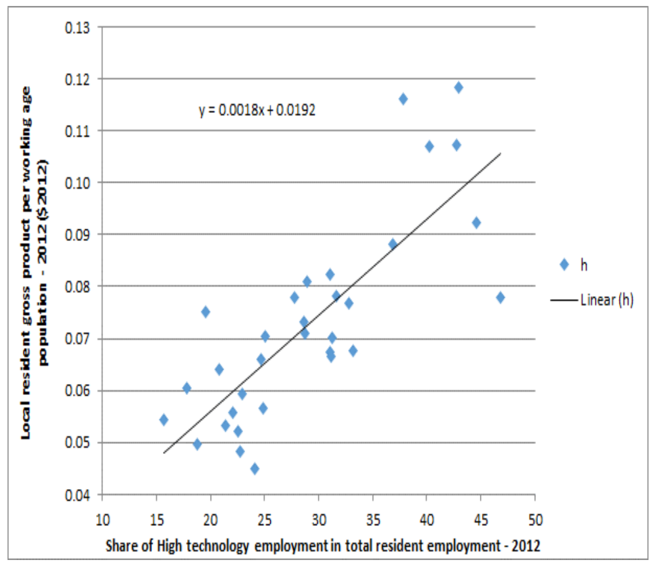


Figure 2.13(b): Melbourne: Local gross resident product versus high technology employment share – 2012



9. High-technology industries require the concentration of high-skilled households within their labour market catchments.	The relationship between household skills available within a labour market catchment of a region and the concentration of high technology industry. This is indicated by the strong empirical relationships shown in Figures 2.14.	This rule is complementary to Rule 7. If Rule 7 is valid, then the validity of Rule 9 would indicate that the mechanism to improve the concentration of skilled households in a region is to encourage high-technology industry activity within the labour market catchment.

Figure 2.14(a): Sydney: Catchment skilled household availability versus high technology industry activity

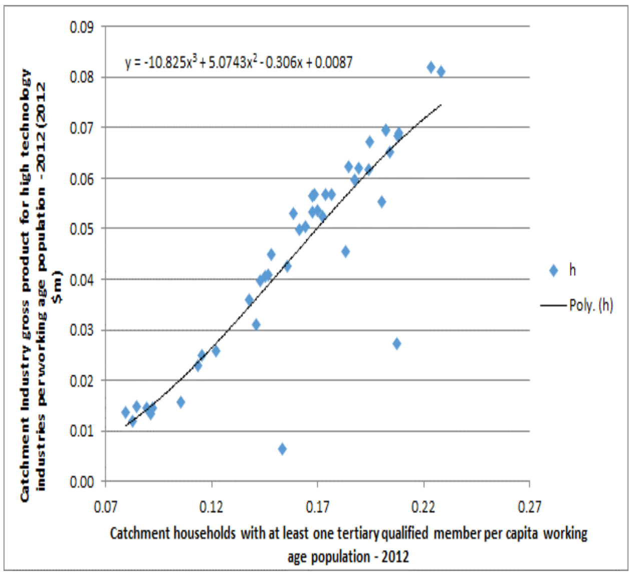


Figure 2.14(b): Melbourne: Catchment skilled household availability versus high technology industry activity

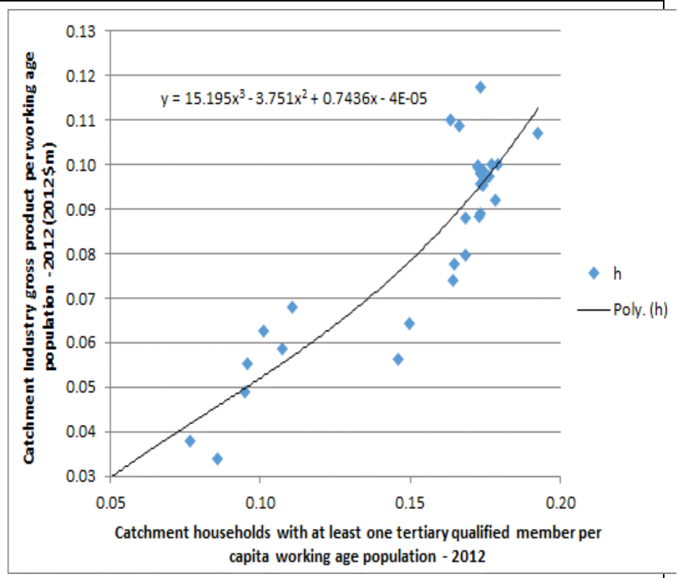


Table 2.3 The 'rules of economic development' in Melbourne and Sydney (continued)

MICRO RULES	Empirical tests	Context
10. The main reason why high-technology industries have high multipliers is the importance of scale and scope to productivity in these industries and hence profitability and the capacity to expand. Therefore, the rule is the greater the scale of high technology industries the greater will be the productivity.	The relationship between high-technology scale in a region and its productivity. The positive relationship between productivity in scale is particularly strong for high technology industries as Figures 2.15 indicate. It is also strong for all industries (chart not shown)	Rule 10 complements Rule 8. The validity of Rule 8 would help to establish that high technology industries have relatively high multipliers. The validity of Rule 10 would reinforce evidence that this is the case by establishing a link between the expansion of high-technology industry and increases in the productivity and profitability of other, and in particular high technology, enterprises within the region and surrounding regions.

Figure 2.15(a): Sydney: Productivity versus scale -2012 High technology industries – Catchment on both axes

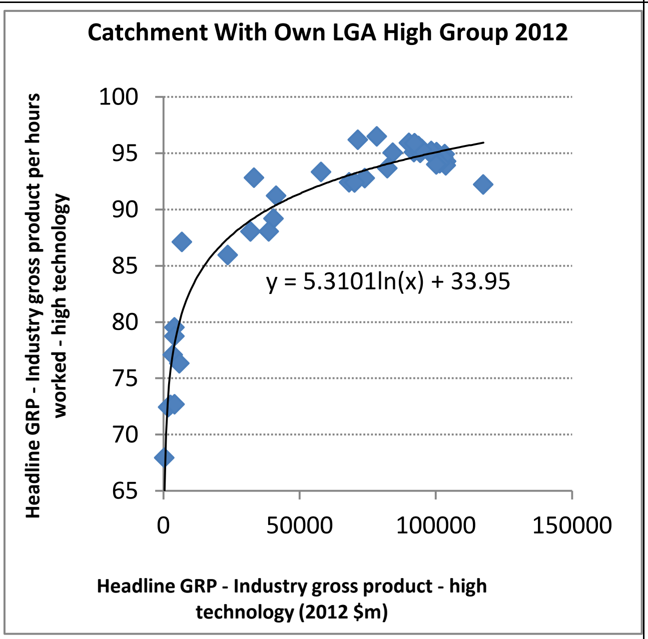
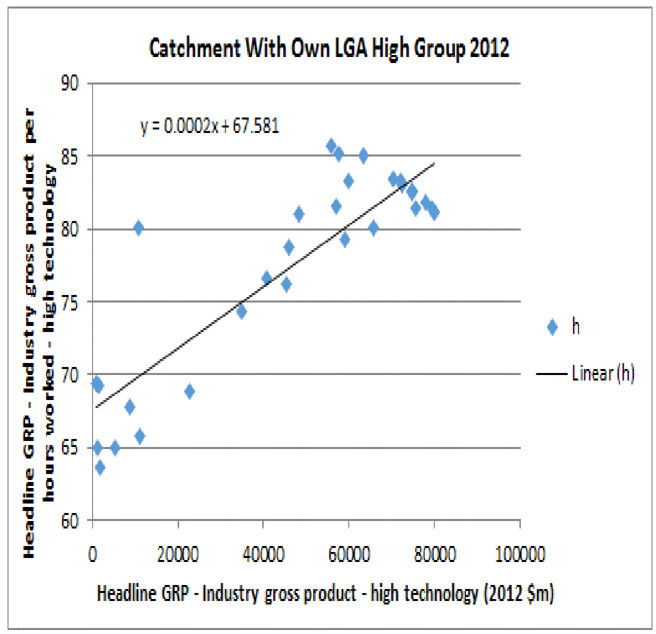


Figure 2.15(b): Melbourne: Productivity versus scale - 2012 High technology industries – Catchment on both axes



MICRO RULES	Empirical tests	Context
11. High-technology industries need to cluster in and between regions. Hence, the rule is that the share of high-technology industry in a region's economic activity diminishes with distance from the central activity areas of Australia's major metropolitan areas.	The relationship between the distance of a region from the central activity area of major metropolitan regions such as Sydney and Melbourne and industry productivity. Figures 2.8 and 2.9 above showed that this is strong for both all industries and high technology industries. The closer to the central region the higher the productivity.	The comments to Rule 10 apply. If economies of scale and scope were not important in high-technology production the multiplier associated with these industries would be similar to low and medium technology industry clusters and there would be no argument against forcing high-technology industries to be distributed fairly equally across the metropolis. The empirical validity of the rule is also important in justifying a central premise of Melbourne's planning strategy, that an important, and perhaps difficult, task of developing the Plan is to ensure that decentralising high-technology industry

		further from central regions should be encouraged and resourced in a way that does not undermine the benefits from the continued development of existing high-technology industry clusters.
12. High technology industries require sustained innovation to be competitive. High-technology industries will prefer to locate where there is strong knowledge-creation infrastructure within a region's catchment.	The correlation between high-technology industry concentration and the availability of tertiary education, advanced health and advanced business services. This strong correlation is evidenced by Figure set 2.16.	Rule 12 is important for the application of policy instruments. The location of supporting knowledge creation infrastructure involves resource allocation decisions which are under the direct control of the public sector. Given the validity of Rule 12, resource allocation decisions for knowledge-creation infrastructure (e.g., where universities, hospitals, research institutions are placed and their rate of expansion) can help facilitate the concentration of high technology industry activity within a region and therefore determine which regions will have superior economic performance outcomes.

Figure 2.16(a): Sydney: High technology industry activity versus knowledge creation industry capacity – 2012

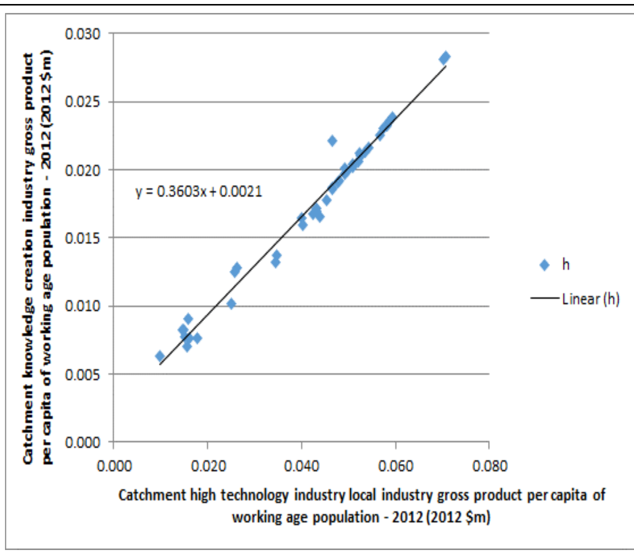
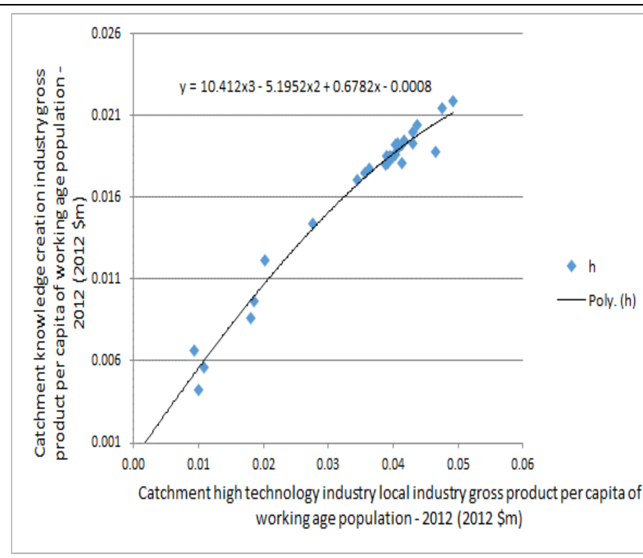


Figure 2.16(b): Melbourne: High technology industry activity versus knowledge creation industry capacity – 2012



13. Skilled households locate in regions where strong cultural and community infrastructure is available within the region's catchment. The thesis is that high-technology industry has to locate within the catchment of where high-skilled households want to reside.	The correlation between community and cultural infrastructure services and the regional concentration of skilled households. This strong correlation is evidenced by Figure set 2.17.	If Rule 13 is valid, it indicates that the instruments of Plan implementation, to the extent that they influence the distribution of community (health, education) and cultural (entertainment, recreation) infrastructure services, can also influence the location and scale of high-technology industries. The rule relates to the ability of Plan implementation to impact on a Planning Area's economic performance.

Figure 2.17(a): Sydney: Skilled household availability versus community and cultural service availability

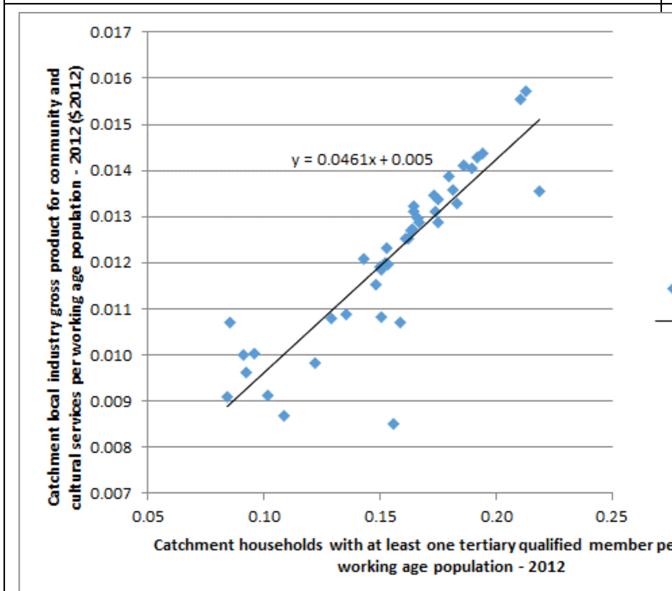
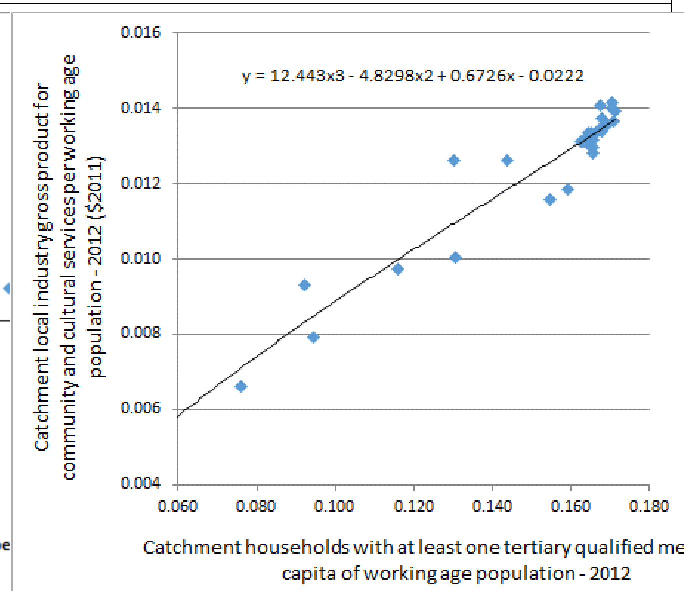


Figure 2.17(b): Melbourne: Skilled household availability versus community and cultural service availability



A summary of the empirical results and inferences from the rules set out in Table 2.2 is as follows.

(i) In the absence of intervention there is a tendency for increasing inequality between regions, especially between fringe regions and regions closer to the centre.

(ii) The scale of the metropolitan region, either as measured by population size or the scale of labour market/economic catchment of individual sub-regions, as determined by travel times, is a key driver of productivity and the ability of residents to capture hours of work.

(iii) Some industries are more important and effective, per $m value-added, in driving regional economic development than others. High technology industries have particular importance, in part because of the importance of economies of scale and scope in driving productivity and profitability and in part because they are innovation-intensive industries, whose innovations tend to benefit a much wider circle of firms and industries than just the businesses undertaking the initial innovation, including firms in other industry sectors.

(iv) Because of the importance of economies of scale and scope and the indirect benefits which can be captured from innovation by others, high technology firms want to cluster together, either in the central region or in regions not too far from the central region.

(v) As a result, if the outer fringe regions have poor economic outcomes in terms of hours of work available per working age resident and/or dollars earned per hour of work, one important reason for this would be a lack of high-technology employment opportunities within the labour market catchments.

(vi) If (v) is empirically valid, a plausible strategy to improve the economic performance of outer regions would be to enhance and expand high value add employment precincts within commuting range of these regions, and/or increasing catchment diversity, by reducing travel times and/or increasing catchment population densities (especially in those catchments with the best characteristics in terms of scale and high technology industry activity).

(vii) The enhancement of high-technology industry capacity further away from the central area must not come by redistributing activity away from existing or developing precincts. Compared to major cities overseas, the existing high-technology clusters found in Australian cities are of a relatively small scale. It is therefore important that existing clusters, including the central region, must be encouraged to expand as fast as is feasible.

(viii) A core task of policy and implementation is therefore to implement strategies that will enhance the development of high-technology clusters in the middle and outer regions with net additional resources that do not detract from the growth at the centre.

(ix) For the rules to work, capital expenditure is the enabler that is necessary to realise the benefits of economies of scale and scope. There is a one-to-one relationship between the capital stock in place and the level of economic activity.

The ‘rules of regional development’ are at their strongest when applied at the disaggregated industry level and, in particular, at the high technology industry level, which are the core drivers of regional growth. In 1992 the share of high technology industry value added at factor cost in total all industry value added was 35 per cent in Sydney, which increased to 43 per cent by 2012. The corresponding figures for Melbourne were 34 and 41 per cent respectively. This means that high technology industry directly explained 52 per cent of total Sydney industry growth (that is, excluding dwelling surplus) between 1992 and 2012. Assuming a modest multiplier impact from high technology industry activity, in terms of spillover benefits on medium and low technology industry, the total impact of Sydney’s high technology industry growth between 1992 and 2012 would account for nearly 70 per cent of the Sydney metropolitan area’s total growth.

It is a similar outcome for Melbourne, where high technology industry employment growth explained 46 per cent of total regional growth between 1992 and 2012. This increases to over 60 per cent allowing for modest multiplier impacts.

2.4 The changing role of policy and the importance of high technology industries

For much of the 20th century, planning centred upon the following two concepts:

(i) an adequate supply of land should be set aside in fringe regions to accommodate the transfer of manufacturing and logistics industries from inner regions, as well as investment in new capacity to meet fringe area supply requirements

(ii) investment in transport infrastructure, to connect the new industrial and commercial precincts efficiently to the existing sea ports, airports and transport links to other regions in Australia.

Success, or otherwise, in planning for desired outcomes in this era was affected by over- or under-prediction of population growth, understanding about where newly-created households would want to live and/or the under-provision of adequate supporting infrastructure. Since the 1990s, however, dramatic changes to the drivers of local economic success have changed the way that planning can achieve desired outcomes. With the internationalization of production, broad technological change and the rise of digital technologies have altered the rules of success. Today's local economies are defined by their capacity to generate globally and regionally competitive goods and services and to attract highly skilled workers capable of creating and generating high value outputs. Technological competitiveness is essential and, by definition, high technology industries are industries where technological competitiveness is essential. Planning today requires a focus on supporting, directly or indirectly, this employment-creation opportunity.

The local capacity to create high value, knowledge intensive goods and services that are able to export and/or out-compete imports in local markets is a primary driver of local prosperity. The growth of such industries depends on:

- labour catchment reach, with catchment size determined by the quality and quantity of installed transport infrastructure and catchment yield determined by the skilled households within the catchment
- supporting skills creation and knowledge creation in the catchment (universities, training, research, quality business services)
- the scale and scope of nearby supporting general goods and services industries
- the quality and quantity of supporting commercial infrastructure
- the diversity of life-style and cultural choice to ensure the long-term commitment of highly skilled workers to the labour market catchment, and
- global connections, both for the export of the product and the maintenance of the knowledge base that goes into continued product development.

The planning instruments by which increases in exports may be pursued include:

- transport infrastructure, especially as it affects labour catchment size for a given region
- government allocated high-technology industry capacity (health, education, research), and
- investment in the skills of the workforce.

2.5 The characteristics of high technology industries that explain the rules

Three points stand out.

(i) The probability of successful innovation depends on the cumulative experience and interactions between personnel relevant to the knowledge-creation process required for successful innovation. The greater the number and variety of skilled personnel that can be incorporated into the knowledge creation process, the greater the probability of successful and sustained innovation.

(ii) The greater the number and variety of skills available within a given region's labour market catchment, the more likely an enterprise can optimise its skilled labour input for maximum competitiveness.

(iii) The greater the scale and scope of supporting goods and services industries, the greater the probability an enterprise will be able to select production inputs to maximise competitiveness.

At the centre of the role of high technology industries is the recognition that the multipliers that can be generated from expansion in these industries are higher than those from low and medium technology industries.

The multiplier associated with medium technology industry expansion from, for example, an increase in exports, is linked to the input-output inter-regional trade multiplier. For most regions the value of this multiplier will be between 1.1 and 1.6, depending on a region's scale, the complexity of its industrial base and the strength of its linkages with nearby regions. The full multiplier effects are realized after a limited number of years. Other than these demand impacts, there are few technological spillover impacts on other enterprises and industries from the expansion of a medium technology enterprise.

High technology enterprise expansion generates similar demand multipliers but, in addition, produces a supply response multiplier, both within the investing industry and from technological spillover impacts on other firms and industries. An internal supply response multiplier may be generated by a positive shock to cash flow (from an exogenous increase in exports), which enables the firm to devote additional resources to research and development, product innovation, skills formation, and marketing, etc., which will allow additional increases in exports, allowing further increases in competitive improvements and hence capacity installed.

Spillover impacts on other high technology enterprises in the region and nearby regions (in the economic classics, these spillovers are called 'external economies') come from the firm's expansion increasing the scale and scope of skilled labour in supporting industries and increases in the quantity and quality of the capital stock available in the region of the firm and nearby regions. This will generate an additional supply response.

The supply multiplier process is cumulative and will take place over many years. Although the multiplier is open ended, a practical rule of thumb would be that (including the demand multiplier) the total high technology industry multiplier would be between 2.5 and 4 depending on the industry of the firm, the ownership structure, the supply chain and product characteristics of the expanding enterprise, the degree of knowledge generating capacity in the nearby region, etc.

By contrast, low-technology, non-resource industries and enterprises have low export performance and largely rely on the demand multipliers generated from medium to high technology industry expansion for their sales volumes. They can be considered, effectively, as zero multiplier industries.

Planning can play a role in stimulating high-technology industry expansion, through measures such as the location of education, health, research and training infrastructure and the regional allocation of transport and community infrastructure. Transport infrastructure can play a direct role in increasing the value of the high technology industry expansion multiplier, both by underpinning exports and by increasing labour and service market catchment size, which for high technology enterprises will directly increase economies of scale and scope.

2.6 The benefits of scale – population versus connectivity

The rules clearly demonstrate that the potential for capturing the benefits from economies of scale and scope is a core driver of both employment opportunities per capita and achieving high productivity levels. From Figure 2.9, for cities of between 3 and 5 million people, a 1 per cent increase in population is associated with a 0.4 per cent increase in per capita productivity. A similar result is obtained from Figure 2.10 in the Brisbane-Melbourne-Sydney comparison, where a 1 per cent increase in population leads to a 0.5 per cent increase in real income per hour worked.[7]

However, Figure 2.9 indicates a high degree of variation for individual cities around the average schedule. This is likely to reflect different degrees of connectivity between different cities, linked to differences in the scale and quality of transport infrastructure.

From the catchment based figures supporting rule two, increasing the degree of connectivity of a metropolitan area would have the effect of pushing the catchment of each LGA up the schedule. To illustrate this point, using equations from Table 2, a 10 per cent reduction in

[7] The data in Figure 10 is adjusted for a Brisbane equivalent for Sydney and Melbourne.

travel time between all LGAs in the metropolitan area would increase weighted average gross regional product per capita of residents for Melbourne by 5.7 per cent and 3 percent for Sydney. For Melbourne, those LGAs which would experience the highest increase in economic catchment and, therefore, capture the largest benefits (to both residents and industry) from such travel time improvements are Hobsons Bay (9 per cent), Hume (7 per cent), Kingston (8 per cent), Melton (7 per cent), Nillumbik (8.4 per cent), Whittlesea (8.3 per cent) and Wyndham (8 per cent). The inner LGAs increase in economic catchment size is between 2 and 3 per cent, with the middle regions between 4 and 6 per cent.

In Sydney, the largest increase in catchment economic activity would be 8 per cent for Hawkesbury, 8.7 per cent for Hornsby, 8.6 per cent for Pittwater and 9.0 per cent for Sutherland. The middle and outer Western LGAs increase catchment economic activity by between 5 and 7 per cent.

The gain in Sydney productivity is less than that of Melbourne because of the large difference between the central region and the other regions in Sydney, evidenced by the concentration of LGAs in the middle of the schedule in Figure 2.8(a), compared to the Melbourne distribution shown in Figure 2.8(b). Thus for Sydney the reduction in travel time does not impact on the average competitiveness of the LGA's compared to the central region, as much as in Melbourne, given existing industry structure. Longer term, however, such travel time improvement may help to drive new industry development, in both cities.

Considerable sums of money would have to be spent on transport infrastructure and also on the availability of direct industry capital stock, to enable the additional potential productivity gains to be realized. These potential productivity gains will, however, provide an incentive and supportive underlying cash flow to fund the investment expansion, as suggested more generally in section 2.2. The investment that will be associated with these productivity gains will generally be in accordance with rule three, which suggests that a 1 per cent increase in regional gross product requires a 1 per cent increase in construction capital stock.

Which is the more cost effective strategy, population increase or enhanced connectivity? The prima facie answer would be connectivity enhancement, up to the point of world best practice standards, assuming availability of suitably skilled labour resources. The reason is that population increases would also require supportive expenditures on housing, social and community infrastructure. A 1 per cent increase in population for Melbourne, for example, will require between $7 and $10 billion in housing, social and community capital stock.

The most effective and efficient strategy is likely to be one that supports improved connectivity, that flows from improved transport infrastructure, with increasing population densities in inner and middle areas, supporting productivity growth from agglomeration and increasing the possibilities for infrastructure savings, by more efficient use of the infrastructure that is already installed. This needs case-by-case demonstration in individual cities to identify the most effective locations for such densification.

2.7 The benefits of extending the central region catchment

While it is clear that the rules suggest that nothing should be done to undermine the economic potential of the Central City region of our capital cities, does this infer that the growth of the Central City region should be the only focus of policy for enhanced urban productivity, as distinct from also developing some strong high technological nodes elsewhere in the metropolitan area?

One way to test the hypothesis is to use the equations from Figures 2.15, and similar equations for 'all industries' (not shown) to assess the impact on productivity of hypothetically reducing travel time to the central region. As before, we assume a 10 per cent reduction in travel time. For Sydney the all industry result is a 0.2 per cent lift in productivity, while the corresponding result for Melbourne is 0.6 per cent. These results reflect the pattern of the distribution of LGA's in Figures 2.8. The reduction in travel time is more effective in integrating the Melbourne LGA's with the central region than is the case in Sydney, in accordance with the distribution of the LGA scatter points in Figures 2.8.

On reflection, these results should not be surprising. The high technology indicators which are sensitive to distance from the central region have largely settled within the 30 minutes, or a little above, travel range, in Sydney. The assumed 10 per cent reduction in travel time is not large enough to make a significant relative difference to those industries where productivity is sensitive to distance from the central region but which are outside the critical 30+ minutes travel time. Given existing industry structure, this suggests that the major impact of reducing the travel times to the CBD, from outer areas, is to reduce the inequality of opportunity for employment opportunities for those residents who live in outer suburbs, relative to residents who live closer to the central region. The impact on productivity for those industries operating in the more remote LGAs from the central region, on the other hand, will be relatively low.

In this situation a planning solution is to develop a network of clusters of high technology industries in middle sub-regions to act as conduits to connect and strengthen industry connectivity across the entire metropolitan area. To enable the full benefits of this type of policy to be achieved, the issue of housing affordability needs to be assessed.

2.8 Housing affordability indicators for Sydney and Melbourne regions: The importance of high technology strategic node development

For sustainable housing expansion, defined as the number of houses actually built, to be sufficient to accommodate the increase in the growth in adult population and steadily reduce any backlog in the demand for housing, the following conditions need to be met:

- new house construction cost should not be significantly below the established dwelling site price
- as a long-term law, the income from work in the region's labour market catchment should be able to support the average mortgage on a newly constructed dwelling. Mortgage costs should be no more than 35 to 40 per cent of income.

If the average dwelling price for established dwellings is significantly below the new construction price, then there is limited incentive to construct new dwellings, because of the high risk of short-term capital loss. If the mortgage cost to catchment income ratio is significantly greater than 35 to 40 percent, then housing and population stock growth are likely to fall well below expected outcomes.

The Tables in Appendix A2 summarize the housing affordability position for sub-regions of Sydney and Melbourne. It should be noted that the affordability calculations are based on the long-run housing variable lending rate, not the current relatively low rate.

For inner regions (regions closer to the central region), the basic housing expansion dynamic depends on the continual inflow of new households from overseas, interstate or elsewhere in the metropolitan area, with wealth or realized capital gains or dwelling sales to offset the high mortgage cost to income ratio on new construction. This is not the case for middle or outer suburbs. In these cases, if metropolitan-wide housing shortages are not to develop, then the basic requirement is that the mortgage cost on new construction must be able to be supported by income generated from the local labour market catchment. For the Sydney sub-regional zones of Parramatta-Bankstown, Outer North and Outer West, for example, the dwelling affordability gaps are very high. For Sydney Outer West the average mortgage cost on new construction is 72 per cent of the average household incomes that can be obtained from the local labour market catchment.

The types of households that can afford to construct or buy new houses in the Sydney Outer West are households which:

- can secure relatively high paying employment within the local labour market catchment
- secure employment outside the local labour market catchment, such as the central region, and/or
- possess accumulated wealth.

Those households who do not possess these characteristics (i.e., can only obtain average to below average income employment from the local labour market catchment), will not be able to undertake new housing construction and will have to either rent, live in group households or remain with parents.

The failure of regions, such as the Outer Sydney region, to provide employment opportunities with productivity levels capable of supporting new housing construction is the key reason why, since the turn of the century, Australia has developed a significant housing shortage. Estimates vary, but based on the 2011 estimates of the National Housing Supply Council, the shortage is currently at around 300,000.

For Melbourne's outer suburbs, the housing affordability gap is less than Sydney's but, in some sub-regions, is still imposing severe constraints on affordability. For Melbourne Eastern Outer, for 2014 the new dwelling construction to catchment income support ratio is 35 per cent. However, for Southern Outer the ratio is 50 per cent and 41 per cent for Northern Inner.

The solution for these sub-regions in Sydney and Melbourne is to increase the access of the residents of these regions to high productivity employment. One effective way to do this is to use industry and planning policies to support increased concentration of higher technology employment within the catchment, at locations such as emerging high technology nodes of Parramatta, Ryde, Monash (around Monash University), Latrobe University and similar middle suburban nodes with a strong education foundation.

These nodes should be expanded at a rate sufficient to significantly increase the high technology employment share for outer urban residents. Typically, the high technology employment share for the outer metropolitan regions is of the order of 20 to 25 per cent. From the relationships in Figures 2.17(a) and 2.17(b), a 10 per cent increase in the share of high technology employment for local residents would increase real per capita income from work by 35 to 40 per cent. Hence, if the affordability gap is 50 per cent then the increase in the income in the high technology employment share would have to be around 10 per cent to reduce the affordability gap to 35 per cent. For a region within a 40 per cent mortgage cost for new construction to average labour market catchment household income, the increase in the resident high technology employment share would be less than 5 percentage points.

For Sydney, accelerated expansion of the established high technology nodes at Ryde (around Macquarie University) and Parramatta would be essential to alleviate the housing affordability issues in the Outer West to North West Sydney regions. The task here would be demanding, with the required expansion in the resident high technology employment share being in the 15 percentage points and above range.

2.9 Towards a rule for the number of strategic nodes

The analysis suggests that there may well be a fourteenth rule of metropolitan development: that the number of strong strategic nodes a metropolitan area should possess for sustainable development is approximately one per million people. There would appear to be little case for Adelaide to have more than one strategic node, the CBD. There is a strong case that Sydney should have at least four, with an additional node established in the South West, and there is a strong case for Melbourne to possess four.

The relatively poor response of productivity growth, with respect to travel time reduction, in Sydney compared to Melbourne, noted in sections 2.6 and 2.7 above, is reflected in large-scale strategic nodes within the Sydney metropolitan area being less significant than might have been expected. The focus on Parramatta in the recent Infrastructure NSW Strategic update is thus timely (INSW 2014), since it will support growth in that cluster, including high tech growth. For Melbourne the situation is not as difficult but the analysis does indicate that no time should be lost in also accelerating the future development of a few nodes in that city.

2.10 Implications

The analysis in sections 2.3 to 2.9 supports the following propositions:

1. regional (city) economic performance, as measured by productivity, access to employment opportunities and housing affordability can be improved by effective planning, particularly focused on various levers that can support development of high tech industry clusters and access thereto
2. The use of policy instruments, co-ordinated via a planning blueprint, is necessary to achieve desired outcomes, because of the range of policy areas that interconnect to affect outcomes
3. In terms of productivity growth and sharing the benefits from this growth, policy instruments should be utilized which directly and/or indirectly influence
    - the types of industries (particularly high technology industries) developed
    - where industries are located and their scale
    - the spread and intensity of compact, mixed use, transport oriented developments
    - transport system capacities and travel times, particularly to (and within) a small number of key employment clusters (transport investment is critical)
    - workforce skills, particularly skills to support high tech industry development
    - social/cultural and community infrastructure provision, which is important in attracting skilled labour (and in sustaining liveability more broadly).
4. Policy instruments should also be used to influence the capital stock and its distribution across the region, to reinforce desired development patterns and help share the benefits of productivity growth across the wider city
5. Policy instruments should continue to support growth of the central activity region and surrounds, which is the core for high tech industry growth.

3. Micro-economic perspectives

3.1 Scope

Markets are the primary means of allocating resources in most economies, determining what is consumed, what is produced, selling prices of goods and services, wage rates, interest rates and so on. While markets are usually regarded as an efficient way of allocating resources, there are a number of well-known situations where free markets fail in terms of achieving an efficient allocation of resources. These situations include, with some transport examples (Stopher and Stanley 2014):[8]

- public goods (e.g., law and order, such as lead to road rules)
- merit or quasi-public goods (e.g., social safety net minimum service standards on public transport; local roads)
- externalities (e.g., agglomeration economies; congestion; air pollution)
- natural monopoly (e.g., rail)
- limited extent of markets (e.g., not all things that are valued pass through markets, such as individual 'costs' of social exclusion)
- lack of information for making informed choices
- distributional considerations.

Market failures are the major rationale for transport policy interventions led by governments, on the presumption, disputed by some, that such intervention will deliver better outcomes for society than a market that is failing. We focus in this chapter mainly on externalities, particularly the negative external impacts often associated with urban transport, and also on the merit goods/limited extent of markets issues that arise with respect to social exclusion, as it is affected by urban transport/mobility.

Externalities are probably the most important micro-economic concept for modern urban transport policy. Pearce and Nash (1981, p. 120) define an externality as 'unpriced goods or bads that accrue to third parties'. A *consumption externality* arises when a person's enjoyment of some good or service is affected by another person's production or consumption behavior, and that effect is not priced. Examples of consumption externalities that are of interest for transport policy are mostly 'bads', such as noise, air pollution and traffic congestion. *Production externalities* arise when the production possibilities of a firm are influenced by the unpriced activities of another firm or by a consumer. The productivity (agglomeration) benefits discussed in section 2 are a highly relevant transport example.

The existence of an externality implies the lack of current pricing of the effect that gives rise to the externality and pricing solutions are commonly proposed by economists to deal with problems of negative externalities. This is linked to concepts such as 'polluter pays'. The main externality focus in this report is on congestion, greenhouse gas emissions and air pollution. Energy and health are discussed in companion papers so we do not explore them in this paper,

[8] For an extensive discussion of such market failures in a transport setting, see Stopher and Stanley (2014).

other than obliquely, as elements that would need to be considered in a reformed transport pricing regime. We also consider social inclusion as it relates to urban transport, with the associated concept of social safety net service levels on public transport (a 'merit good'). Social exclusion has large costs for affected individuals and also has associated external cost dimensions. Because the focus of the paper is economics, we seek to indicate some monetary measures of scale for the matters under discussion.

Policy responses to the micro-economic issues outlined above, and discussed in more detail below, and to some related matters (e.g., the costs of fringe growth compared to urban infill), include economic responses such as pricing reform, regulatory/legislative approaches (e.g., emission standards for new vehicles) and, increasingly, include a significant land use planning component, with a focus on more compact, mixed-use settlement patterns. The focus in this report is on economic responses and land use planning responses (which have a significant economic component), with the macro analysis of section 2 providing a linking element on the land use side (via the productivity impacts of alternative settlement patterns).

3.2 Congestion

Congestion is mainly discussed as a problem of road use but is also relevant to public transport operation and use, particularly at peak periods. The main focus in this paper is on road congestion, which is of two types: *incident-related congestion* results from traffic accidents, road works and such like; *recurring congestion* occurs when there is a bottleneck in the system. In both cases congestion is associated with traffic input volume exceeding transport (e.g., road) facility output capacity to some degree. Stopher and Stanley (2014) explain how the traffic engineering conception of road congestion differs from the economist's conception, the former referring to a situation where a route or intersection is operating at or beyond its maximum capacity and the latter as any situation where traffic operates at less than the applicable free speed because of traffic flow interruption.

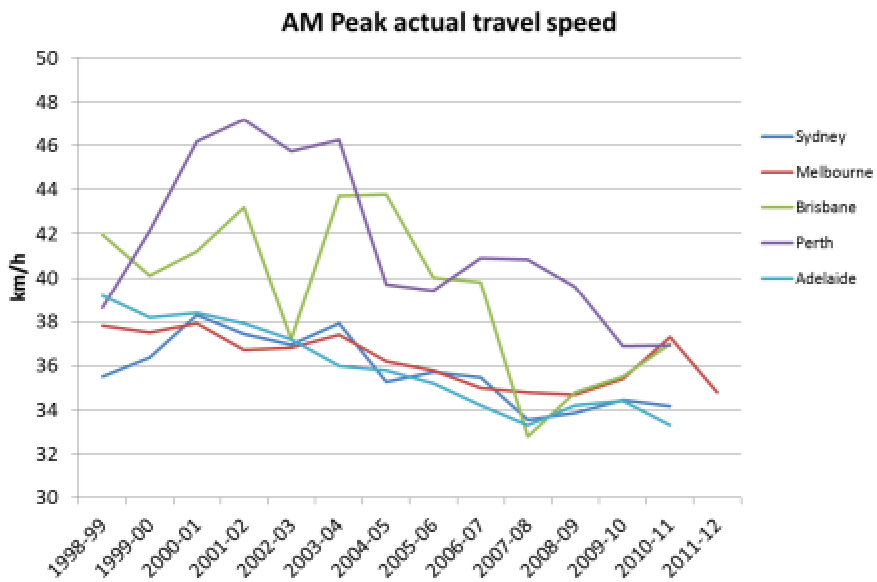
Urban transport analyst and blogger Chris Loader draws on Austroads' data to show trends in travel speeds in Australia's mainland state capital cities. Figure 3.1 shows his chart for the AM peak for the five mainland capitals from 1998-99 to (mainly) 2010-11. In general, declines in AM peak speeds of about ten per cent or more have occurred over the decade, reflecting *inter alia* increasing congestion.[9] BITRE's (2013) analysis of changes in commuting patterns generally mirrors this travel time information: average commute times in Sydney and Melbourne increased by about ten per cent between 2002 and 2010, with times in Brisbane and Perth increasing even more in relative terms.

BTRE (2007) estimated that road traffic congestion cost Australia almost $10 billion nationally in 2005 and projected that this cost would double by 2020. The costs they calculate are what economists call 'deadweight losses', which measure the potential economic value that can be derived from pricing road use at 'social marginal cost'. Social marginal cost at any traffic volume is the full cost of adding/subtracting an additional vehicle in the traffic stream, including all

[9] Other contributory factors might include, for example, reduced speed limits on some arterial roads.

externalities and private costs incurred by the traveller (see Stopher and Stanley 2014 pp. 72-3 for a more extensive discussion).

Figure 3.1: Trends in AM peak travel speeds



Source: http://chartingtransport.com/2010/10/31/trends-in-melbourne-traffic/. Viewed 27th March, 2014.

In dollar terms, road congestion is typically the largest of the external costs of urban road use (Stanley 2012), often leading to proposals to tackle congestion by pricing it. Such congestion pricing essentially aims to remove, or at least substantially reduce, deadweight losses, which represent an estimate of the potential annual benefits of an optimal congestion pricing scheme. May (2010) has reviewed congestion pricing schemes and found strong evidence that no other initiative can reduce road traffic levels so much, so quickly and in such a sustained manner. A pricing solution to congestion helps to avoid the traffic stimulus effect that typically follows road construction as a way of tackling congestion.

An important aspect of recurring road congestion is the high rate at which congestion costs increase for additional units of traffic growth (high 'marginal social costs of congestion' in economic jargon), at high volume/capacity ratios. Using the standard US Bureau of Public Roads speed-flow curve, Stopher and Stanley (2014) show, for example, that time costs alone increase by about 80c/km per additional vehicle at a traffic volume of ~1400 vehicles/lane hour in an Australian city. UK research has suggested that urban congestion costs in that country can be cut by over 40 per cent if congestion pricing reduces urban traffic volumes by about 4 per cent (DfT 2004). However, if the benefits of such a reduction in traffic volumes and associated congestion costs are to be sustained, measures are needed to limit any subsequent traffic rebound (generation) caused by lower congestion costs.

The steep slope of the congestion cost curve at high volume/capacity ratios has been shown, in recent European research, to frequently lead to overestimation of congestion reduction benefits from planned road improvements (Nicolaisen and Næss 2015). Congestion tends to discourage traffic in the 'do-nothing' situation, damping down prospective user benefits from improvement. This analysis is a good reason for requiring, as Infrastructure Australia has done (IA 2013), that major road projects be evaluated as if congestion pricing was in place.

Road traffic volumes for person movement in Australian capital cities have flattened off in recent years (BITRE 2009; ABS 2013). While car passenger kilometres increased by 20.8 per cent across the mainland capitals in the decade from 1989-90 to 1999-2000, the growth rate slowed to only 10.6 per cent over the ensuing eight years to 2007-08, with most of this growth being in the first half of this period. Rising fuel prices (until recent times) are, no doubt, one factor contributing to this pattern, with 2005-06 being the start of a period of high fuel prices.[10] ABS (2013) then suggests that total kilometres of motor vehicle travel in Australia's capital cities declined marginally from 2010 to 2012, from 123.9 billion VKT to 123.8 bVKT, although this scale of change is not statistically significant.

The flattening in growth of car traffic in Australian capital cities over the past decade is also apparent in many other countries (e.g., the UK and US; see Stanley 2014a). This flattening will have slowed the growth in road congestion costs and suggests that trucks and light commercial vehicles are now the major contributors to increasing urban road congestion costs. Stanley (2014a) suggests that increasing road congestion levels and improved public transport service levels have both contributed to the decline of per capita car use, alongside rising fuel costs. This opens up the possibility that future growth in VKT could also be lower than population growth, an indicator of a more sustainable land transport network, if policy settings can reinforce recent trends.

The scale of congestion costs on Australian urban road networks emphasizes the importance of governments looking more seriously at reforming road pricing. Pricing is the most effective way to remove the deadweight losses of congestion, and other negative externalities, and to improve the efficiency with which existing road assets are used. Road building solutions (additions to supply) provide short term benefits but traffic growth generated by road improvements tends to cancel this benefit out over the medium term (Duranton and Taylor 2009). The Productivity Commission (2014a, b) has recently supported moving to reform road pricing, although it imposed the arbitrary constraint that any such moves should be revenue neutral.

Any jurisdiction seeking to pursue congestion pricing has to resolve many issues, such as whether to follow London and Stockholm and implement cordon/zonal charging systems or to implement a broader GPS-based scheme, like the Dutch recently considered, whether to just price congestion or to pursue a broader pricing of external costs, and how to design a scheme that will be acceptable to voters. We return to pricing in section 3.6.

[10] Average 2005-06 fuel prices were over 10 per cent above 2003-04 prices and 2006-07 prices increased even faster.

3.3 Greenhouse gas emissions

Australia is one of the world's highest per capita emitters of greenhouse gases. Our transport emissions are particularly high, per capita transport GHG emissions for Brisbane (for example) being about three times those for London and Melbourne's almost three times those of London. These high emission rates are partly a function of Australia's low-density urban settlement patterns and partly due to associated lower Australian public transport service-densities.

Total Australian GHG emissions (all sources) in the year to March 2014 were 542 million tonnes (Mt) of CO_2 equivalent, with 94.6 Mt (just over 17 per cent) being from the transport sector.[11] The National Greenhouse Gas Inventory suggests that road transport emissions in 2011 were 75Mt, which was 41.4 per cent higher than in 1990.[12] Transport emissions grew faster than emissions from all other sectors except electricity. However, emissions from the electricity sector have declined over the past few years, whereas transport emissions have continued to grow. The flattening of growth in urban VKT in recent years is reflected in a decline in the consumption of automotive gasoline within the sources of road transport GHG emissions but there has been an increase in diesel as a source, reflecting growing freight traffic and also a swing to diesel within the motor vehicle fleet.

From an efficiency perspective, national priorities for GHG emission reduction should focus on the lowest cost emission reduction opportunities. Transport will need to be a priority sector in mitigation efforts, because of its absolute emissions scale, the likely scale of overall emissions reductions Australia will need to pursue in coming decades and the fact that emissions from the sector are still growing, at a time when the global and national focus is on emissions reduction.

Many commentators have canvassed the need for high GHG-emitting developed countries to reduce their emissions by 80 per cent, or higher, by 2050, to help stabilise global temperature increases to 2° C. An 80 per cent reduction target has been legislated in the UK, in the *Climate Change Act 2008.* President Obama has announced a goal for the US to cut its 2050 emissions to 83 per cent below 2005 emissions.[13] The European Council's long-term emission reduction target is 80-95 per cent by 2050, with a transport sector reduction target of 60 per cent on 1990 levels (EU 2011), recognising the difficulties of achieving reductions in this sector.

Although Australia has currently adopted a 2050 target of 60 per cent cut in emissions on 2005 levels, we expect that international pressure will see this target increased to 80 per cent or higher in coming years, to better align with (for example) European, UK and US targets. Meinhausen et al. (2009) and Stern (2008) have estimated carbon budgets of 1.8 tonnes per capita and 2 tonnes respectively, within a contraction and convergence approach to global GHG

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[11] http://www.environment.gov.au/system/files/resources/7d5f76fe-3128-44dd-bef1-f6fa008f686f/files/nggi-quarterly-update-mar-2014.pdf. Viewed 6th January 2015.

[12] http://www.environment.gov.au/system/files/resources/6b894230-f15f-4a69-a50c-5577fecc8bc2/files/national-inventory-report-2012-vol1.pdf. Viewed 6th January 2015.

[13] In June 2009, the U.S. House of Representatives passed the *American Clean Energy and Security Act*, which includes economy-wide GHG reduction goals of 3 percent below 2005 levels in 2012, 17 percent below 2005 levels in 2020, and 83 percent below 2005 levels in 2050.

mitigation aimed at limiting temperature increases to 2° C. By 2050, the Meinhausen budget reduces to 0.33 tonnes per capita. Australia will need to achieve a dramatic change in the trajectory of its GHG emissions (currently exceeding 20 tonnes per capita), including from the substantial transport sector, to contribute to emission reductions in any way approaching this magnitude. On a positive note, Read (2014) has shown how substantial reductions in per capita emissions are consistent with maintaining or even increasing life expectancy in high-emitting countries such as Australia and the US, an indicator of better meeting human needs in those countries.

Stanley et al. (2011) have provided a rough indication of the scale of changes in travel behaviour and vehicle emissions technology that might be required for Australian urban road transport to meet an 80 per cent reduction target in 2050, on 2000 emission levels, as summarised in Table 3.1.

Table 3.1: Indicative Australian road transport emission reduction scenarios that achieve an 80% cut on 2000 levels by 2050

Measure	Target	2007	2050 extreme efficiency	2050 high efficiency
1. Fewer or shorter car trips	Less car kms	-	10% (-4 Mt)	30%
2. Shift from car to walk/cycle	Active transport urban mode share	16%	29% (-11 Mt)	53%
3. Increase PT mode share plus green rail power	PT mode share (% urban trips) - car share (% urban trips)	7.5% 77%	16% (-4 Mt) 57%	38% 23%
4. Increase car occupancy rate	People/car	1.4	1.7 (-5 Mt)	2.8
5. Freight efficiency gain	Less fuel	-	30% (-20 Mt)	80%
6. Car emissions intensity - Truck emissions intensity	Less than 2007 (grams/km) Less than 2007	220	92% (-36 Mt) 18 84% (-42 Mt)	75% 54 75%
TOTAL REDUCTION			**80% (-123 Mt)**	**80% (-123 Mt)**

Source: Based on Stanley, Hensher and Loader (201).

The two scenarios shown in Table 3.1 are labelled as '2050 extreme efficiency' and '2050 high efficiency', primarily reflecting the assumed improvement rates in vehicle GHG emissions intensity in each case. The 'extreme efficiency' scenario assumes car emissions intensities fall 92 per cent on 2007 levels by 2050 and truck emissions intensities fall 84 per cent. If the "2050 extreme efficiency" outcome can be achieved on vehicles emissions intensity, then achievement across the other measures shown in Table 3.1 will meet an 80 per cent emissions reduction target for road transport against a 2000 base. The other measures embedded in this scenario include an increase in active transport and growth in public transport mode share (measures 2 and 3), the sum of the two increasing the Australian capital city mode share for active transport plus public transport combined from about 24 per cent in 2007 to 45 per cent by 2050. Vancouver is targeting a 50 per cent share by 2046, from 27 per cent in 2011 (Translink 2013). The scenario also includes a 10 per cent reduction in car VKT; Vancouver is aiming for stability in VKT to 2046, with a cut of one third in average trip lengths and the mode share increases noted above as the two key drivers of this outcome target (Translink 2013). The '2050 Extreme efficiency' scenario thus benchmarks well against Vancouver on complementary policy measures that will support improvements in vehicle emissions intensity, which is doing most of the heavy lifting in this scenario.

The 'high efficiency' scenario embodies reductions in emissions intensity of 75 per cent for both cars and trucks by 2050, which does not appear to be dramatically lower than for the "extreme efficiency" scenario. However, to achieve the aggregate target of an 80 per cent cut in emissions by 2050 against a 2000 base with the 'high efficiency' scenario requires implausibly large changes in travel behaviour with respect to urban car travel, walking, cycling and public transport use, as shown in Table 3.1. The implication is clear: road transport will need to be close to GHG emission free by 2050 if a target of an 80 per cent transport emissions cut, on 2000 levels, is to be approached. Taking fleet age into account, the emission free requirement will need to be met on new vehicles by about 2035. This will, in turn, need to be complemented in the shorter term by strong policies to affect travel behaviour towards increased use of low emission modes and policies that support shortening of trip lengths. Moving to more compact settlement patterns is very important in this regard, as Vancouver has long recognised.

It is important to note that the policies needed to achieve a substantial cut in road transport GHG emissions will also typically produce substantial co-benefits, which will tend to exceed (in economic dollar value terms) the benefits from GHG reduction. For example, policies which contribute to achievement of measures 1 to 4 in Table 3.1 will also generally reduce congestion costs, lower the road toll, promote social inclusion, promote better health and increase energy security.

As a matter of value judgement, we believe that an 80 per cent emission-reduction target for 2050 should be embedded in national legislation and that the land transport sector should be expected to achieve a reduction of this broad order. The implication is for a much stronger push towards more compact cities, with high quality public transport systems, and setting time-lines for substantial reduction in vehicle emissions intensity. Europe, for example, has set a GHG fleet average emission target of 95 grams/km by 2021[14], whereas the Australian car fleet average in 2007 was 220 grams/km. Schadea and Kraila (2014) suggest that conventional fossil fuel vehicles will need to be banned from the European market completely by about 2035, to achieve the European targeted 60 per cent transport sector GHG emission reductions by 2050 (on 1990 emissions), in line with our suggestions above. They argue that only with such a policy

[14] http://dieselnet.com/standards/eu/ghg.php. Viewed 9th January 2015.

in place will alternative technologies diffuse into the market quickly enough for target achievement. It is time that such policy considerations were the subject of debate in Australia.

A wild-card in the push for GHG emissions reduction seems likely to be the Chinese policy response to its problems of urban air pollution. Air quality data assembled by the US Embassy in Beijing, for example, shows that small particle ($PM_{2.5}$) readings have averaged over 100 micrograms per cubic metre since 2008, peaking at far higher levels (e.g., the Sydney Morning Herald on 26 Feb 2014 reported that the last time the level dropped below 150 ppm was 19/2/14, with a then recent peak level of 462 ppm[15]). The US Embassy website lists ratings of under 50 as good and over 150 as 'unhealthy'.[16] At readings of over 300, children and elderly are advised to stay indoors!

About one-third of air pollution in Beijing comes from vehicle exhaust fumes. Government transport-related plans to combat this pollution include short-term measures like limiting vehicle access and scrapping high-emitting vehicles[17] but longer term will include changes in energy sourcing for electric vehicles. Electric vehicles fuelled by coal-sourced power would be problematic in GHG terms but renewables deliver much better air quality and GHG outcomes. In this regard, the national government has indicated it intends to close coal-fired power stations and other coal facilities by 2020 in six of its capital districts. This will have a direct impact on local air quality and, longer term, be beneficial for electric vehicle emissions. The scale effect of a large Chinese push into electric vehicles would make it easier for Australia to achieve the transport-related GHG emission reductions discussed above.

Costs

Stopher and Stanley (2014) point out that estimating marginal GHG emission costs is not easy. Estimating GHG emissions as a function of travel activity is relatively difficult but selecting an appropriate unit cost value to apply to these emissions over time is even more so. Global damage costs are the most appropriate way to approach unit costing of the externality but, as Weitzman (2012) points out, estimation of such damage costs is subject to layer upon layer of uncertainty. As a result, there is a wide range of relevant estimates, with differing bases for such estimation.

Avoidance costs are frequently used as a proxy cost for GHG emissions, with common values in the range of €50-100/tonne of CO_2. The major European study on costing transport externalities, Maibach et al. (2007), proposed central values for GHG costs that are increasing over time, from €25/t for 2007-10 to €40/t for 2020, €55/t for 2030, €70/t for 2040 to €85/t for 2050. The UK Government required use of £56/t CO_2 for GHG emissions in the non-traded sector (which includes petrol and diesel), in evaluations of public infrastructure proposals in that country for 2012 (HM Treasury and DECC 2011). Using the latter (long term) cost and an

[15] http://www.smh.com.au/environment/beijing-barely-suitable-for-life-as-heavy-pollution-shrouds-chinas-capital-20140225-33ghq.html. Viewed 9th January 2015.
[16] http://www.stateair.net/web/post/1/1.html. Viewed 9th January 2015.
[17] http://www.bbc.com/news/business-27583404. Viewed 9th January 2015.

exchange rate of one pound sterling to $A1.90, Australia's transport GHG emissions would have an implied annual cost of ~$10 billion, with the road transport externality comprising about $8 billion within this total. The urban road transport share would be close to $5 billion annually and these costs are increasing.

3.4 Air pollution

Motor vehicles emit a number of potential air pollutants which are harmful to human health and may have other adverse impacts (e.g. on buildings, ecosystems), with five primary air pollutants emitted: carbon monoxide (CO), volatile organic compounds (VOCs) also referred to as hydrocarbons (HCs), oxides of nitrogen (NO_X), oxides of sulphur (SO_x), and particulate matter (PM - particles of 10 microns or less, referred to as PM_{10}, and particles of 2.5 microns or less ($PM_{2.5}$) are the main elements of concern here). A National Environment Protection Measure (NEPM) sets national standards for these air pollutants in Australia, based *inter alia* on expected health impacts.

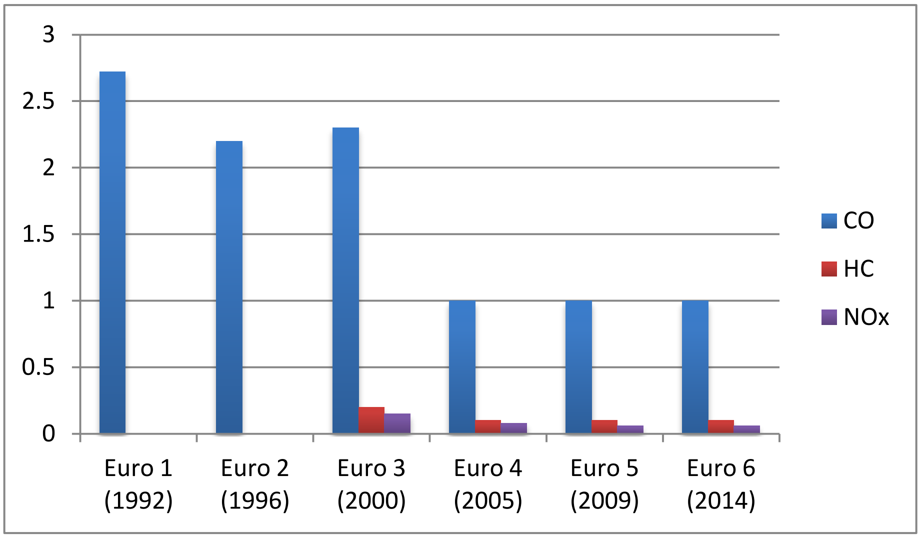
The National Environment Protection Council reports achievement against the Air Quality NEPM. The 2012-13 NEPC Annual Report said that (NEPC 2013, p. 40):

> '… Monitoring results show that the NEPM standards are mostly being met and air quality in Australia is generally good compared with international standards. Most jurisdictions consistently meet the standards and goals for nitrogen dioxide, carbon monoxide and sulfur dioxide (except in areas with smelting activities).
>
> However, meeting the goals for ozone and particulates continues to be difficult in a number of regions across the country. Weather conditions continue to affect PM_{10} and $PM_{2.5}$ levels both positively and negatively …
>
> Challenges for jurisdictions in meeting NEPM AAQ standards include impacts of the use of domestic wood heating, increasing economic activity and motor vehicle use and urban expansion. Bushfires and controlled burning continue to be sources of exceedences of particulate levels in a number of jurisdictions, particularly those in eastern Australia.'

With diesel being a source of PM emissions, growth in the road freight task and increasing use of diesel fuel in motor vehicles are sources of some concern.

Legislated vehicle emission standards, such as the set of Euro standards and their US equivalents, which have been steadily tightened in recent years, are important ways of ensuring that air quality benchmarks are met. Examples of how emission standards have been tightened in Europe in recent years are shown in Figure 3.2, for petrol passenger cars. Australia tends to lag Europe slightly on the timing of adoption of these standards.

Figure 3.2: EU Emission Standards for Petrol Passenger Cars (grams/km)



Source: http://en.wikipedia.org/wiki/European_emission_standards

Costs

Air pollution costs typically include health costs (the largest component), building and material damage, crop losses and costs for ecosystem damage (biodiversity, soil and groundwater). In terms of putting a cost on air pollution damage associated with transport, Johnson et al. (2012) cite three studies for the UK, in which cost estimates range between 0.34 pence/km and 1.7 p/km (1998 prices), with a more recent estimate of 0.57 p/km (2009 prices). Parry (2009) derives an estimate for the US of 1c/mile (2007 prices). Australian Transport Council guidelines include default values for urban passenger cars of 2.45c/km (ATC 2006, in 2005 prices). Stanley and Hensher (2011b) updated that cost to 2.6c/km.

Maibach et al. (2007) is perhaps the most comprehensive source of emission cost estimates for use in transport evaluations. They provide air pollution costs on a per tonne of pollutant basis for a range of pollutants, then express these costs on a per vehicle kilometre base (and per train kilometre). The costs per vehicle kilometre take account of vehicle type (passenger car/truck, by engine size for cars and vehicle mass for trucks), fuel type (petrol/diesel), the relevant Euro emission standard and the operating environment. For motor vehicles in Germany, as an example, their air pollution cost estimates for a car of 1.4-2L engine capacity in metropolitan urban operation range from between €0.059 vkm for a Euro 0 Passenger car (2000 prices) down to €0.03 vkm for a Euro 3 to Euro 5 equivalent vehicle (reflecting the tightening of standards shown in Figure 3.2). These costs are considerably higher than those cited above for Australia, which will be partly due to higher urban densities in Germany, which increases exposure risks. Their highest air pollution cost estimates are for large trucks (>32t) with EURO 0 emission controls in metropolitan operation (€0.383 vkm in 2000 prices). This air pollution cost estimate reduces to only €0.052 per vkm for a EURO 5 truck (>32 t), which is similar to the EURO 0 car cost cited above.

The EU is moving towards including air pollution costs in its heavy vehicle road pricing regime, the European Transport White Paper (EU 2011) indicating that its transport pricing reform pathway would have two stages. In stage one, up to 2016, phasing in of mandatory infrastructure charges for heavy vehicles is envisaged, with provision for incorporation of air pollution, noise pollution and congestion costs. The second phase (2016-2020) envisages full and mandatory internalization of external costs for heavy goods vehicles (as well as mandatory recovery of infrastructure costs), with the possibility of this being extended to all vehicles.

The European approach to charging heavy vehicle road use goes further in the direction of including external costs of road use than is discussed in Australia but is still only in its early stages in terms of implementation. For heavy vehicles it is not as comprehensive as Australia's charging system in relation to infrastructure costs, because fewer roads are included in the EU cost base. However, the institutional environment is easier in this country (e.g., fewer jurisdictions involved than in Europe). Regulatory measures remain the main way in which external costs such as noise and air pollution are internalized for heavy vehicles.

3.5 Social exclusion

Social exclusion arises as a result of the existence of barriers that make it difficult, or impossible, for people to participate fully in society. Australian research suggests that the lower a person's level of realised mobility, and hence the fewer the number of activities in which the person is likely to engage, the higher the likelihood that the person is at risk of social exclusion (Stanley et al. 2011a,b). Related research supports a conclusion that undertaking trips may improve a person's likelihood of social inclusion and their wellbeing, both directly and/or through a mediating influence of building social capital and connection to community (Stanley et al. 2010). While personal characteristics (for example, *locus of control* and *affect*) are related to the uptake of opportunities to undertake activities, it would seem that, without the ability to be mobile, many opportunities simply cannot be taken up. In Sen's (1979) terms, this suggests a role for mobility (as a means of achieving accessibility) as an important *capability* or means of meeting human needs, that should be pursued through transport (and social) policy (hence our support for mobility as well as accessibility in section 1.2).

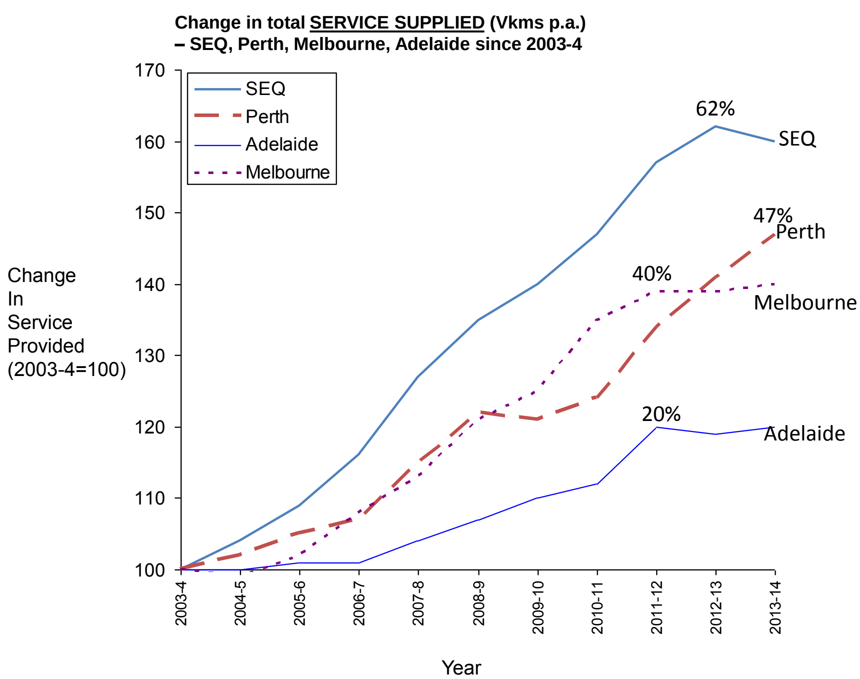
To our knowledge, there is no data which tracks performance of Australia's land transport systems over time in terms of reducing transport disadvantage and the associated risks of social exclusion, reflecting the conclusions of the COAG Capital City Strategic Planning Review about the need to build understanding in this area (COAGRC 2012). However, research undertaken for the Australian Bus Industry Confederation (BIC) has been important in establishing that an important way to reduce urban risks of social exclusion that have their origins in mobility is to ensure that there is a reasonable base level of public transport service available (Stanley and Hensher 2011a). A reasonable service level we define as one that enables

- most people
- to access most of the things they need for a fulfilled life
- at most times.

The appropriate service level in any particular circumstances will depend, inter alia, on the land use/transport/demographic circumstances of particular locations but should be embedded in integrated land use transport plans for our capital cities and in relevant regional plans. In our capital cities, research by Loader and Stanley (2009) suggests that the *absolute minimum* should be an hourly public transport service within 400 metres of where people live between 6.00am and 9.00pm start of run for most days of the week, with later services on Fridays and Saturdays. Higher frequencies are obviously desirable for supporting social inclusion. Areas that do not meet this benchmark are likely to have relatively more residents who are at risk of social exclusion than areas that do meet it.

Figure 3.3 shows that, after a period of growth, per capita public transport service levels in several mainland capital cities have stabilized or declined in recent years. This is largely because service levels have just kept pace with, or fallen behind, growth in population, particularly on the fast growing fringes of our capital cities. It seems likely, therefore, that exclusion risks with transport origins will have reduced somewhat in the cities shown but are now getting worse, or at least not continuing to improve.

Figure 3.3: Indices of public transport service kilometres per capita (Source: Currie 2014).



Problems of poor accessibility to the many opportunities that are available in any society can be tackled by improving mobility (e.g. providing public transport service levels that at least meet minimum standards, as suggested), changing land use arrangements (to enhance accessibility) and/or by changing service delivery models (e.g. in low patronage settings, new delivery models are currently being explored). Integrated approaches to transport policy and program delivery should incorporate all these opportunity pathways. In terms of the land use perspective, urban development policies and programs that promote more compact cities will necessarily focus on increasing opportunities for public and active transport (walking and cycling), as key elements in delivering effective compact cities. Increasing opportunities for active transport will also support social inclusion, through expanding travel choices.

Costs/Value

Australian empirical research shows that the value of additional trip making by those at risk of social exclusion is very high, such that there is a convergence between what might be seen as a social justice argument for minimum service levels (i.e., supporting capabilities) and an argument based on economic benefits of service provision. Stanley et al. (2011a, b; 2012) have shown that the value of an additional trip to a person at risk of social exclusion is about $18-22, for a person from a median income household, with this value increasing in inverse proportion to household income of the at-risk person (i.e., for an at-risk person with half the median household income, the value of an additional trip/activity doubles). Research undertaken for Bus Association Victoria suggests that the largest single benefit from urban route bus services in Melbourne is their social inclusion value, which has been assessed at almost $800 million annually, or 60 per cent higher than the costs of providing the service for this benefit alone (Stanley and Hensher 2011a). When other benefits of route bus services are added, particularly congestion costs savings, the overall benefit-cost ratio rises to about 3.8 for Melbourne route bus services.

Provision of improved mobility/accessibility opportunities will not only provide benefits to individuals whose risks of social exclusion are reduced, as valued above, it will also reduce what can be seen as external costs that are associated with social exclusion. These costs include, for example, health and medical expenditures, lost productivity, costs of criminal activity and the pursuit thereof, etc, that may flow from social exclusion. We are not aware of any studies that have quantified such costs but we expect that they would be considerable.

3.6 Conclusions on micro-economics

The discussion in this section of the paper points to some key areas for national land transport micro-economic, and related, reforms, particularly:

1. improving the way road use is priced, particularly in our cities where external costs are substantial. If road pricing is reformed, then public transport fare setting can also be reformed, to ensure that travellers get better pricing signals across a wider range of travel opportunities
2. beyond pricing reform, implementing a regulatory regime that will substantially accelerate the reduction in GHG emissions from land transport and continue the improvement in air quality that has been achieved over the past two decades, primarily through emission control requirements and travel behavior change programs
3. planning our public and active transport systems in a way that recognizes the high economic value of reducing risks of social exclusion that are associated with improved mobility opportunities

4. more closely integrating urban planning and transport planning to achieve more compact settlement patterns, because of the significant long term impact of urban settlement patterns on sustainability outcomes across all dimensions.

These elements are discussed briefly below, with some further elaboration in section 4.

Pricing Reform

Economically efficient road use pricing is based on the idea of users paying the marginal social costs attributable to their road travel choices, including external costs. Any jurisdiction seeking to pursue such pricing has some fundamental considerations to resolve, such as (for example):

- how to ensure that cost recovery targets are met, if a jurisdiction believes this is important, where the usual answer is to price at short run marginal social costs and raise any additional revenue required to meet cost recovery targets by charging higher prices to users who are least deterred by higher prices
- deciding which externalities to include and how to calculate relevant marginal social costs, when there are frequently many joint and common costs involved in provision of transport services and the analytics of costing is still emerging. The European Commission has supported substantial valuable research to improve relevant marginal social cost estimates, with Maibach et al. (2007) a comprehensive source
- how to design a pricing scheme that will be acceptable to voters (also the subject of a wide literature, with many commentators proposing dedicating (or hypothecating) the revenues that are raised to specific transport and/or closely related applications and upgrading alternative travel options prior to implementing charges, to give people a choice.

Productivity Commission (2014a, b) identified that government revenue streams which might notionally be seen as charges for road use (esp. fuel excise and registration) are now barely meeting the direct costs governments spend on road construction and maintenance. When a number of wider 'external' costs of road use are taken into account, particularly congestion costs, accident costs not met by road users, greenhouse gas emissions and air pollution costs, Table 3.2 (building on Stanley 2012) suggests that Australian road users pay governments considerably less than half the social costs that are attributable to their road use. The range of external costs involved suggests that road pricing reform needs to go beyond just seeking to put a price on congestion costs – it should tackle road user charging reform more broadly. Inclusion of health costs would widen the scale of the gap.

Marginal social cost pricing does not use total external costs, of the kind included in Table 3.2, but looks instead at how costs change with traffic levels. However, a lack of detailed knowledge about the shape of the relevant damage functions for a number of externalities (i.e., how unit costs change as traffic volumes change) means that marginal and average social costs per unit are effectively assumed to be equal, such that the scale of gap identified in Table 3.2 is probably pretty informative of the need for significantly higher costs of urban road use, particularly in peak periods.

Fuel taxation is an administratively simple way to impose such a charge but is not as well structured for charging purposes as a distance-based charge that varies by location and vehicle mass. Stanley and Hensher (2011b) analysed what marginal social cost pricing might mean for fuel excise levels if that mechanism was to be used to seek to recover external costs. They suggested that Australian fuel excise on petrol would need to be raised by about 14c/L to better reflect the external costs of car use (heavy vehicle charges were not assessed), with congestion accounting for the largest component of the charge. Such a charge would raise an additional $5b a year, Stanley and Hensher arguing for separately quarantining urban and rural/regional revenue collections for use in those respective areas, recognising the absence of congestion costs in rural/regional settings.

Table 3.2: Indicative External Costs of Road Transport and Road-Related Revenues

Cost/Revenue Item	Costs/Revenues est. ($b)
COSTS	
Road expenditure	20*
Congestion	13**
Air pollution	4 (inc. noise)***
Climate change	8****
Noise	(in air pollution)
Accidents (externality component only)	10***
Total Costs	**~55**
REVENUES	
Commonwealth excise	
Less diesel fuel rebate	
Less DAFGS	
Registration fees	
Total Revenues	**20**
ROAD "DEFICIT"	**~35**

Notes: * = Rounded from 19.5b, as cited by Productivity Commission 2014b, for 2011-12. Road revenues are included as equaling this amount, because of the uncertainty around some revenues noted by Productivity Commission (2014b). ** = Interpolating between the BTRE $10b (2007) and $20b (2020) estimates and scaling down a little, to allow for slowing growth in car travel. *** = From Stanley (2012). **** = This figure was as derived in section 3.3 above.

The conjunction of:

- a substantial Australian land transport infrastructure backlog, with increasing economic returns in prospect from tackling this backlog (as demonstrated in section 2 above)
- current road user taxes/charges barely covering direct road expenditure costs and being well short of covering the external costs of road use and
- declining fuel excise collections

in a fiscal environment where governments are wary of increased borrowings, demands a new approach to how Australians pay for road use and how transport investment is funded. A *user pays* approach to charging and funding should be one foundation for this new approach. It will help to change behavior in ways that will improve the efficiency with which existing road capacity is used, give better price signals for when and where capacity should be expanded and generate a revenue stream to help fund improved transport infrastructure and services. A research program to update and refine estimates of relevant external costs, along the lines of the Maibach research, for Australian application in a reformed road pricing regime, would assist the process of pricing reform. Infrastructure Australia could broaden its pricing studies to include consideration of how all road users, not just heavy vehicle operators, can be best engaged in the 'user pays-user says' process they have proposed (IA 2013), with heavy vehicles an early priority because of their link with increasing congestion costs.

A time line for the passage to a new road pricing regime in Australia, including all vehicle classes, should be announced as an early priority. 2020 would be a reasonable target for implementation, given that Europe and the US have already undertaken considerable bodies of work around similar dates. The pathway to pricing reform could start by accelerating the work of the Heavy Vehicle Charging Initiative on implementation of an improved distance-based heavy vehicle pricing regime for infrastructure (likely to eventually be a mass-distance-location model), adding in some of the European work on air pollution and noise costs as an early priority. Complementary vehicle kilometer travelled (VKT) charging trials for light vehicle charging could be put in place in a couple of cities within the next two years. Motorway-based charging of externalities should also be an early priority. If a fully fledged VKT charging system was eventually put in place, fuel excise and registration charges should be largely removed (unless a carbon price is levied through the fuel excise). This will provide the opportunity to review public transport fare setting, to make this more cost reflective, subject to meeting minimum service standards.

A large-scale community conversation must be an integral part of road pricing reform, preferably led by independent people, to help gain community buy-in and ease the process of transition. The identification of ways in which assistance will be provided for people who are likely to be adversely affected by a new pricing regime must be a key part of the consultation program, if wide community support is to be achieved. The London approach of improving bus services in areas where risks of adverse impacts are high has much to commend it.

Vehicle emission standards

Since the advent of the (then) National Road Transport Commission and National Environment Protection Council in the 1990s micro-economic reform agenda, Australia has kept close to world's best practice in vehicle emission standards as they relate to 'local pollution'. For air quality that has been largely through setting air quality standards and (slightly delayed) adoption of European emission standards in the *Motor Vehicle Standards Act*, with supporting in-service regulations.

Air and noise outcomes could, in principle, be achieved via pricing of relevant external costs but an apparent Australian aversion to such pricing, and problems in cost quantification, have seen legislative/regulatory approaches largely used to meet relevant standards. This is the usual approach internationally, pricing being the exception. Use of legislative/regulatory approaches should continue for managing air quality and noise as they relate to transport. At the same time, pricing systems should be refined so they can play a larger role, as costing approaches are improved and community acceptability increases. A first step in relation to pricing air pollution from land transport, for example, could be to vary vehicle registration charges as a function of a vehicle's emission-control technology, with higher charges for more polluting vehicles. The costing exercise undertaken by Maibach et al. (2007) provides some useful insights in this regard, as illustrated in section 3.4. This has the disadvantage of not being linked to vehicle use but does have the benefit of reinforcing the principle of the polluter pays.

We see an inevitable increase in the scale of GHG emissions cuts that the international community will demand from Australia in coming years. The land transport sector will need to be a significant contributor to the achievement of these cuts, given its size and emissions trend. In the long term, a price on carbon is an effective way to approach transport GHG emissions reductions. In a reformed road pricing regime, in which a wider range of external costs are priced as a function of the circumstances of travel behaviour and vehicle type, carbon pricing would be a reason for retaining part, at least, of the current fuel excise, as the means of implementing the carbon charge.

In the absence of a carbon pricing regime, or until such time as a regime is in place, a focus on reducing the emissions intensity of the vehicle fleet and fuel might initially rely on voluntary industry-based approaches. However, such approaches have not achieved the rate of sustained reductions in emissions intensity that would be required to meet targets of 80 per cent, or thereabouts. We expect that mandatory standards will be needed to achieve cuts of this order, probably implying largely GHG emission-free new vehicles by about 2035. Mandatory standards are the norm in Europe and the US.

Because changing vehicle technology will take time to filter through the fleet, an early start should be made on driving the kinds of behavioural changes outlined in section 3.3 and Table 3.1, to cut GHG emissions. Capital city long term land use transport plans should, as a matter of course, report on GHG emissions expected under their proposed future land use transport arrangements, and performance should be regularly monitored and reported, to indicate progress.

Minimum Public Transport Service Standards

In terms of the social leg of the sustainability triple bottom line, we have argued that the provision of minimum public transport service levels is an effective threshold way to support sustainable outcomes. A very low service standard has been suggested in this regard and further research is warranted on significantly increasing the service frequencies and operating spans embedded in that minimum, to half hourly services for at least 18 hours a day within 400 metres of dwellings, within five years. The economic value of inclusion supports this approach.

4. Implications for Australian cities

4.1 Goal setting for land use/transport policy planning

The triple bottom line sustainability elements of economics (productivity), environment and social inclusion are reflected in high level vision (or intended outcome) statements for Australia's capital cities, which are strikingly similar. Liveability, health and governance outcomes are also specified in some cases. For example:

- Sydney: balanced growth; a liveable city; productivity and prosperity; a healthy and resilient environment; accessibility and connectivity (a strong global city, a liveable local city)
- South East Queensland: strong, green, smart, healthy and fair
- Perth: liveable, prosperous, accessible, sustainable and responsible
- Melbourne: preserve and enhance distinctiveness; ensure city remains globally connected and competitive; promote economic/social participation; build strong communities; ensure environmental resilience.

Distinctiveness, which is so important in a city's branding and competitive strengths, typically emerges at a finer level of detail. However, end-state conditions are notably absent from vision statements and supporting material.

In asking the question "Is sustainable transport policy sustainable?" Eliasson and Proost (2015) draw attention to the difference between what they broadly characterize as planning approaches to sustainability and economic approaches. At the risk of over-simplification, planning approaches tend to focus on the kind of city that is envisioned and its associated transport systems/services, with a focus on identifying policy measures best suited to delivery of the intended land use and lifestyle outcome. The economic approach focuses, instead, on identifying the marginal damage costs (and benefits) of different arrangements and using pricing mechanisms to correct for these market failures. The land use and transport outcomes that result will do so as a consequence of the market pricing interventions, rather than being a specifically planned result.

Our view is that elements of both approaches are required for developing sustainable mobility/transport systems in sustainable cities, for reasons such as what Simon (1957) calls 'bounded rationality' (for example, our incomplete understanding of how cities function as systems, and of the economic costs and benefits of different land use/transport arrangements) and, from a value perspective, the limited role we see for of markets in informing social and ecological outcomes over the long term. Economics can help to identify the most efficient ways to achieve particular policy goals and to inform decisions about the social and environmental constraints that are involved in sustainability but ultimately the latter are questions of societal value judgment.

Transport policy responses to the multiple, pressing and near universal city problems of urban productivity, traffic congestion, air pollution, greenhouse gas emissions, a high road toll, energy insecurity, social exclusion and increasing obesity from a lack of exercise are increasingly looking to long term, land use based solutions, as part of an integrated policy approach. The long term response typically focuses on achieving more compact urban settlement patterns (higher densities, mixed use), which are widely thought to help promote urban productivity and manage/reduce most of the transport problems listed. Links between regional and neighbourhood level built form variables (e.g. density, distance from the CBD, diversity of land uses, street network connectivity, distance from transit) and travel, particularly kilometres of motor vehicle travel, tend to be small in relation to individual policy measures but can be significant when policy packaged (Ewing and Cervero 2010). Desired land use futures for sustainability are thus increasingly being placed at the centre of urban planning.

Across the developed world, there is widespread agreement among urban planners about the broad principles of effective city planning that should contribute to cities meeting triple bottom line outcome goals as they grow. The ADC Forum's Cities Summit 2010 expressed these principles as follows (ADC 2010, p. 34):

- planning should be for 'whole communities', providing for access to jobs, schools, shops and services, recreational facilities, open space, and for access to other people
- this planning should involve the relevant communities in the planning processes and encompass both 'top down' and 'bottom up' perspectives[18]
- outward growth of cities should be constrained
- 'green' areas should be retained within and around cities
- 'close to market' agricultural and horticultural land should be retained as far as possible
- large cities should have a networked polycentric shape rather than a single CBD
- higher density and mixed-use development should be encouraged at public transport stops, particularly rail stops but also along major public transport routes (e.g. tram lines and key trunk bus routes)
- all neighbourhoods should have access to urban villages and be walkable and cyclable
- use of public transport, walking and cycling should be encouraged wherever possible
- use of the car should be discouraged wherever possible
- open space and recreational space should be accessible to every neighbourhood
- public space should be human scale, well designed and encourage concentrated and varied activity
- neighbourhoods should have diverse housing to enable people of a wide range of ages and economic levels to live there
- housing, neighbourhoods and cities should be planned to maximise energy and water efficiency and resilience
- planning for industry and freight should include consideration of neighbourhood amenity as well as economic efficiency
- regional residential and employment land use should be built around public transport
- regional institutions and services should be located in urban areas

[18] This point was not included in the ADC (2010) listing but has been added following discussion at the subsequent ADC National Infrastructure and Cities Summit in March 2014.

- cities should have the capability to respond to disasters and the resilience to respond and rebuild.

In many instances these planning principles are reflected in the land use transport plans that have been released by Australia's capital cities in the past two to three years. Economic instruments, particularly marginal social cost pricing, can be an effective way to support implementation of some of these planning directions and understanding of structural economic influences is vital for the most effective deployment of policy measures in pursuit of high level goals.

Following the discussion in section 1 of the present report, we would add end-state outcome goals for social inclusion and GHG emission reductions at the vision statement/goal setting stage in capital city long term land use transport plans. The particular end-state goals we would propose involve (1) supporting minimum public transport service levels, to support capabilities and associated social inclusion, and (2) aggressive transport GHG emission reduction targets, to help ensure the sector plays a significant role in contributing to the easing of global warming pressures (while also contributing to cleaner air and its associated safer urban living). The GHG emission target constraint, in particular, we believe implies a need for transformational changes in land transport, rather than continuing the incremental changes of the past, which have only served to see an inexorable increase in transport GHG emissions. We have argued that the urban transport sector should be expected to deliver GHG emission cuts of about 80 per cent by 2050 and expect that this would require new motor vehicles to be virtually emission-free by 2035. We have also indicated that achievement of the following outcomes by 2050 would help to deliver the 80 per cent cut:

- a 10 per cent cut in car VKT travelled in our cities, against current levels
- the mode share for urban trips that is provided by walking, cycling and public transport increasing from about 24 per cent in 2007 (across capital cities) to about 45 per cent (if car VKT increase, then this mode share needs to increase as an offset)
- Car occupancy rates increasing by about 0.3 persons (from 1.4 to 1.7 across cities)
- road freight productivity increasing by about 30 per cent.

Vancouver is aiming for a slightly larger mode share for active (walking and cycling) plus public transport (50 per cent) and is targeting zero growth in car VKT by 2050, so the first two of these supportive 'targets' are certainly in the realm of feasibility. A 30 per cent improvement in freight productivity over 40 years requires only a 1 per cent cumulative annual rate of improvement, which should also be achievable. Developments such as Uber could help to lift car occupancy rates over time, supported by incentives to car sharing (e.g., roll out of more high occupancy vehicle lanes). While these magnitudes of change have initially been formulated in the present paper from consideration of cutting GHG emissions, they will also deliver substantial co-benefits in areas such as congestion mitigation, a lower road toll, cleaner air, increased energy security, and a healthier population. Separate and complementary land use transport policy directions are needed for productivity and inclusion.

4.2 Major policy directions

In summary, from an economic viewpoint, improving the sustainability of our urban transport/mobility systems we see is essentially about pursuing four main strategic land use transport policy directions:

1. **supporting the clustering of economic activities** in a select number of inner and middle urban high tech nodes, to promote productivity growth and a wider sharing of the benefits of this productivity growth. It has been shown that an accelerated infrastructure investment program can lift the rate of productivity growth and, if well targeted, can be self-funding in terms of government revenue gains. The idea of clustering also extends to how we plan neighbourhoods, where clustering is likely to support some local job growth. Spatial economic sustainability is rarely included in discussion about sustainable mobility/accessibility/transport but is very important because of the role of transport in supporting effective urban density, which is an important driver of productivity. Achieving a more compact city will reduce travel distances, a useful indicator of a sustainable transport system (i.e., VKT)
2. **changing the modal balance for transport of people and goods** away from such a high dependence on motor vehicles and more towards methods of transport with less adverse impact on the triple bottom line. This will reduce a number of external costs of urban travel
3. **improving the environmental performance of all transport modes** but particularly of cars and trucks, because of their dominant roles. In this domain, we have suggested a need for new cars, in particular, to be essentially GHG emission-free by about 2035, with trucks well down the same path by that time. An end-state goal related to absolute transport GHG emissions at 2050 has been suggested, based on cuts of about 80 per cent on 2000 levels by 2050
4. **ensuring that travel opportunities (and, by implication, the associated activities they support) are available to all, irrespective of personal circumstances**. This will help to better meet human needs for all urban dwellers. We see the implementation of minimum public transport service levels as an effective way to meet this goal area, supported by improving walking and cycling opportunities across each city. Improving access from outer urban areas to clusters of high tech employment in inner and middle suburbs is also an important way of enhancing social inclusion.

The four urban transport policy objectives can be translated into **five major action areas**, with indicative actions of the type shown below.

1. Support development of compact, mixed-use polycentric cities (reducing the requirement to travel to accomplish any given range of activities and promoting productivity growth)
    - Land use planning for more compact cities, focusing on building strong CBDs and a small number of high-end knowledge-based hubs; increased density across the whole city; more mixed-use planning; better jobs/housing

balance; development of '20 minute neighbourhoods'[19]; planning for 'last-mile' freight access)
    - Transport planning to promote clustering and the strengthening of neighbourhoods, in support of the 20 minute city, with protection from heavy vehicle intrusion
2. Promote a mode shift to low carbon transport modes
    - From cars to public transport, walking and cycling (e.g., road pricing - as per section 3.6; PT service improvements; comprehensively designing active transport opportunities in to cities, at regional and local levels)
    - From trucks to rail for freight (e.g. road pricing, development of inland freight hubs)
3. Improve vehicle utilisation
    - Higher car occupancy rates (e.g., priority to, and policing of, high occupancy lanes on freeways and major arterials)
    - More efficient freight movements (e.g., freight-only roads; accelerated vehicle performance-based standards innovation for productivity)
4. Reduce vehicle emissions intensity (esp. with respect to GHG emissions and air toxics)
    - More efficient vehicles (mandatory GHG, air and noise emission standards)
    - Smaller passenger vehicles (e.g. pricing reforms)
    - Alternative fuels
    - Intelligent transport systems
    - Better driving practices
5. Increase mobility opportunities, especially for people at risk of transport-related social exclusion
    - Provision of reasonable base public transport service levels (as discussed in section 3.5)
    - Urban design to increase opportunities for active travel.

The logic flow of this approach is summarized in Figure 4.1. Figure 4.2 shows how the five action areas positively impact on a number of the major urban land transport issues discussed in this paper. Pricing reform could be listed as a sixth (separate) action area, since it is a useful instrument in contributing to most policy directions. Most measures can help to address several of the critical issues, underlining the importance of integrated land use/transport planning for realization of potential co-benefits.

[19] These are neighbourhoods from which people can undertake most of the activities needed for a good life within 20 minutes by foot, bicycle or public transport. Melbourne's new long term land use plan, Plan Melbourne, has promoted this model (DTPLI 2013).

	KEY SUSTAINABILITY DIMENSIONS	**LAND USE/TRANSPORT ACTION AREAS**
	Economic Productivity - agglomeration - congestion - energy security	Support development of mixed-use, clustered, more compact cities
Meeting current human needs (& respecting species rights)	Social inclusion - min. PT service levels - active travel opportunities	Increase mobility opportunities, esp. for at-risk people
		Improve vehicle utilization
Meeting future human needs (& respecting species rights)	Environment - air quality(/noise) meeting health standards	Promote a mode shift to low carbon transport modes
	- GHG emissions to support global climate objectives	Reduce vehicle emissions intensity

Figure 4.1: Sustainable urban mobility/transport framework

Figure 4.2: Alignment of land use transport action areas measures and their expected policy benefits

Critical urban land transport issue	**1. Support more compact urban development patterns**	**2. Mode shift to walking, cycling and public transport**	**3. Improve vehicle utilisation**	**4. Reduce vehicle emissions intensity**	**5. Increase personal mobility opportunities**
Urban productivity (inc. congestion management)	Yes, particularly linked to developing strong a CBD and key knowledge-based nodes	Yes, with suitable infrastructure provision, to ensure congestion is not shifted to another mode	Yes, provided traffic generation is managed	Neutral	Yes, because of the link between equality and economic output
Greenhouse gas emissions/air quality	Yes	Yes	Yes	Yes	Depends on how provision is made. Low emission modes best.
Social exclusion	Should target shortening trip lengths, not eliminating activities	Yes. Because these means of travel are low or no cost, they are inherently relatively inclusive.	Yes. This is a common way people at risk of social exclusion improve their mobility options	Price increases may have negative impacts	Yes
Energy security	Yes	Yes	Yes	Yes	Yes
Safety/health	Yes	Yes	Yes	Yes	Yes

4.3 Spatial application in Australian cities

The broad policy directions outlined above are relevant to all Australian large cities. In terms of application, Stanley (2014b) highlights five issues that seem likely to be important for successful development and implementation through integrated land use transport strategies:

1. the central area is very important for a productive city and its growth should be supported. However, the CBD but does not account for most jobs or residences in any capital city. Its needs should not dominate those of the rest of the city
2. structural economic changes are increasing the importance of the central city but also of parts of the 'forgotten middle suburbs', as places for future employment growth, population growth and urban renewal. Accessibility improvement is critical in enabling these middle suburban areas to play a greater role. This improvement is mainly about systemic and programmatic changes in arterial roads and bus services, particularly for movement around the city (not just radially), and for walking and cycling to support more compact urban form. Improving access from outer urban areas to the job-rich middle suburbs is important
3. a strategic approach to land use transport integration should look both regionally and locally, the latter focusing on the way a neighbourhood functions. It is unusual to see both done in strategic land use/transport studies (which tend to be top down) but very important in terms of citizens' wellbeing. Future land use transport planning should devote more attention to the local level
4. long term integrated land use transport strategies should be intimately linked to (integrated with) short to medium term (5-10 year) implementation plans, that specify the particular project initiatives intended to be to be undertaken, financing/funding plans and governance arrangements for delivery[20]
5. in preparing both long term and short to medium term strategies/plans/actions, community engagement should be seen as both a right of communities and a practical way of improving content and prospects for implementation.

Applying the policy directions and action areas outlined above to land use development in Australian capital cities, and taking account of the preceding five points, suggests that priority should be accorded to:

1. promoting agglomeration economies in the CBD/inner city and in a small number of selected mixed-use, knowledge-based suburban hubs, due to the productivity benefits associated therewith (e.g., Parramatta in Sydney and the Monash precinct in Melbourne). Our feel is that there is a case for about one high tech node per million people living in a city (this needs further research). Radial road capacity can never hope to adequately serve more than a minor part travel demands to high density nodes efficiently and effectively, particularly for CBDs. In transport terms, then, a strong CBD and surrounds is primarily about ensuring that adequate trunk public transport capacity is available to facilitate growth. Public transport is also crucial to strong suburban knowledge-hubs. With CBDs and key suburban knowledge hubs accounting for a significant portion of national GDP growth, the Federal Government should have a strong interest in supporting transport initiatives that facilitate further development in such precincts, including public transport improvements
2. supporting precinct scale urban renewal more broadly, including unlocking capacity in the most accessible parts of the middle suburbs (e.g., transit-oriented development),

[20] Space has precluded consideration of governance arrangements in the present paper.

especially where these areas are relatively job-rich. This implies a need for good radial and circumferential accessibility, including by public transport. The latter, in turn, requires high quality road capacity to support circumferential movement of cars, road-based public transport, with on-road PT priority where possible, and freight movement, in and through middle suburban areas (crossing and supporting trunk radial rail lines and linking activity centres). High frequency trunk PT services should be provided along these circumferential corridors and good quality opportunities for walking/cycling should be provided within and to/from activity centres

3. improving accessibility for outer urban residents, particularly those living in growth corridors to areas of employment concentration. For person movement, this means providing adequate arterial road capacity and high quality trunk PT services between outer suburbs and the most proximate employment hubs in the local vicinity and middle suburbs, where jobs are more readily available
4. supporting freight and logistics movements, tourism and other trade-exposed businesses, through a focus on key trunk demand corridors and major freight hubs (e.g., ports, airports, manufacturing/logistics hubs)
5. supporting strong and sustainable neighbourhoods/communities, which requires an emphasis on providing local public transport services and walking and cycling opportunities, connecting with trunk services, at a frequency that will help to facilitate social inclusion. The analysis in section 2 also identified the important role of social/cultural and community infrastructure in attracting talent, underlining the importance of taking a broad approach to integrated policy and planning for outcome achievement (at both regional and local levels)
6. ensuring that the land use transport plan development process provides choices or options for people to consider during the plan development process. When availability of funding is scarce, it is important that people have the opportunity to reflect on choices, and the associated trade-offs that will follow from those choices, when they consider their preferences for overall strategies/plans or elements.

A recent review of the land use transport plans for Adelaide, Sydney and Melbourne has suggested that these broad directions are increasingly being reflected in Australian capital city long term land use transport plans but suggests that there is too much focus on a few big projects, insufficient emphasis on improving accessibility more widely across our cities and little focus at neighbourhood level (Hansen and Stanley 2014), the latter implying that social and community infrastructure typically receives insufficient attention. Land use transport plans are still too narrowly conceived. Also, Australian capital city land use/transport plans do not typically set strong targets in terms of social inclusion or GHG emissions, they rarely (if ever) report expected trends in GHG emissions if plans are implemented, and funding plans are rarely included. These are all areas for improvement in terms of the value perspectives set out in the current paper. They imply a need to examine governance arrangements that will be supportive of more integrated policy and planning frameworks.

In terms of the phasing of cluster developments included above, the analysis in section 2 suggests that the best strategy is one which:

1. short term, strengthens existing clusters and catchment integration
2. at the same time allocates foundation investments to potential or emerging clusters
3. over the medium term drives rapid growth in the clusters in 1 and allows those in 2 to further mature
4. uses land use planning, both directly and via the distribution of population growth, to maximize the outcomes of 1, 2 and 3 and
5. relates all decisions to the objectives of raising employment and income and increasing regional equality. Environmental, social and process goals are also still applicable.

Freeway/tollway extensions/expansions figure prominently in some cities' land use transport plans but pose a challenge in terms of the above strategic directions. They usually satisfy the general purpose of involving a substantial increase in infrastructure spending and, to that extent, are likely to support urban productivity growth to some extent. However, over time, such projects are also very likely to increase vehicle kilometres of travel, with associated (unpriced) external costs.[21] Pricing reforms should be in place to mitigate such additional external costs (including externality pricing of tollways) and integrated land use transport plans should set specific outcome targets to reduce the risks of unintended adverse consequences from major additions to the road network. Detailed project cost-benefit studies should be published as a matter of course, to demonstrate that the best major projects have been chosen, projects that are most consistent with the city's desired development directions and other goals, and that unwanted external costs are not exacerbated by the project(s). This is not always done. Road projects that assist movement around the city and concentrate on freight movements are less likely to be a concern than those whose major focus is radial people movements. These are often best served by public transport (which may include a road component, in the case of Bus Rapid Transit or light rail).

The current investment in city infrastructure across a number of sectors is huge. Making the most effective use of that existing infrastructure base is a fundamental pre-condition for productivity. Pricing reforms to internalize the various external costs of road travel within road prices that users must pay, and also to make public transport fares more cost reflective (subject to meeting social inclusion outcome objectives), will help to drive the kinds of behavioural changes that are implicit in many of the required travel change outcomes and also to improve the efficiency with which the existing transport asset base is used. As well as pricing reforms, there are also other ways in which existing transport infrastructure in our cities can be used more efficiently, such as by:

- use of smart systems to optimise demand/supply balances (e.g., freeway ramp metering to regulate flows onto congested freeways, increasing flow capacity by about one-fifth)
- free or discounted public transport for travel before or after peak usage times, an example of load shifting

[21] We note that Vancouver has solved this conundrum by not proposing major new freeways, over the past 40 or so years.

- use (and policing) of high occupancy vehicle lanes to raise the passenger carrying capacity of the road system.

Integrated approaches to improving the performance of our cities must ensure that first bases are covered and that existing infrastructure efficiency is optimised before expensive upgrades are entertained.

4.4 Needs identification and project evaluation

The way major transport projects are evaluated is currently in a state of some flux. Traditional cost-benefit analysis (CBA), which has developed over the past fifty or so years for transport project evaluation, has focused mainly on user benefits/costs and implementation/operating costs, with external costs progressively being added over time, within a 'willingness-to-pay' economic framework (Stopher and Stanley 2014). Important recent additions within this economic framework have included wider economic benefits (e.g., agglomeration benefits), largely driven by UK research, and social inclusion benefits, primarily driven by Victorian research (Stanley et al. 2011 a, b; 2012). A recent trend in the UK, however, has been to move away from the traditional CBA approach and focus primarily on expected GDP benefits and GHG emissions outcomes, linked to the evolution of the UK Cities Deal (between the national government and major cities, such as Manchester and Leeds).

This change seems to be partly due to shortcomings in analysts' abilities to forecast just how major transport interventions will affect city spatial development patterns and associated travel arrangements. Generated traffic and unexpected urban sprawl, for example, challenge the assumptions on which traditional transport CBA has been built, because such flow-on effects have external costs that are rarely included in analyses. Unless these flow-on external costs are recognized and included in the analysis, they contradict some of the assumptions that are needed for the traditional economic approach to be a valid way of measuring benefits and costs.

Bridging between the traditional and narrower GDP/GHG approach requires a much better understanding of how urban economies work, particularly in terms of residential and business location choices, the way these dynamic markets affect travel behavior, associated external benefits/costs and how transport interventions will work their way through urban systems. A new evaluation model framed to handle these richer understandings is currently under development at Sydney University's Institute of Transport and Logistics Studies, under the leadership of Institute Director Professor David Hensher. This will enable traditional and GDP oriented approaches to be included within an integrated evaluation framework. It should provide valuable insights into how to best shape our cities and transport systems for sustainable mobility.

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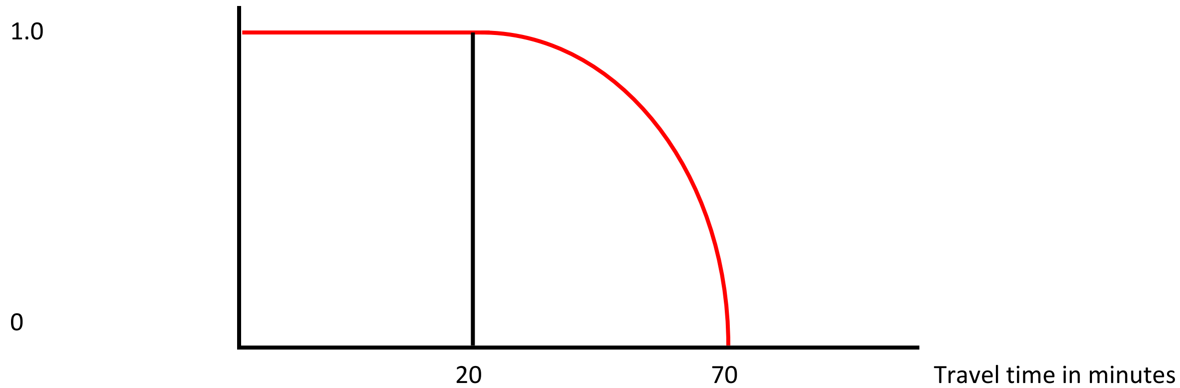
Appendix A1: Data used in NIEIR modelling

All data for Sydney-Melbourne is Local Government Area (LGA) based. The headline gross regional product (GRP), productivity (or GRP per hour worked) and industry employment indicators all apply to the level of economic activity generated within an LGA boundary. The word 'resident' applied to the same indicators represents the capture of the indicator by the residents of an LGA, irrespective of source. Clearly, employment and hours of work achieved by residents of an LGA will be sourced from across a number of LGAs.

From the resident perspective, what is important is not so much their own LGA so much as those LGAs that the resident can effectively access, represented by the labour market and economic catchment of the residents of a given LGA. For a given LGA the catchment is defined in the present paper terms of the following. Those LGAs that can be accessed within a 20 minute travel time receive a weight of 1. Those LGAs that can be accessed within a 20 to 70 minute travel time receive a weight which declines in accordance with the pattern in Figure A.1.

Figure A.1: Catchment weights



The NIEIR database contains 2-digit ANZSIC industry series for employment hours of work, sales, exports, gross product, etc. In terms of the indicators presented in this study, the industry classification is either 'high technology' or 'all industry'. Table A.1 classifies the list of 2-digit ANZSIC industries as either high technology, medium technology or low technology industries. The indicators presented for high technology industries are the result of summing the individual 2-digit high technology industries. The central region referred to is the City of Melbourne or Sydney LGA.

Table A.1:	The grouping of industries into low, medium and high technology		
Industry	**Tech classification**	**Industry**	**Tech classification**
Agriculture	M	Accommodation	L
Aquaculture	M	Food and beverage services	L
Forestry and logging	L	Road transport	L
Fishing, hunting and trapping	M	Rail transport	L
Agriculture, forestry and fishing support services	H	Water transport	L
Coal mining	M	Air and space transport	L
Oil and gas extraction	M	Other transport	L
Metal ore mining	M	Postal and courier pick-up and delivery services	L
Non-metallic mineral mining and quarrying	M	Transport support services	M
Exploration and other mining support services	H	Warehousing and storage services	L
Food product manuf.	M	Publishing (except internet and music publishing)	H
Beverage and tobacco product manuf.	M	Motion picture and sound recording activities	H
Textile, leather, clothing and footwear manuf.	M	Broadcasting (except internet)	H
Wood product manuf.	M	Internet publishing and broadcasting	H
Pulp, paper and converted paper product manuf.	M	Telecommunications services	H
Printing (including reproduction of recorded media)	M	Internet service providers, web search portals and data processing services	H
Petroleum and coal product manuf.	H	Library and other information services	H
Basic chemical and chemical product manuf.	H	Finance	H
Polymer product and rubber product manuf.	H	Insurance and superannuation funds	H
Non-metallic mineral product manuf.	M	Auxiliary finance and insurance services	H
Primary metal and metal product manuf.	M	Rental and hiring services (except real estate)	L
Fabricated metal product manuf.	H	Property operators and real estate services	L
Transport equipment manuf.	H	Professional, scientific & technical services (except computer system design & related services)	H
Machinery and equipment manuf.	H	Computer system design and related services	H
Furniture and other manuf.	M	Administrative services	M
Electricity supply	M	Building cleaning, pest control & other support services	M
Gas supply	M	Public administration	M
Water supply, sewerage and drainage services	M	Defence	L
Waste collection, treatment and disposal services	M	Public order, safety and regulatory services	L
Building construction	M	Preschool and school education	M
Heavy and civil engineering construction	M	Tertiary education	H
Construction services	M	Adult, community and other education	H
Basic material wholesaling	L	Hospitals	H
Machinery and equipment wholesaling	L	Medical and other health care services	M
Motor vehicle & motor vehicle parts wholesaling	L	Residential care services	L
Grocery, liquor and tobacco product wholesaling	L	Social assistance services	L
Other goods wholesaling	L	Heritage activities	M
Commission-based wholesaling	L	Creative and performing arts activities	H
Motor vehicle and motor vehicle parts retailing	L	Sports and recreation activities	L
Fuel retailing	L	Gambling activities	L
Food retailing	L	Repair and maintenance	M
Other store-based retailing	L	Personal and other services	L
Non-store retailing and retail commission based buying	L	Private households employing staff and undifferentiated goods	L

Appendix A2: Housing data

Table A2.1	Sydney Central: Housing					
Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	478.5	681.7	773.1	3	4	3.1%
Avg dwelling prices to household disposable income (%)	4.5	5.6	5.6	2	3	1.4%
Mortgage burden on average dwelling purchase (%)	36.0	44.6	45.0	2	3	1.4%
Greenfield construction costs to avg dwelling price (%)	77.7	82.4	80.2	64	60	0.2%
Catchment dwelling purchase income support ($cvm)	86499	105475	112313	5	10	1.7%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	44.2	51.6	54.9	4	5	1.4%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	34.3	42.5	44.1	23	18	1.6%
Adult population per dwelling	2.0	2.0	2.1	56	43	0.2%

Table A2.2	Sydney Eastern Beaches: Housing					
Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	554.6	890.8	973.5	1	1	3.6%
Avg dwelling prices to household disposable income (%)	4.6	5.7	5.5	1	4	1.2%
Mortgage burden on average dwelling purchase (%)	36.5	45.5	44.3	1	4	1.2%
Greenfield construction costs to avg dwelling price (%)	67.0	63.1	63.7	66	66	-0.3%
Catchment dwelling purchase income support ($cvm)	94511	118263	125873	3	5	1.8%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	46.8	60.1	61.7	1	2	1.8%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	31.4	37.9	39.3	33	33	1.4%
Adult population per dwelling	2.0	2.0	2.1	48	29	0.3%

Table A2.3	Sydney Northern Beaches: Housing					
Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	552.3	899.6	905.0	2	2	3.2%
Avg dwelling prices to household disposable income (%)	4.4	6.1	4.9	3	10	0.8%
Mortgage burden on average dwelling purchase (%)	34.7	48.8	39.4	3	10	0.8%
Greenfield construction costs to avg dwelling price (%)	67.3	62.5	68.5	65	65	0.1%
Catchment dwelling purchase income	98672	125886	134151	2	3	2.0%

support ($cvm)						
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	44.7	57.0	53.8	3	6	1.2%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	30.1	35.6	36.9	39	40	1.3%
Adult population per dwelling	2.1	2.1	2.2	16	23	0.2%

Table A2.4 Sydney Old West: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	335.1	542.7	652.0	7	9	4.3%
Avg dwelling prices to household disposable income (%)	4.2	6.1	6.3	4	1	2.5%
Mortgage burden on average dwelling purchase (%)	33.8	49.0	50.1	4	1	2.5%
Greenfield construction costs to avg dwelling price (%)	110.9	103.5	95.1	51	50	-1.0%
Catchment dwelling purchase income support ($cvm)	85886	104130	111106	6	11	1.6%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	31.1	41.6	46.8	13	12	2.6%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	34.5	43.1	44.5	20	17	1.6%
Adult population per dwelling	2.2	2.2	2.3	10	12	0.2%

Table A2.5 Sydney Outer North: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	476.1	718.6	791.8	4	3	3.3%
Avg dwelling prices to household disposable income (%)	3.3	4.9	4.5	10	13	1.9%
Mortgage burden on average dwelling purchase (%)	26.5	39.1	35.7	10	13	1.9%
Greenfield construction costs to avg dwelling price (%)	78.1	78.2	78.3	63	62	0.0%
Catchment dwelling purchase income support ($cvm)	86771	103489	110062	4	12	1.5%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	43.8	55.4	57.4	5	4	1.7%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	34.2	43.3	45.0	25	15	1.8%
Adult population per dwelling	2.4	2.3	2.4	3	4	0.1%

Table A2.6 Sydney Outer South West: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3	2014.2	Annual

				Rank	Rank	Growth 1998-14
Avg value of dwellings ($cvm '000s)	203.0	392.7	400.5	21	25	4.4%
Avg dwelling prices to household disposable income (%)	2.6	4.6	4.1	21	22	2.8%
Mortgage burden on average dwelling purchase (%)	21.1	36.5	32.4	21	22	2.8%
Greenfield construction costs to avg dwelling price (%)	192.3	150.3	162.7	5	5	-1.1%
Catchment dwelling purchase income support ($cvm)	65365	73579	79712	25	40	1.3%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	24.8	42.6	40.1	27	23	3.1%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	47.7	64.0	65.2	5	4	2.0%
Adult population per dwelling	2.2	2.2	2.4	9	6	0.4%

Table A2.7 Sydney Outer West: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	194.8	385.0	398.3	24	26	4.6%
Avg dwelling prices to household disposable income (%)	2.4	4.6	4.0	30	24	3.3%
Mortgage burden on average dwelling purchase (%)	19.4	36.4	32.1	30	24	3.3%
Greenfield construction costs to avg dwelling price (%)	200.4	153.3	163.6	3	4	-1.3%
Catchment dwelling purchase income support ($cvm)	62307	66016	72468	31	50	1.0%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	25.0	46.6	43.9	26	16	3.6%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	50.0	71.4	71.8	3	3	2.3%
Adult population per dwelling	2.2	2.2	2.3	14	9	0.3%

Table A2.8 Sydney Parramatta Bankstown: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	261.2	440.9	490.4	11	14	4.1%
Avg dwelling prices to household disposable income (%)	3.3	5.6	5.2	11	8	2.9%
Mortgage burden on average dwelling purchase (%)	26.2	44.5	41.1	11	8	2.9%
Greenfield construction costs to avg dwelling price (%)	142.3	127.4	126.5	33	24	-0.7%
Catchment dwelling purchase income support ($cvm)	80921	95890	102564	9	16	1.5%
Dwelling affordability - average mortgage on existing dwelling to catchment income	25.8	36.7	38.2	23	28	2.5%

support (%)						
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	36.7	46.8	48.3	17	13	1.8%
Adult population per dwelling	2.3	2.3	2.4	5	3	0.3%

Table A2.9 Sydney South: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	393.4	600.9	668.9	6	7	3.4%
Avg dwelling prices to household disposable income (%)	3.9	6.0	5.5	6	5	2.1%
Mortgage burden on average dwelling purchase (%)	31.4	47.8	43.9	6	5	2.1%
Greenfield construction costs to avg dwelling price (%)	94.5	93.5	92.7	62	51	-0.1%
Catchment dwelling purchase income support ($cvm)	81710	98695	105536	8	14	1.6%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	38.4	48.6	50.6	7	8	1.8%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	36.3	45.4	46.9	18	14	1.6%
Adult population per dwelling	2.2	2.2	2.3	11	13	0.2%

Table A2.10 NSW Illawarra: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	223.5	417.0	415.2	15	24	4.0%
Avg dwelling prices to household disposable income (%)	3.1	5.0	4.4	15	14	2.3%
Mortgage burden on average dwelling purchase (%)	24.5	40.1	34.8	15	14	2.3%
Greenfield construction costs to avg dwelling price (%)	121.5	98.4	109.1	45	38	-0.7%
Catchment dwelling purchase income support ($cvm)	64363	75794	82359	26	34	1.6%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	27.7	43.9	40.2	21	22	2.4%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	33.7	43.2	43.9	27	19	1.7%
Adult population per dwelling	2.1	2.1	2.2	19	25	0.1%

Table A2.11 Melbourne City: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	297.7	435.5	492.8	8	13	3.3%

Avg dwelling prices to household disposable income (%)	3.2	4.3	5.2	13	9	3.0%
Mortgage burden on average dwelling purchase (%)	25.7	34.6	41.1	13	9	3.0%
Greenfield construction costs to avg dwelling price (%)	110.0	111.7	106.8	52	41	-0.2%
Catchment dwelling purchase income support ($cvm)	70833	91262	101877	17	18	2.3%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	33.5	38.1	38.6	10	27	0.9%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	36.9	42.5	41.2	14	28	0.7%
Adult population per dwelling	1.9	1.9	1.8	65	67	-0.5%

Table A2.12 Melbourne Eastern Inner: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	285.7	567.0	764.4	10	5	6.4%
Avg dwelling prices to household disposable income (%)	2.9	5.1	6.0	17	2	4.8%
Mortgage burden on average dwelling purchase (%)	22.9	41.1	48.0	17	2	4.8%
Greenfield construction costs to avg dwelling price (%)	114.6	85.8	68.8	48	64	-3.2%
Catchment dwelling purchase income support ($cvm)	69367	88934	99809	19	21	2.3%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	32.9	50.9	61.1	11	3	4.0%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	37.7	43.7	42.1	12	23	0.7%
Adult population per dwelling	2.2	2.2	2.3	12	10	0.2%

Table A2.13 Melbourne Eastern Outer: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	195.3	385.3	466.7	23	18	5.7%
Avg dwelling prices to household disposable income (%)	2.4	4.2	4.3	31	17	3.8%
Mortgage burden on average dwelling purchase (%)	19.1	33.5	34.3	31	17	3.8%
Greenfield construction costs to avg dwelling price (%)	134.8	101.5	90.7	38	54	-2.5%
Catchment dwelling purchase income support ($cvm)	66448	84623	95348	22	25	2.3%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	23.5	36.3	39.1	33	26	3.3%
Dwelling affordability - average mortgage on new dwelling to catchment income	31.6	36.9	35.4	31	45	0.7%

support (%)						
Adult population per dwelling	2.2	2.2	2.2	8	16	0.0%

Table A2.14 Melbourne Northern Inner: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	211.1	416.7	530.2	19	11	6.0%
Avg dwelling prices to household disposable income (%)	3.0	4.9	5.3	16	6	3.8%
Mortgage burden on average dwelling purchase (%)	23.6	39.5	42.5	16	6	3.8%
Greenfield construction costs to avg dwelling price (%)	155.2	116.7	99.2	24	48	-2.8%
Catchment dwelling purchase income support ($cvm)	71014	91873	103415	14	15	2.4%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	23.7	36.2	40.9	31	20	3.5%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	36.8	42.3	40.6	16	30	0.6%
Adult population per dwelling	2.1	2.1	2.1	18	34	0.0%

Table A2.15 Melbourne Northern Outer: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	174.7	327.0	370.7	33	31	4.9%
Avg dwelling prices to household disposable income (%)	2.2	3.8	3.8	39	28	3.7%
Mortgage burden on average dwelling purchase (%)	17.3	30.1	30.5	39	28	3.7%
Greenfield construction costs to avg dwelling price (%)	150.8	119.6	114.2	28	35	-1.8%
Catchment dwelling purchase income support ($cvm)	72467	94352	107026	12	13	2.5%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	19.2	27.7	27.6	49	52	2.3%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	29.0	33.1	31.6	48	56	0.5%
Adult population per dwelling	2.3	2.3	2.4	4	5	0.1%

Table A2.16 Melbourne Southern Inner: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	287.9	542.6	660.8	9	8	5.4%
Avg dwelling prices to household disposable income (%)	3.2	5.1	5.2	12	7	3.0%
Mortgage burden on average dwelling	25.8	40.6	41.3	12	7	3.0%

purchase (%)						
Greenfield construction costs to avg dwelling price (%)	113.8	89.7	79.6	49	61	-2.2%
Catchment dwelling purchase income support ($cvm)	70932	91143	101726	15	19	2.3%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	32.4	47.5	51.8	12	7	3.0%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	36.9	42.6	41.3	15	26	0.7%
Adult population per dwelling	2.0	2.0	2.1	43	33	0.2%

Table A2.17 Melbourne Southern Outer: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	156.7	322.7	385.5	42	28	5.9%
Avg dwelling prices to household disposable income (%)	2.1	3.9	3.9	42	26	4.0%
Mortgage burden on average dwelling purchase (%)	16.9	31.4	31.2	42	26	4.0%
Greenfield construction costs to avg dwelling price (%)	168.0	121.2	109.8	17	37	-2.7%
Catchment dwelling purchase income support ($cvm)	56635	64321	68255	46	56	1.2%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	22.1	40.0	45.1	36	14	4.6%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	37.1	48.5	49.5	13	12	1.8%
Adult population per dwelling	2.1	2.1	2.2	26	20	0.3%

Table A2.18 Melbourne Western: Housing

Housing Indicator	1998.3	2007.3	2014.2	1998.3 Rank	2014.2 Rank	Annual Growth 1998-14
Avg value of dwellings ($cvm '000s)	180.5	345.1	426.7	27	22	5.6%
Avg dwelling prices to household disposable income (%)	2.5	4.2	4.6	26	11	4.0%
Mortgage burden on average dwelling purchase (%)	19.8	33.3	36.6	26	11	4.0%
Greenfield construction costs to avg dwelling price (%)	145.9	113.4	99.2	31	49	-2.4%
Catchment dwelling purchase income support ($cvm)	72132	92715	102203	13	17	2.2%
Dwelling affordability - average mortgage on existing dwelling to catchment income support (%)	20.0	29.7	33.3	43	35	3.3%
Dwelling affordability - average mortgage on new dwelling to catchment income support (%)	29.1	33.7	33.0	46	54	0.8%
Adult population per dwelling	2.2	2.2	2.2	13	14	0.2%