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0 Overview

In common with many other countries, Australia's major cities face the challenges of sustaining employment and productivity growth while decoupling growth in a manner that reduces negative externalities, in particular greenhouse gas emissions and local air pollution. However, among developed nations, Australia is perhaps unique in terms of the likelihood of significant population growth over the next 30 – 50 years. A commonly stated view is that the population might increase by 60%, from a current 22 million to around 35 million. If the trends of the last 20 years are followed, over 95% of this increase will be in urban areas: the net growth in rural area population has been minimal over this period. Therefore, it is the urban areas and especially the nation's largest cities that will see the greatest share of future population growth. Australia's two largest cities might each have to accommodate a further 3 to 4 million residents and with them a further 2 to 2.5 million jobs.

The task is not limited to employment numbers, because productivity growth will be essential to provide the resources required to improve living standards, including the provision of better healthcare, education and public services. While much of the recent focus in research on cities, productivity and transport has been focussed on relationships between proximity or accessibility to economic mass and productivity, it must be remembered that transport's most direct impacts on productivity and productivity growth are through its impact on business costs and in enabling workers, suppliers and customers to interact, whether in city centres, on the periphery or around ports and airports. A significant increase in population will add economic mass, increase the availability and diversity of the labour pool and expand markets, which will tend to increase productivity through agglomeration effects. However, as is well known in economic geography analysis, there are also potentially powerful dispersal forces which arise because of higher (explicit or implicit) prices of fixed assets, including land, housing and transport infrastructure. Put more simply, there may be a tipping point at which urban growth reverses, when costs, including deadweight congestion costs, become too high in relation to the benefits. Thereafter the most likely outcome would be a less dense, lower productivity, lower growth economy.

City centres are the most productive locations in the knowledge economy, and still have scope to grow considerably, by using air space and the elevator. The constraints lie in moving people, so to avoid a reversal of agglomeration effects, investment in transport infrastructure and services is one essential component. However, new infrastructure in existing cities will be expensive, and urban land (at and below street level) is scarce and must be used productively. As we show, urban 'transport' land is more productive when used by pedestrians and by mass transit. Transport land productivity can also be increased by rationing its peak time use through market mechanisms, which will ensure the highest value use of that resource. This is well known, but politically difficult. Other measures must reinforce planning and market mechanisms, especially in shaping urban form to increase use of the most productive transport modes. What distinguishes Australia is population growth, which implies that large numbers of new residents will be seeking residential and business locations. This means that, over time, mechanisms can be engaged to shape location choices which make the most productive use of space, and in turn make best use of people's time by reducing the deadweight of congestion.

1 Cities and the transport task

The focus of this paper is on enabling urban growth. We have adopted this focus for two reasons. First, it is highly likely that most of the population growth forecast in Australia will be in cities, and therefore, at a minimum, cities need to be able to function at a significantly larger scale than now. And second, cities have been, and are likely to continue to be, engines of growth in the economy, due to direct and indirect effects of urban mass on productivity and on productivity growth. Urban growth on the scale associated with a 60% increase in population will massively increase demands for personal travel. A basic premise of the paper is that per capita demand for travel will not decline over this period – in other words, we expect that the 'people task' is going to increase[1], thanks to a combination of more people, higher incomes and, more people in employment and more peak time demands on transport for travel to work. Growth in population, employment and incomes will therefore drive growth in the aggregate number of occasions of travel for work, business and leisure, including tourism. If there is also further dispersal of or increasing separation between places of residence and work, travel distances will also tend to increase.

While we cannot predict future virtual technologies, these will have some impact on travel demand, especially in relation to travel to work: the significance of travel to work is of course that it is highly peaked, and therefore any forces which deliver 'peak lopping' will reduce the need for additional network capacity. In contrast to freight movements[2], one might therefore look to new technologies to change elements of the 'people task'. For example, future technology might enable businesses to create effective virtual offices, so that growth in travel to work volumes into city centres can be de-coupled from growth in employment. We can already envisage a future in which some types of work will involve a greater level of home-based activities, due to the use of information and communication technologies (ICT). However, the experience of the last 20 years has been that, thanks to ICT, the demand for personal contact has increased rather than decreased. It has been suggested that ICT expands market reach, but personal contacts continue to be required to create transactions. Therefore if technology and competition continue to drive growth of domestic and international business to business transactions, the level of face to face business dealing might expand at a similar or faster rate than income growth. Similarly, the evidence of city centre growth indicates that businesses in much of the services sector believe there are benefits of being close to each other, and of bringing employees together in a physical space in order to work collaboratively.

There are, therefore, considerable uncertainties with regard to the role of technologies that might impact on work and business travel. Additionally, investment in any new technology will be expensive for early adopters and will involve risks, for example in terms of employee productivity. Businesses might, therefore, reduce their reliance on city centre offices, for example by allowing some home working and hot-desking within the urban office, but the

[1] In parallel there is a freight task, which is measured in tonne-kilometres. This is expected to treble if population increases by 60%

[2] Most organisations already hold virtual meetings, for example using video links, but physical movement of actual products is necessary for the consumption of goods such as groceries and clothing, and for intermediate inputs such as grain and coal.

impacts such changes on peak travel demand might be limited. Certainly, based on current evidence, the benefits to businesses of collaborative working and physical co-location with other businesses appear to be strong.

The role of improvements in transport – broadly defined - has been twofold. First, better transport reduces business costs and impacts on the labour market: this is a direct effect on productivity which we largely take as given. Second, transport improvements impact on urban form, specifically transport has enabled the urban form that allows more people to get together in physical spaces in order to work collaboratively while also satisfying people's demands for residential quality, variety and scale. The evolution from horse-drawn vehicles to streetcars, trams and cars has enabled higher volumes of travel and a greater separation between home and work-place, while the elevator has enabled the air space above city centre floorplates to be used more intensively through high rise developments. Together the horizontal and vertical technologies have simultaneously enabled urban land to be used more productively than it was 100 years ago: the scale of activity that can be undertaken per square metre of built land is greater thanks to the elevator (and building technologies), while urban street space is used more productively than in the era of non-motorised transport. We return to the productivity of street-space later in this paper, but we note here that while there remains considerable potential for the increased use of air space in our cities, there are significant constraints on expanding the quantity of urban core street-space: consequently, a key theme is how to increase the productivity of that space.

The reason why urban space productivity matters is that dense clusters of activity – economic mass – within an area such as a CBD are more productive there than if they were spatially dispersed. Simple observation shows that this is the case. CBD businesses pay the highest floor-space costs in the region, and do so because the benefits of being there exceed the costs. One of the reasons businesses co-locate is to have ready access to each other, and proximity reduces the time spent in travelling between locations. However, observation suggests that the propensity of people to interact is much stronger when distances are short. Interactions play a role in creating trust and understanding to enable transactions to take place, and they can be creative in that new ideas can emerge from both formal and informal contacts. There is some debate over whether the productivity benefits of interaction are due to the characteristics of the people, whereby smarter people might sort for larger centres or whether there is a size of place effect, whereby individuals with the same characteristics will be more productive by working in a larger place. We return to this in the next section.

The other reason why businesses seek city centre locations is that the centre usually coincides with the location with the densest (radial) transport networks, which provides maximum access to the labour force. This matters not only because businesses need workers, but also because labour is not homogenous: businesses have specialised needs and individuals have specialised skills or talents, and productivity is enhanced (and costs are avoided) by the successful and accurate matching of people to jobs. The impact on a business of failing to match people to high level jobs can be significant, both in terms of the costs of recruitment and termination, and the costs associated with poor job performance[3].

[3] In contrast, the consequences of a poor match in less specialised areas of work are likely to be much smaller.

Where severe transport constraints exist, city centre businesses could also have unfilled job vacancies[4]. This would give rise to a direct and negative impact on productivity, because those who are unable to travel to the centre will work in less productive jobs elsewhere[5].

The availability of transport capacity at peak times therefore plays the key role in enabling people to access the dense urban core, and a lack of transport capacity at peak periods will limit the growth of employment in an urban centre and impact upon productivity growth. This is recognised, but unfortunately much of the work in transport policy has a short run focus, reflecting the constraints that transport deficiencies impose on the performance of cities right now. This short term focus may be understandable in places like Europe, where urban form is largely settled, where population growth is low and where migration is limited and takes place primarily within a local area. This is not the context within which Australia needs to plan its future transport: in contrast to Europe, population growth is expected to be significant, with large numbers of new migrants likely to choose the major cities in preference to smaller ones or rural areas. In this context, the role of transport in shaping urban form through location choice, and the parallel influence of physical planning over transport demand, must be brought to the fore.

2 Urban size, agglomeration and productivity

This section looks further at the fundamental issue of why policies and resources should be devoted to enabling further growth of the cities; it considers the evidence on relationships between city characteristics and their economic performance. The underlying model of growth of the urban economy is one of supply side endogenous growth, in which the economy of a city or region grows by enabling more existing residents to join the employed labour force and by attracting more people who can participate in the labour force. Within this model, income per capita grows through increasing added value per worker: the critical insight is the relationship between change in size, productivity and productivity growth. Attracting labour depends on a range of factors including migration policies, housing costs and availability and real wages; better real wage prospects in an economically successful region will tend to attract more workers[6].

Increasing factor productivity is critical to sustaining economic growth in the long term. Productivity increases by using fewer inputs to produce a given output and by changing the structure of outputs towards higher added value areas. Key processes include greater exploitation of economies of scale, increasing the amount and quality of human and other capital employed and higher rates of exploitable innovation. Critical contributors towards structural changes include innovation, investment in research and development, the attraction of new businesses, technology transfer and business reorganisation to locate higher value functions within a region. The role of increased competition is less clear, in that there is a need for balance between competitive pressures to increase efficiency and cut costs on the one hand, and on the other hand, the need for constraints such as patents which are needed to reward research and development activity that generates innovations.

[4] And therefore could sell more output if it had the resources to produce that output.
[5] As discussed later, there may be further indirect impacts
[6] Industries such as mining attract workers, but the issue here is that of attracting and retaining workers who are also residents.

The existence of some form of relationship between economic mass and productivity is now well documented, and the literature on agglomeration has largely settled on the model set out by Duranton and Puga (Duranton & Puga, 2004) based on sharing (of resources and infrastructure), matching (especially between employers and employees) and learning (through the transmission of knowledge and ideas). However, these effects, while easy to state in qualitative terms, are extremely hard to distinguish quantitatively: this is especially the case with dynamic effects, whereby larger groupings of people promote a more rapid dissemination of ideas throughout a larger number of receptors, which enhances the likelihood of an idea being developed through to a new process or product.

In a 2009 OECD discussion paper (Estimating the Agglomeration Benefits of Transport Investments: Some Tests for Stability, 2009), Graham and Van Dender noted that quantitative work on agglomeration and productivity has been going on outside of the transport field for some 40 years. Most of these studies have been concerned with the effects of agglomeration on manufacturing industries and have used measures of city and industry size to represent urban and industrial agglomeration. As the authors note 'Generally, urban scale or density is found to have a positive and significant effect on productivity, with agglomeration elasticities for manufacturing industries typically found to be somewhere between 0.02 and 0.10.' There have been several other meta-analyses of the relationship between economic mass and productivity. For example, for the EU's 15 five largest countries, Ciccone (Agglomeration effects in Europe, 2002) obtained an estimate of the elasticity of approximately 0.05 for the economic mass – labour productivity relationship for the end of the 1980s period. Taking an average of the findings of various studies, doubling city size appears to increase productivity by around 3% to 8%. Actual scale also matters, as productivity has been estimated to be some 8 per cent higher in cities with populations of two million or more, compared with smaller cities (Rosenthal & Strange, 2004). The reason for a threshold is unclear. It is also dangerous to assume that Australian cities would exhibit similar mass – productivity relationships: Melo et al (A Meta-Analysis of Estimates of Urban Agglomeration Economies, 2009) carried out a meta-analysis of 729 measurements of agglomeration effects from 34 studies, and concluded that agglomeration estimates for any particular region might have little relevance elsewhere.

As Graham and Van Dender (Estimating the Agglomeration Benefits of Transport Investments: Some Tests for Stability, 2009) note, our understanding of the processes involving transport and other factors is currently somewhat limited, and it is possible that the mechanisms involve several complementary (and possibly also conflicting) elements which are present in different forms (or strengths) in different location. Nonetheless, the evidence does suggest that some other factors that could affect productivity might be discounted. In particular, the evidence indicates that larger cities are more productive because of agglomeration rather than factors such as natural advantage. Combes et al (The Productivity Advantages of Large Cities: Distinguishing Agglomeration from Firm Selection, 2009) concluded that 'while localised natural advantages are possibly important location determinants, accounting for them as carefully as possible does not detract much from their estimates of the magnitude of agglomeration economies in French regions' (Combes, Duranton, Gobillon, Puga, & Roux, 2009). Another possible explanation of productivity differences between regions is the role of competition. At low levels of transport (trade)

costs firms can locate in one region but service other markets by 'exporting'. As trade costs fall, firms in different locations lose the protection of distance, which adds to the costs faced by external firms and therefore each firm faces increased competition. This provides a survival of the fittest mechanism which would 'weed out' the least productive firms. However, Combes, Duranton, Gobillon, Puga and Roux (The Productivity Advantages of Large Cities: Distinguishing Agglomeration from Firm Selection, 2009) examined spatial productivity differences and the role of selection / competition within product markets, and concluded that selection could not account for productivity differences, which they ascribed almost entirely to differences in agglomeration.

Rice, Venables and Patacchini (Rice, Venables, & Patacchini, 2006) outlined an analytical framework which enabled them to investigate the relationship between variations in productivity in the UK and proximity to economic mass. A key finding was that the effects of economic mass decay very rapidly with driving time: the effects are greatest within 40 minutes and taper rapidly beyond that. The authors also estimated that more than one third of the productivity variations between areas are due to variation in their access to economic mass, and that this effect was more important for lower productivity areas. The framework enabled the effects on earnings to be decomposed into an occupational effect and a productivity effect, and the study found that most of the variations in earnings are explained by the productivity effect, which is attributed to proximity to economic mass. While regions with high productivity tended to have 'good' employment structures[7], there was no evidence of a systematic relationship between occupational structure and proximity to economic mass. The factors that might underlie the economic mass - productivity relationship are not explored; in addition the authors do note that there could be important differences within occupational categories, so that not all variations in the quality of jobs are controlled for.

Maré and Graham (Agglomeration Elasticities and Firm Heterogeneity, 2010) investigated the effects of firm level heterogeneity and non-random sorting of firms across space using a dataset from New Zealand. The authors use a range of specifications: the 'within local industry' model using industry specific production functions is intended to remove the influence of higher productivity firms sorting into high density regions (but is still affected by sorting within regions, which will tend to overstate the elasticity values). This is found to be the most reliable indicator. One interesting suggestion by the authors is that it is possible that firms which benefit most from density, rather than firms that have higher productivity per se, sort into the more dense locations. This seems plausible, although we would observe that the densest locations also tend to be the most expensive, so that firms located there must both benefit from density (or they would not be willing to pay for it) and must be productive, or they would not be able to pay for a dense location. The authors suggest that using the within industry model there is a possibility of negative sorting between areas combined with positive sorting within areas. There is, unfortunately, no discussion of the economic rationale for negative sorting between areas, if this is indeed what is happening.

There is evidence that the relationships between the quality of people in (or accessible to) an agglomeration and the size of the job market in that agglomeration play a critical role.

[7] Causation could run both ways here.

There is an emerging body of work on how people 'sort' for the most productive locations. An important study in this area was undertaken for the Northern Way by the LSE's Spatial Economics Research Centre (SERC, 2009). This study examined the productivity impacts of transport schemes and distinguished between place-based and people-based effects, and found that people based effects were strongly dominant. An absence of a place-based effect can be interpreted as saying that simply doubling the size of a city but at the same time replicating its existing population and industry base will have little impact on per capita productivity. Graham and Van Dender (Estimating the Agglomeration Benefits of Transport Investments: Some Tests for Stability, 2009) examined the robustness and reliability of productivity – economic mass elasticity estimates, especially for use in transport appraisal. They highlighted two issues that arise in estimating values. The first issue is reverse causality: Graham and Van Dender note that 'If reverse causality does exist then it implies estimation with endogenous regressors could give biased and inconsistent estimates of the agglomeration-productivity effect'. They also note that if causation runs principally from productivity to density, transport measures that increase density would have limited productivity benefits.

Graham and Van Dender (Estimating the Agglomeration Benefits of Transport Investments: Some Tests for Stability, 2009) also noted the existence of 'unobserved confounders' and indicated that variance in labour quality is a likely source of confounding. The argument here is that the occupations performed by workers tend to vary systematically with city size, that is, the highest productivity jobs tend to be found disproportionally in the most urbanised locations. This seems to be a likely situation, especially in very large cities which house national or regional headquarters, where board level and top management functions are likely to be located. Graham and Van Dender noted that there is empirical evidence supporting this effect. Other studies provide strong evidence for the role of 'sorting' by people, with the most talented people selecting the largest cities. Combes, Lafourcade, Thisse and Toutain (The Rise and Fall of Spatial Inequalities in France: A Long-Run Perspective, 2008) confirmed the presence of strong agglomeration economies in France during the full period from 1860 to 2000. However, their analysis indicates that during the period 1930 to 2000, the driving force in France was higher education. The authors noted that a sorting of the best educated people into the larger locations which also display sectoral diversity accounts for the spatial distribution of the productivity gains over this period. Jin, Fang and Bullock (The Impact of High Speed Rail on Regional Economic Development: Spatial Proximity and productivity in an emerging economy: econometrical findings from Guangdong Province, 2010) also noted this issue in research in China. Their data analysis identified a high correlation between hourly earnings and the proportion of employees with qualifications at college level and above. The authors suggest that this could indicate employee spatial self-selection and sorting across the counties and urban districts, and explain this as higher skilled workers gravitating towards the more highly paid jobs. They note that 'very high correlations are found between the proportion of employees with college and above qualifications and workers in IT and financial services (0.75 and 0.83), and between IT and financial service workers (0.81), suggesting that there are possible collinearity problems to be considered when choosing the regression models'.

Our conclusions from the literature are first that natural advantage and competitive selection effects do not appear to provide an adequate explanation for productivity

differences between regions, while agglomeration effects do provide an explanation. Second, it remains uncertain whether greater agglomeration increases productivity or whether the relationship is the other way around. Third, there is some evidence that variations in productivity may be due largely to sorting effects by skilled people, who tend to locate in the largest agglomerations. However, the role of economic mass as a factor influencing people sorting has been insufficiently explored to date. Intuitively it seems unlikely that people 'sort' for locations independently of location decisions by businesses, and also unlikely that businesses choose locations independently of where skills are located[8]. The process of interaction is, therefore, fairly easy to conceptualise, but as with any process involving feedbacks, undertaking quantitative analysis is extremely challenging. Recent economic history would suggest that the transformation of most developed countries' economies from manufacturing to the tertiary sector involved growth of service industries in places that already had large populations and also had a service sector base. In Western Europe there were gainers and losers in this process of change[9], but there were no instances of large new agglomerations forming. This in part reflects the fact, that across much of Western Europe, migration has been low historically, compared with the USA. (see for example the work on productivity differences by Puga, 2002).

Therefore the process over the last 40 years has been one of service sector growth and further attraction of service sector firms into large centres on the one hand, and upskilling of the workforce on the other. Firms had to be competitive to survive, but because a high proportion of the major service industry players are multi-site if not multi-national firms, regional differences in productivity in such firms would tend to be addressed through actions by internal management. In parallel there has been a significant change in the skill base, partly through residents acquiring new skills and partly through migration. Again in Europe, much of that migration has been driven either by moves of students to cities offering higher education, or by immigration from abroad. Over time, competitive and productive firms and talented people have collocated, creating in some cases larger agglomerations from what were previously manufacturing cities. This process is what most New Economic Geography (NEG) models would predict, namely that large places have expanded through a series of feedback effects at the expense of smaller ones. The distribution of impacts has been uneven, and there are instances of larger cities losing population and suffering a loss of employment while smaller ones in the same region have gained population and new employment[10]. This suggests that city size is one factor, but the distribution of gainers and losers among cities points to other factors, which could include liveability, quality of higher education, housing costs and whether the city is a national or regional capital. Some of these factors will also affect the quality and variety of the talent within the resident population, and based on experience in regional and urban economic development, we would argue that it is quality and variety that matter, rather than simply numbers. Observation also suggests that people who are prepared to migrate for economic reasons are also more likely to be risk-takers or to have above average skill or creativity

[8] There is qualitative evidence in the field of foreign direct investment that skills are a critical factor in location decisions by high added value sectors. There is little evidence that city quality of life exerts a strong influence on country choice by mobile skilled people, but once a country has been selected liveability is likely to exert an influence over choice of city.

[9] And in the UK it is possible that the roles of some cities changed because of changes in travel times.

[10] In the UK, the decline of Glasgow and the growth of Edinburgh (65 kms apart) is a good example.

levels. Part of the size effect would therefore arise if large places attract proportionately more migrants than smaller places. As noted above, however, size is not the only factor involved in attracting talented people, and in retaining people who have completed higher education.

3 Transport, agglomeration and productivity

Transport has a direct impact on productivity through its effects on business costs and on the labour market, principally through impacts on travel to work. However, transport will also affect the effective size of a place, and as discussed above, size and productivity are related. We present a brief discussion of this before discussing the direct relationship and how it is affected by urban form. The role of transport with regard to productivity has been the subject of both theoretical work and empirical research. Trade costs (of which transport costs are an element) are central to the New Economic Geography literature, which illustrates how lowering trade costs can result in strong spatial agglomeration taking place because of feedback processes which are mutually reinforcing. Baldwin et al (Baldwin, Forslid, Martin, Ottaviano, & Nicoud, 2005) provides a useful analysis of NEG models within a policy framework. The authors describe a range of models shows how complete agglomeration can take place when factors of production are fully mobile. However, where people are relatively immobile, at very low trade costs economic activity will once more become dispersed. (Combes, Lafourcade, Thisse, & Toutain, 2008).

In the area of transport research, the work of Graham , (Wider economic benefits of transport improvements: link between city size and productivity, 2005) and subsequently with a number of co-authors, is relevant here, especially as it underpins the UK Department for Transport's guidance on wider impacts (Department for Transport, 2005) which is used in UK transport appraisal. Graham has calculated productivity elasticities with respect to 'effective density', which is a construct based on the amount of economic mass accessible from each location. By improving accessibility, transport increases effective density, even where everything remains in the same physical location. Rice et al (Rice, Venables, & Patacchini, 2006) examined the spatial decay of this 'effective density' relationship and estimated that the effects of economic mass decay very rapidly with driving time: the effects are greatest within 40 minutes and taper rapidly beyond that.

While some form of physical density - productivity relationship appears reasonable[11], the – albeit limited – evidence on effective density is weak, and there are important questions in the area where it matters for policy, namely in terms of how economic actors respond to changes in accessibility. Unfortunately, real ex-post evidence is limited on the topic. However, Gibbons, Lyytikainen, Overman, Sanchis-Guarner and Laird (Evaluating the Productivity Impacts of Road Transport Schemes - Report on pilot study findings, 2010) investigated the impacts of the combined effect of all major road transport schemes between 1998 and 2003 for the UK DfT, and did not find evidence of positive total factor productivity, labour productivity, or wage changes. The study did find some evidence of growth in the numbers of local plants in postcode sectors that are strongly influenced by the transport schemes relative to others, but the evidence for consequent employment

[11] Passing over the issue of whether the relationship is a direct size relationship or a more complex indirect one involving people sorting effects that may be partly related to city size.

increases is weak. This suggests that direct cost impacts affected location choices for some firms, but the authors state that their work calls into question 'the idea that there are large additional benefits associated with accessibility changes and agglomeration created by transport improvements that bring firms closer to other firms and workers. The study does not find any convincing evidence that the schemes of the scale witnessed in Britain between 1998 and 2003 had created any measurable agglomeration benefits in terms of total factor productivity, labour productivity or wages'. One explanation is that a change in accessibility is relevant to behaviour where that accessibility is used, so that measures of 'effective density' do not capture how firms perceive or exploit time savings. As the authors note, 'there could be many firms that experience direct time savings (and productivity increases), but are not in locations experiencing very large accessibility changes on average'. In other words, accessibility measures potential for change, but actual outcomes for productivity depend on which businesses and workers use particular routes. The ex-post evidence at the micro level of impacts between improvements in accessibility through transport investment and productivity is therefore still limited.

Laird and Mackie, in a review of the literature on the linkages between transport improvements and productivity growth, concluded that our understanding in this area is still developing (Laird & Mackie, 2010). While this understanding is important for transport appraisal, however, at a more strategic level, the issue for Australia is best framed in terms of the effects of worsening transport on urban performance. We express the issue this way because, faced with significant growth in population and employment – most of which will seek to locate in the existing cities - transport conditions will worsen in the absence of measures to address the expansion of excess demand. This will be manifest especially during the periods of travel to and from work, but evidence in Australia and elsewhere also indicates that peak periods will get longer and journey times will become less predictable. It is axiomatic that worsening accessibility to urban centres and across urban areas through congestion will have a negative impact on business costs for both travel on business and for freight movements in the urban area. Once key parts of the network are severely congested, the effects of congestion permeate across that network, so that adverse impacts on mobility are experienced on almost all routes. In addition to the direct costs associated with network performance, businesses could face higher reservation wages to compensate workers for additional travel times.

The theoretical NEG literature acknowledges that, while agglomeration forces tend to centralise activities in the urban core, there are also dispersal forces which can ultimately counter the agglomeration forces and deter clustering of activity and people in cities. The chief dispersal forces are travel congestion and high land and housing costs, both of which tend to rise as city size increases. See for example a discussion in Baldwin et al (Economic Geography and Public Policy, 2005). The authors point to the possibility of congestion causing a stable equilibrium to emerge, where growth is low and where there is high regional spatial concentration and high levels of inter-regional inequality in incomes. Baldwin et al point to scenarios where transport costs are low between regions and where there is congestion in the larger (richer) region. Here, lowering inter-regional costs can lower growth; the authors state that 'it is important to identify the market failures and to act directly at the source of those market failures, rather than further lowering transport costs on goods, which can magnify the effects of these market failures'.

While this is based on a particular theoretical construct, it does have resonance with what has happened in Western Europe, where transport costs have fallen substantially but where growth has been low in many countries and where there are regions with severe performance disparities (Puga, 2002). However, the market failures of significance are arguably less to do with congestion and more to do with labour markets. Nonetheless, the NEG analysis does highlight the potential impacts of congestion on growth[12] This is especially important in Australia, because of the expected pressures for population growth to take place in the major urban areas and the constraints on transport infrastructure, including the amount of land that could be available for new transport infrastructure under alternative physical development strategies for the cities.

4 Transport, land use and urban form

We now turn to the role transport plays in shaping urban form, by changing accessibility between locations. This process has been gradual, but the evolution of transport modes and the provision of transport (and other) infrastructure and services have helped to create the present physical characteristics of our cities. Measures that change urban form in turn affect transport costs within and around cities. A dispersed urban form is associated with high levels of car ownership and car use, and high levels of car use at peak times are a principal factor in urban congestion. Congestion adds to business costs and deters some travel to work[13] and therefore has a direct impact on productivity. There is also a potential feedback process, if high levels of congestion cause the urban core to fragment into a multi-centre model, the evidence on productivity and economic mass would suggest that this would have an adverse impact on productivity. Urban form and congestion also impact upon the liveability of cities, which might affect productivity through the attraction of skills and through business location.

That transport costs influence location choice is most apparent in the freight sector, where location decisions are based on rational analysis of costs and benefits. The combination of low transport costs and high land costs has led to a dispersal of land intensive activities such as warehousing. As discussed earlier, for high value parts of the service sector, businesses such as banks, legal firms and professional services are the highest bidders for CBD space, as these seek locations with maximum access to each other, to other customers and suppliers and to workers.

For individuals and families, location decisions are more complex, as amenity factors enter into the mix. Amenity is itself a complex mix of factors: research on quality of life would suggest that the weights attached to different elements also vary with household size and life-stage. Personal and property security appear to be important across the age range, but access to schools is important for families with school age children. Living space is also important, and cities have tended to become less dense through a desire for more space per dollar on the demand side, and better transport links on the supply side. Observation suggests that in most cities a substantial proportion of higher income earners exercise

[12] It is possible that congestion becomes the dominant market failure in countries where other markets have been reformed.

[13] Congestion should also impact on the reservation wage, but the evidence on this is weak.

preferences for high-amenity suburbs with large lots, with highest property values at locations with high amenity and low crime levels, access to transit systems and in the case of Sydney, views over water. Giulliano (The weakening transportation-land use connection, 1996) examined choice factors and found that the role of transport appears to be weakening as a factor in location choice, a finding which is consistent with more recent work by Ahlfeldt (If Alonso was Right: Residual Land price, Accessibility and Urban Attraction, 2008) who undertook empirical research for Berlin. This study found that "the standard theoretical frameworks may become unsuited to explain the spatial structure of cities and metropolitan regions if, among other reasons, transport costs are sufficiently low". Our work for the Victorian Competition and Efficiency Commission's (VCEC) Inquiry into a State-based reform agenda, titled "More Productive Space and Time" (AECOM, 2011), put forward a possible explanation for this, namely high levels of car ownership and the way in which car owners perceive the costs of car use. We suggested that when an individual or household has access to one or more cars, their accessibility landscape becomes relatively flat, so that differences in accessibility exert a small effect on location choice. This is because when comparing alternative residential locations, perceived differences in accessibility to a set of destinations are reduced to the differences in fuel costs and personal travel time costs. Where there is a high tolerance of commute travel times of up to 45 (or even 60) minutes, and where fuel costs are low, location choice is likely to be strongly influenced by amenity[14]. In contrast, where a household chooses not to have access to its own car, factors such as fares, convenience, reliability, frequency and personal security are likely to play a more significant role in location choice, as (aggregate) access costs by public transport vary considerably across an urban area. As we discuss later, for new households the car purchase – home location decision becomes central in influencing travel choices.

This outward tendency has been enabled partly by the low level of perceived financial costs of transport and partly by public investment in road transport improvements which (at least initially) reduce journey times. Glaeser provides evidence that transport improvements combined with land use policies have been the main factors in causing urban sprawl (Glaeser, 2011). Our work for VCEC discussed the relationship between land use and transport, drawing on a large literature dating back to Von Thunen. Much of the more recent literature stems from the work by Alonso (Location and Land Use: Towards a General Theory of Land Rents, 1964), who recognised that households and businesses in different sectors have different priorities, including the benefits of agglomeration for co-located businesses. From this he derived a rent-bid model whose concentric rings of activities closely follow that of most cities, and in which changes in transport costs change the desired locations of activities[15]. Evans (The economics of residential location, 1973) and subsequently Glaeser and Khan (Sprawl and Urban Growth, 2003) examined the phenomenon of urban sprawl, and attributed the movements of populations to the outer suburbs to the development of road networks and growth in car ownership as incomes increased.

As Glaeser and Khan (Glaeser & Kahn, Sprawl and Urban Growth, 2003) noted, residential locations became very dispersed during the post-war period, largely because of the

[14] There is also some evidence of a psychologically fixed allocation of time to commute travel (Marchetti), so that as travel times improve places of residence have become more dispersed.
[15] Actual locations may of course be strongly influenced by planning and zoning factors.

convenience of car travel and the appeal of suburban space to a large cohort of the population. The outward expansion of the urban boundary is caused by a number of factors, including limited opportunities for infill, redevelopment and intensification within inner and middle ring suburbs, as well as housing affordability and lifestyle choices. We would note that planning policies also have to be permissive, in the sense of supply being allowed to vary to meet demand. This raises wider issues with regard to planning and zoning[16] is that of place competition: in practice, places compete for people and investment (Porter, 1990) and might change zonings and build infrastructure in order to secure competitive advantage over other locations. However, the Glaeser and Khan analysis shows clearly that car use is by far the most important factor in enabling this outward expansion to take place.

The State of Australian Cities 2010 report (Infrastructure Australia, 2010c) noted that there have been strong trends in outward urban expansion, "which has meant a greater distance between residential and employment areas with a resultant greater use of cars, higher transport cost and the loss of agricultural land or habitat". More recently, however, the "pattern of growth has seen an increasing proportion of population growth accommodated in existing inner and middle suburban areas, most notably in Sydney". This is in keeping with the Newman and Kenworthy analysis (Newman & Kenworthy, 1989) which shows a possible trend back towards denser urban areas since 2005, possibly as a response to higher fuel prices. It is therefore possible that transport costs can be made to exert a stronger influence on location choice, both for people or households which have access to one or more cars, and importantly (in the context of new residents) in the area of choice between owning and not owning a car.

One interpretation of Newman and Kenworthy's observations is that to a degree outward sprawl is self-regulating, because higher levels of congestion increase mobility costs, and so should in principle cause people working in the CBD to choose to locate closer to the urban core, while those working in less congested areas would tend to move away from the core. However, excessive congestion[17] is evidence of a market failure, such that even where there is some self-regulation of travel and location choices, the outcome is inefficient. The most direct way to deal with this market failure is to create a market for road use. However, travel and location decisions are inter-dependent (and are linked to a further decision, namely car ownership), and therefore the optimal approach must address both location and travel decisions. Influencing decisions on residential locations therefore provides a further, but less direct (or possibly slower acting) relationship with productivity, through land use.

This relationship is especially important in looking at the future of Australian cities and the potential for population growth on a significant scale. While there is a case for addressing the immediate issue of a lack of a market for road based mobility, for the medium to long term, it is possible that location choice is the critical area for policy makers to seek to influence, as once a location is selected it is costly to reverse, even within the rental sector but especially within the owner occupied sector. This is partly due to transactions costs and partly to factors such as the inconvenience and upheaval involved in moving, and the likely erosion of social networks which people tend to build up around their place of residence.

[16] Similar concerns apply to policies on parking and to congestion charging.
[17] There is an optimal level of congestion: excessive congestion generates deadweight costs.

Choice of location is therefore like an investment decision, after which 'operational' factors have to 'work around' that investment choice. From the perspective of productivity growth, it is possible that the constraints imposed once a choice of residential location has been made can limit accessibility to the best (most productive) job matches. In particular, living in some locations may limit opportunities for moving jobs. If people treat residential locations as relatively fixed, in a dynamic economy where more productive jobs become available (for example due to growth of the urban core), the combination of location choice and transport might render the more productive jobs sufficiently inaccessible as to obviate the possibility of an optimal match between job and worker. As discussed above, lack of people to fill such jobs, or poor matching between workers and jobs, will have an adverse impact on productivity. This type of problem will tend to be exacerbated by city size, due to dispersion of locations (which add to travel times), but more importantly due to congestion, which not only adds to travel times by road but also increases the unreliability of journey times. Similarly, congestion on transit systems creates negative impacts such as having to stand on public transport vehicles and vehicles arriving full at intermediate stops or stations.

5 The productivity of urban space

In turning to the policy area, we have taken as given that the major cities will have to accommodate an additional 11 – 12 million people during the period to 2050. For this level of population growth to happen and to be economically sustainable, these cities must achieve and sustain productivity growth that is at least as good as, and preferably better than, their performance over the last 20 years. It is also likely that the future growth will be accompanied by sustainability objectives, which in broad terms will require (at least) a degree of decoupling between population and income growth and global emissions. Beyond this, we have no preconceptions regarding issues such as urban form and land use plans. For this section our starting point is the proposition that, other things being equal, a further increase in the economic mass of Australia's cities will have a positive impact on productivity and on productivity growth. Higher productivity and productivity growth are assumed to be central objectives for the economy.

On the supply side, there may be a further 5 – 6 million people who will seek employment and housing in metropolitan areas. However, this growth in the scale and density of urban employment can happen only if additional demand for travel does not enable dispersion forces to overwhelm agglomeration ones. This will require investment and other measures to make more productive use of mobility space, including the management of demand for travel. As we discussed in our VCEC paper (AECOM, 2011), the latter is not limited to managing the use of mobility, but extends to influencing decisions on location and car ownership. Making more productive use of existing mobility space, and potentially investing in additional space, involves fundamental rethinking about the use of space by competing transport modes.

Thinking in two dimensions, cities comprise three main types of space, namely building floorplates, mobility space (vehicle, walking and cycling space), and public open space. Looked at in three dimensions, buildings in city centres have grown principally upwards, but with functions such as retail and car parking below ground. Mobility space comprises pavements, pedestrianized areas, cycleways, roads, railways and segregated corridors for

buses, trams and light rail. Mobility space is mainly at street level, but major cities also have extensive below ground rail and metro networks and some cities also have roads in tunnels. There remains considerable scope for building floorplates to be used more productively through the demolition of low rise properties and the construction of high rise ones. Based on the size – productivity analysis, and other things being equal, the vertical city represents a route to improve urban productivity, by using available three dimensional urban space more fully.

Setting aside matters of aesthetics[18], there are constraints on taking this route, principally in terms of limits on the ability of mobility space to move all the people who could work in a city centre which undertook a major upward expansion of its workspace. A more balanced expansion of work and residential space in city centres would reduce the numbers of people commuting into the centre, but this would be unlikely to eliminate completely the equivalent of the 'last kilometre' problem encountered in the freight sector, namely how to undertake short distance trips within the urban core. It is also difficult to meet all of future demand by expanding the supply of mobility space for people and vehicles, as in the short term supply is constrained by existing city centre street layouts. More mobility space could in principle be created in existing centres at the expense of building floorplates: blocks could be demolished, streets and pavements widened and taller structures erected on the smaller sites left for buildings. This is almost certainly an impractical solution, and would carry the danger of inducing mode shift from public transport to cars if more driving space were made available.

Policies therefore need to be aimed at achieving greater productivity from mobility space, because demand for that space must be enabled to increase significantly without a corresponding increase in total mobility space. In a purely technical sense, at times of high demand the most productive users of mobility space are pedestrians and users of mass transit systems, while cars are the least productive while in motion, and also require parking spaces, some of which could be used either as additional mobility space or for other purposes. In our VCEC paper we presented some estimates of transport land use productivity, which was measured in terms of the passenger distance moved by the land area devoted to the transport mode. Table 1~~Table 1~~ compares the land use productivity of the road and rail networks in urban Melbourne. It shows that the railway moves about 3.7 times as many passenger kilometres per unit area in its land footprint than the road network manages (even with on-road public transport included).

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Table 1: Transport land use productivity in Melbourne - passenger km per square metre

Mode	Passenger kilometres (billions)	Total area (km^2)	Transport land use productivity (Billion passenger kilometre per km^2)
Road network (passenger cars only)	42.07	369	0.11
Road including on-road public transport	43.94	369	0.12

[18] For simplicity: city aesthetics and icons are important in liveability, in attracting business investment and for tourism.

Mode	Passenger kilometres (billions)	Total area (km^2)	Transport land use productivity (Billion passenger kilometre per km^2)
Electrified rail network	3.72	8.2	0.45

Source: BITRE (2011) & AECOM analysis (AECOM, 2011)

Land use productivity matters for transport because land is not a free resource. Although roadway land is often treated as a sunk cost, it is a valuable resource with alternative uses. Regardless of congestion issues, failing to charge road users the equivalent of rent and taxes on roadway land under-prices roads compared with other land uses, and under-prices space intensive travel modes. This leads to an over-allocation of land to car-available road-space and subsequently an under supply of alternative transport modes such as rail. In practice, however, road users appear to consider the costs of road-land as largely sunk cost and therefore believe that they should pay only the maintenance costs plus costs for marginal improvements and increases in road space. Interestingly other netowork industries, such as electricity and freight rail, do require a return on land used for network infrastructure. So there is non-neutrality between industries in respect of use of land.

It is therefore unsurprising that we conclude that, within a given amount of mobility space, a shift to less car space and more pedestrian and mass transit space will be beneficial in terms of the productivity of mobility space. Table 2~~Table 2~~ shows car's share of travel to work journeys in a range of cities in Australia, the USA and Canada. This suggests that car use is related to city size, to a 'cultural' factor (which might be related to attitudes towards environmental issues) and to an urban design factor. Car use is generally lower in large cities, probably because these have the most extensive public transport networks and a higher proportion of mass transit capacity than smaller cities, but possibly also because space is too valuable to be used for parking or because the ratio of street space in the centre to population and/or urban jobs declines with size, so that cars are squeezed out in larger cities. The 'cultural' factor positions Canadian cities as those with generally higher public transport use, possibly reflecting public attitudes to travel as well as opportunities to use public transport. Apart from New York, US cities have the highest levels of car use. Levels of car use in Australian cities lie in between those in the US and Canada.

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The US data are especially interesting, as they enable a broad comparison to be made between older US cities that were not designed around the car and newer cities whose major period of development took place during the 20th century when car ownership was accelerating rapidly. We have no productivity data, but it seems likely that there is no correlation between productivity and car use – New York in particular has low car use, at a similar level to Sydney and to the older cities of eastern Canada. The point here is that low levels of car use can be achieved alongside high levels of productivity and high population numbers. We have included information on density changes where available. This also shows that cities can become denser, in response to changes such as increases in fuel costs.

The levels of car use in cities like New York have evolved over time, but in the face of strong population growth evolutionary adaptation is likely to be neither adequate nor efficient. Australian cities already suffer from congestion and BITRE predicts that the deadweight cost

of congestion will increase to some $20 billion in 2020, with Sydney and Melbourne both predicted to experience significant increases in deadweight congestion costs. This is shown in Figure 1~~Figure 1~~.

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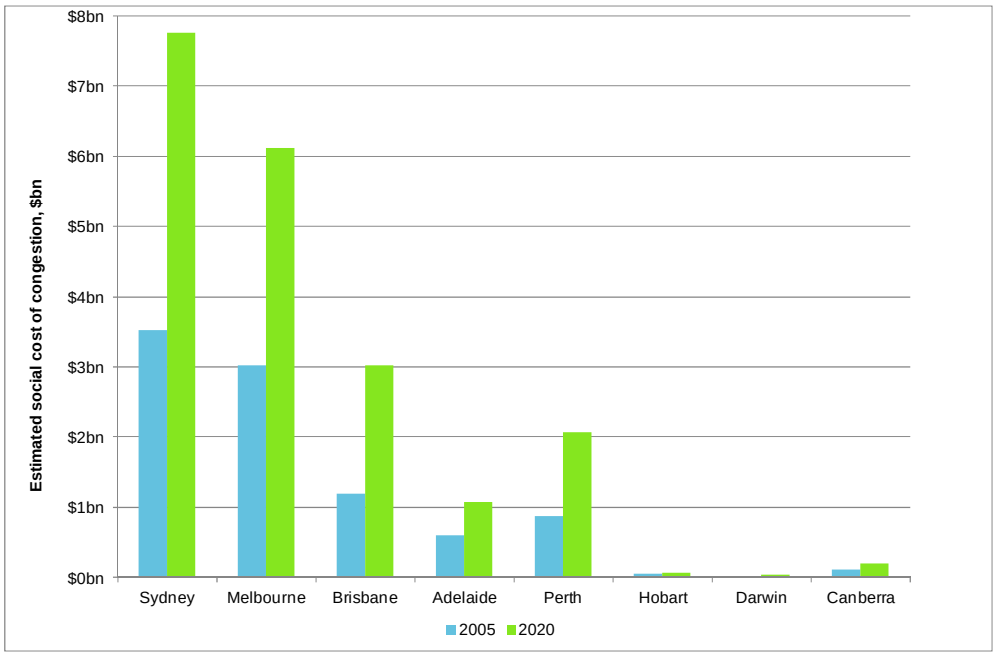
Road congestion in the form of queues, stop-start driving conditions and low speeds wastes business and leisure time, adds to driver stress and causes problems of local air quality. Slow travel times when the network is severely stressed add to business and freight travel costs, and the longer durations of peak periods mean that this effect now stretches into the working day and affects business travel, much of which is undertaken outside the travel to work peaks. For example information presented in VicRoads *Traffic Monitor 2009/2010* (2011b) indicates that there is a general widening of both the morning and afternoon peak periods and that just over one-half of all weekday trips occur during the peak periods 6:30am – 10:00am and 3:00pm – 7:00pm.

Figure 1 Projected avoidable costs of congestion by city



Source: (BTRE, 2007)

Historically, the level of car dependency in Australian cities has increased at a faster rate than population growth, and it is this relationship that has to be decoupled, possibly severely, if congestion is not to lead to conditions which slow economic growth. Congestion is, however, a symptom, whose root cause is the over-use of an asset for which an effective market is missing. A critical element in creating a framework for major population growth is, therefore, proper pricing of road use. The first best solution is pricing at all times of the day and related to levels of congestion. By creating a functioning market for road space for the first time, three important consequences will follow. First, it will become feasible for public transport to set its prices competitively in relation to road use costs, which should

significantly improve the commercial viability of public transport and, with a growing population base, make investment in public transport more attractive to private sector investors. Secondly, a market creates information which will guide investment. Realistically, it seems likely that control of transport investment will remain within the public sector, but our VCEC paper outlines a longer term model of full commercialisation of transport space, in which pricing and investment takes place on the same basis as in other networks.

However, this approach is incomplete: transport use and mode choice are also influenced by choice of location, and choice of location and investment in car ownership are complementary capital investment decisions. As individuals' transport and location decisions are inter-woven, and both involve operational and capital investment decisions, the policy prescription must address individuals' capital investment and operational choices simultaneously and consistently. It may also, therefore, be desirable to influence decisions on location and car purchase.

Table 2 Car and public transport use in large and medium size cities: Australia, USA and Canada

City	Country	Population	Car %	Public transport %	Walking %	Cycling %
Sydney	*AU*	*4,119,189*	*71.2*	*21.2*	*4.9*	*0.7*
Melbourne	*AU*	*3,592,592*	*79.3*	*13.9*	*3.6*	*1.3*
Brisbane	*AU*	*1,763,129*	*78.6*	*13.8*	*3.7*	*1.1*
Perth	*AU*	*1,445,073*	*83.3*	*10.4*	*2.7*	*1.2*
Adelaide	AU	1,105,839	83.1	9.9	3.2	1.5
Canberra	AU	368,129	82.0	7.9	4.9	2.5
Hobart	AU	200,524	82.6	6.4	7.6	1.1
Older US cities						
New York	US	21,199,865	67.6	24.8	5.7	0.3
Philadelphia	US	6,188,463	86.1	8.8	4	0.3
Chicago	US	9,157,540	83.9	11.5	3.2	0.3
San Francisco	US	4,123,740	84.2	9.7	3.4	1.1
Washington DC	US	4,923,153	86.5	9.4	3	0.3
Boston	US	5,819,100	85.1	9.0	4.2	0.4
Seattle	US	3,554,760	87.7	7	3.3	0.6
Newer US cities						
Los Angeles	*US*	*16,373,645*	*91.1*	*4.7*	*2.7*	*0.6*
Detroit	US	5,456,428	95.3	1.7	1.8	0.2
Houston	*US*	*4,669,571*	*93.9*	*3.3*	*1.6*	*0.3*
Dallas	US	5,221,801	95.5	1.7	1.5	0.1
Las Vegas	US	1,563,282	91.2	4.1	2.4	0.5
Miami	US	3,876,380	92.7	3.9	1.8	0.5
Portland	US	2,265,223	89.4	6	3.1	0.8
Canadian cities						
Toronto	CA	5,113,149	71.1	22.2	4.8	1
Montreal	CA	3,635,571	70.4	21.4	5.7	1.6
Ottawa	CA	846,802	68.1	21.2	7.6	2.2
Vancouver	*CA*	*2,116,581*	*74.4*	*16.5*	*6.3*	*1.7*

Source: adapted from Mees (Mees, 2009)Cities in italics showed an increase in density since 1995[19].
Cities underlined showed a decrease in density. Those with neither italics nor underlining are cities for which no density information was available.

6 Market based reform

Future cities will be shaped by market forces operating within a planning and regulatory system. Our main theme in looking at future policy is the greater integration of land use planning and transport planning and provision, both set within a more explicit market-based framework, in which both land use and transport are more clearly and directly influenced by price signals. A fundamental belief is that in economic terms transport is no different from

[19] Using data from (Newman & Kenworthy, 2011)

other networks which have undergone successful market reform, in Australia and elsewhere: transport is, however, more complex than, say, electricity, but complexity is not the core issue.

The main barrier to market based reform of urban road use lies in the history of how urban transport evolved. Historically, street space was simply space between buildings, and everyone seems to have agreed that it was a good idea to have circulation space, in order to make towns and cities work. When streets changed from dirt to metalled surfaces, in most places a public body took on the task of building and maintaining streets. This is not surprising, as it would have been difficult for those with street frontages to organise a proper market for use of their section of street. The street system was typically not expensive to maintain, and people accepted that it should be funded from city taxes: more formally, there was no cost-effective way to exclude users and consumption was perhaps insufficiently rivalrous to cause a rethink of public provision[20]. As a consequence, it is now very difficult to persuade people to pay for use of roadspace, as it is something they might think is either an entitlement good, or something for which they have already paid through various forms of taxation.

In contrast to streets, gas and electricity came much later, and networks were built initially only where people were willing to pay for connection to the network and for its services. Other 'new' forms of transport were similar to gas and electricity, in that canals and railways were built for profit, as were the original turnpikes. In time, the public sector acquired railways and long-distance roads in most countries, so that now large parts of the transport system lies outside a true market mechanism, despite the ease with which markets can be operated for long-distance road travel and for rail. The history or 'baggage' is important for reforming the system, because road users (who are also voters) need to be persuaded to change something that they know does not work too well for something that is perceived to be an added cost burden with uncertain benefits for the individual. There is a large body of work on barriers to changing user and voter attitudes and choices which is not discussed here[21]. Rather, the focus is on the nature of a 'tariff structure' that would achieve economic objectives, specifically on how to price transport and land use together to enable the economy to be as productive as possible. The following ignores both global and local environmental benefits and costs: however market based reforms also provide a basis to use price signals to address environmental issues.

Our view is that 4 things are needed

1. Urban form that enables the high value service sector to agglomerate in a single highest productivity centre
2. Congestion at levels where there are no or very low deadweight costs
3. A reliable funding stream for new transport infrastructure (including roads)

[20] Had the earliest city developers had access to number plate detection, smart tags and back office systems, road space would almost certainly have been treated like railways and energy and not as a public good.
[21] See for example (Laird J, 2008)

4. Greater mobility within the labour market.

The agglomeration literature suggests that the service sector benefits most in terms of productivity from proximity to other service businesses, while the manufacturing sector gains less benefit from proximity. From a land use planning perspective, therefore, it makes economic sense to concentrate new construction for the service sector in the CBD. There are lower value services which benefit less from agglomeration, as does manufacturing, so buildings for these activities should be zoned to where land is cheaper. Manufacturing plants that employ large numbers of workers need to be zoned near areas with good public transport access, but at the same time these generally need good road access in order to move physical inputs and products. Both the agglomeration case and the transport case suggest zoning such plants in the suburbs and not the CBD. Additionally there is a need for sub-urban centres for the supply of retail, education and health services. An efficient land market will tend to deliver this pattern of land use for businesses, which weigh up cost factors in location decisions. Therefore, provided there is enough capacity to enable people movements, development with a single large and dense CBD is likely to be best for productivity because of agglomeration and job-matching benefits. It will also make best use of transport infrastructure, especially mass transit public transport services along key transmission routes. A more dispersed model for knowledge industry employment locations is likely to sacrifice agglomeration and labour market benefits, while requiring a higher proportion of commuting movements by car[22]. A model which facilitates relocations of activities that do not benefit from agglomeration economies out of the existing centre could enable further CBD expansion, but could also reduce travel demand to the centre[23].

The role of land use planning as a policy lever is recognised in the planning literature. According to (Buxton, 2006), urban efficiency is usually defined in terms of travel patterns, infrastructure and energy use, and social and environmental costs including water use, congestion costs and the costs of sprawl. Buxton suggests that it is accepted that societies which consume less land for urban purposes use roads less, use infrastructure more efficiently and can transfer more investment to productive sources. Furthermore, compact and intelligent urban design reduces social costs by increasing social cohesion. Efficiency is therefore lost as cities expand and reduce their average population density. Recognising this, many Australian state governments have developed land-use policies which attempt to alter urban form to gain greater urban efficiency. The common theme among policies is a commitment to more compact cities through higher density, mixed use, transit oriented development in activity centres, improved public transport and limits on outer urban growth.

[22] See for example (Bertaud, 2004), (Clark & Kuijpers-Linde, 1994), (Cervero & Wu, 1998), (Schwanen, Dieleman, & Dijst, 2004), (Meijers & Burger, 2009). A similar point was made by an academic reviewer that reviewed this paper.

[23] For example, relocation of some types of businesses from the centre could have minimal or no impact on aggregate productivity: if the vacated space is used as open space, travel demand would be reduced, which would enhance transport efficiency; alternatively the space might be used for service activity that generates and benefits from agglomeration economies. This use would increase aggregate productivity.

In reality, however, there is evidence of continued reduction in densities[24]. As we noted in our VCEC paper (AECOM, 2011), the leading growth areas in Victoria were the outer Melbourne local government areas of Wyndham, Melton, Cardinia and Whittlesea, which are among the fastest growing in Australia. In addition, in the nine years since Melbourne's growth outstripped Sydney's, five out of every eight new residents had to settle over 20km from the city centre. While Melbourne's outlying growth centres have been the focal points for the absorption of the region's quickly growing population over the past decade, this has not been the case for the creation of employment opportunities, with the majority of higher order employment opportunities continuing to be located in inner city locations or in established employment centres which are either not proximal to, or easily accessible via public transportation from, the growing population centres.

This imbalance between where people live and where employment opportunities are located has led to high levels of single direction congestion into inner city employment centres from the outlying population growth centres. Therefore land use planning and the land market is enabling an urban form which supports positive productivity outcomes, but residential development is not. Projected ahead with large numbers of new residents, further sprawl that is also car-oriented will lead to increasing congestion, while providing additional car mobility space is likely to be an unproductive use of urban land. Patterns of development which lead to sprawl, high levels of car use and congestion are all symptoms, where the underlying cause is that transport is too cheap. The use of congestion charging based on time of day and distance and related to levels of congestion is discussed in many other places: we simply note that this must form a part of the solution, with the timing now being dependent on political will and voter acceptance rather than technology.

Congestion charging has other benefits, including the provision of a new funding stream for mode-neutral land transport, the generation of new data on travel behaviour and positive impacts on public transport revenues, leading to lower (or no) public subsidies. The latter arises because public transport fares are 'priced off' the main competing mode, namely roads: when road charges are increased, public transport fares can also be increased. This raises the issue of whether public transport fares should be set to achieve financial targets or to achieve ridership targets. This is not discussed further here.

In our VCEC paper we argued that not only was use of transport too cheap but that charges for accessibility may be too high. Location in relation to transport systems provides the potential to travel, and this is paid for in house prices and in land-related taxes. We argued that the transport use 'policy lever' needs to be set higher and the accessibility policy lever set lower, to bring about a better balance between costs of actual use and potential use. In Victoria, expenditure on transport is funded approximately 54% by mobility charges (fuel excise, GST on fuel and motor vehicle taxes) and the balance by accessibility (property taxes). This balance seems more a matter of history than deliberate choice. An important task to improve integration between transport and land use will be to analyse the impact of changing these proportions. Ahlfeldt (2008) shows that that urban form is sensitive to the relative costs of mobility and accessibility, so changing the balance could become an important tool for urban planning. Road usage (congestion) charges will tend to steepen the

[24] In contrast to the findings by Newman and Kenworthy (Newman & Kenworthy, Peak Car Use, 2011)

bid-rent curve, making peripheral locations less valuable to those who need to commute into congested areas. A reduction in stamp duty has the added attraction of potentially increasing labour force mobility, making it less expensive to move house in response to employment opportunities.

Reducing land transaction taxes and increasing car usage fees will, over time, tend to redistribute population, depending on car travel and housing needs, and willingness to pay congestion charges. However, this is not to suggest that all CBD commuters will cluster closer to the city: those willing to pay the charge and who place a high value on space and amenity in the outer suburbs will continue to do so. We would also expect increased demand for public transport relative to car from outer areas, which would make public transport more frequent and also more viable. The funding generated by congestion charging also plays a role here, in the context of significantly more travel demand due to population growth. In our VCEC paper we suggested that development of new, dense outer areas linked to the CBD by mass transit would be needed to accommodate population growth without a proportionate increase in commuting. Congestion charging revenue would be available for mass transit[25] investment.

The mix between transport usage charges and accessibility charges has a parallel in the two-part tariffs used in energy networks. However, transport is more complex, in that there is a third area where influence can be brought to bear and which affects both location choice and car use, and that is the decision to purchase a car (or not). As discussed earlier, the reason for considering adjustments to car ownership costs is that the decision to use a car for a particular journey is typically based on perceived private costs, which exclude some of the private operating costs such as tyre wear and servicing, as well as the external costs. This might be addressed through a higher per kilometre usage charge[26], but it is possible that a higher charge at the point of vehicle acquisition and higher annual registration charges would have a stronger effect by deterring some households from car purchase. Car travel demands by households which decide not to acquire a car would be met through the market[27] by provision of car-share schemes. Car share provides the user with a more accurate metric of private costs, and has the added advantage that the vehicles will tend to be newer and smaller than those they replace. In inner urban areas, higher car ownership costs would be expected to 'shake out' marginal car owners who could readily use public transport for most journeys and car share where a car is essential. Residents of outer areas tend to be more car dependent: such residents should still gain if they do not make car journeys to the CBD and would benefit through lower property (accessibility) charges. Lower property charges also reduce the transactions costs of moving, so that households can more readily optimise their residential location based on car, travel and housing costs[28].

[25] We leave selection of the mass transit mode to particular situations: our focus here is on the relative productivity of mass transit compared with car.

[26] In the longer term we expect that the increase in the hybrid and electric vehicle fleet will necessitate a move to a usage charge to replace fuel duty.

[27] Councils would have to provide parking slots for car share: while initially this might reduce car spaces, as more households turn to car share, demand for residential parking is likely to decrease.

[28] Changes in all three costs might also make people change job location. Further evidence and analysis are needed to test whether people would move to a more productive job to pay the costs or to a less productive job to minimise exposure. However, those with the highest productivity are most likely to continue to work in the most productive jobs as they gain most from the time savings delivered by congestion charging.

The VCEC paper identified stages for implementation. The 'advanced' stage was seen as one where government would own all the land under the road, rail and active travel networks, define a broad land-use and transport policy framework but would hand over investment decision-making, investment procurement and delivery, pricing, operations, management and maintenance to one or more arms-length companies, partly or wholly owned by private sector interests. These companies would generate proposals for the allocation of mobility space between modes[29]. They would be funded partly by revenue from charging users for road and mass transit usage (for mobility) and partly by an appropriate tax on land owners (for accessibility). These charges for usage and land accessibility would be subject to independent economic regulation, but the balance between revenue from mobility and accessibility would be set by government policy, because this balance is a driver of urban form. It seems likely that more revenue from mobility could lower required revenue from accessibility, enabling reductions in property stamp duty and reducing impediments to people changing location. One could go further and provide a system that enabled the market to allocate city centre land between mobility space and building floorplates, by enabling the government as mobility space owner to trade with floorplate owners.

A market based reform therefore has much to commend it, provided the benefits can be sold to a doubting public. In addition to better transport and a new funding stream, a market would reduce the costs of transport planning, data gathering, analysis, planning, modelling and appraising which government has to undertake in place of a market. A market would not allow plans for new developments and transport infrastructure to be undertaken independently, nor would it allow infrastructure plans to be pulled apart when there is a change of government. A market would therefore deliver a higher degree of consistency and predictability regarding future infrastructure, which would give more confidence for the investment in residential and other property that will be essential to accommodate the expected increase in urban population.

[29] It would be necessary to apply a shadow value to pedestrian movements, but cyclists could be included in the charging system.

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