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Transport Infrastructure, Lock-Out and Urban Form

Highway Development in Auckland and the United States

When travelling the world, it is impossible not to be struck by the different urban forms of the world's great cities. Cities differ in size, age, shape and height. They have different housing styles and population densities. Some are concentrated around a mess of crooked streets, some are laid out around a planned grid, and some sprawl over wide areas. Many have a central waterfront, while others have ports several miles away. Cities also differ substantially in terms of their transport systems. There are walking cities, light rail-based cities and subway cities. And there are also cities where public transport is little used, as most travelling occurs in private cars.

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Historians, urban planners and economists are trying to understand why cities have evolved in such different ways. Two key questions have concerned the reasons why some cities use much more public transport than others, and why some cities have much higher population densities than others. These questions are related. Careful research across a large number of cities in Europe, Asia, North America and Australasia has shown that cities where most trips are by private car tend to have much lower population densities than cities where public transport plays a more important role (Newman and Kenworthy, 1989). This is not surprising, for people living in cities where car ownership is high can more easily live far from public transport facilities, enabling sprawl. But the evidence also suggests that investments in highway networks create sprawling low-density cities that are then unsuited for public transport.

This evidence is particularly pertinent to New Zealand. By world standards, cities like Auckland and Christchurch are characterised by low population densities and low public transport usage (Bachels, Newman and Kenworthy, 1999). In recent years the adequacy of public and private transport infrastructure in these cities has been reviewed, in part because of concern about traffic congestion. In evaluating the appropriate mix of transport infrastructure, cost-benefit analysis needs to evaluate how investment in one form of infrastructure – say, roads – affects the demand for other forms.

When historic choices about public and private transport infrastructure networks have long-lasting effects on transport demand because they change the urban structure of a city, there is path dependency of a type described by Arthur (Arthur, 1987; Barter, 2004). This path dependency needs to be taken into account, for it affects the way future transport investments will operate, and thus the likelihood of different transport investments occurring in the future. In a network system the value of current transport investments depends on the way the network is extended by future investments. Accordingly, a proper evaluation of current transport projects can only be done while cognisant of the way these investments are likely to affect the structure of a city.

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Transport modes, income and city form

In recent decades there have been several cross-city studies of the relationship between a city's transport systems, its size and population density and its urban structure. Much of this work was pioneered by Kenworthy, Newman and various co-authors (Newman and Kenworthy, 1989; Kenworthy and Laube, 1999; Bachels, Newman and Kenworthy, 1999). Using a consistently assembled data set, they examined the extent to which residents of cities in Europe, Asia, North America and Australia differed in their use of public and private transport (including non-motorised transport) and how these differences were related to various aspects of cities such as population density, average income and the concentration of employment in central business districts. In general, they showed that low-density cities have high private car use and low public transport use and high-density cities have high public transport use and low private car use. More particularly, across cities they showed that (a) there was a strong negative correlation between car ownership and population density; (b) there was a strong positive correlation between the use of public transport and population density; (c) in low-density cities, not only was car ownership greater and public transport use less, but more miles were travelled by car per car and a greater fraction of income was spent on transport; (d) there was little relationship between average income and public transport use; and (e) public transport use was much higher in cities that had intensive rail service. Some of these differences reflect major differences in the style of cities found in different regions of the world, for cities in Asia and Europe tend to have much higher population density and much greater use of public transport than cities in North America or Australasia. Nonetheless, even within broad continental regions the relationship between population density and transport structure appears to hold.

The negative correlation between private transport use and population density raises two related questions. The first is whether there is a causal relationship between private transport use and density. The answer appears to be yes. If private transport infrastructure – a highway – is built, people move out from high-density central city locations to low-density suburban locations, and population density declines; or, to be more succinct, highways induce sprawl.

The best evidence on this point comes from a series of papers by Baum-Snow (2007, 2010) analysing the effect of the United States highway network that was constructed after 1950. This network, which was constructed partly for defence reasons, connected cities across the nation. The way in which it was designed meant that the number of new highways entering any particular city was largely exogenous to the city's initial characteristics, such as size. For example, in most of the country highways were built so that they connected contiguous cities; thus, cities that were close to many other cities gained more new highways than cities located far from anywhere. Given this design feature, Snow-Baum used the original network design as an instrument to examine how the construction of a highway affected the employment and residential location patterns in a city over the subsequent 40-year period.

The data indicate that cities decentralised after highways were constructed. Baum-Snow (2007) estimated that an additional highway ending in the centre of a city reduced the central city population by 9% between 1950 and 1990. Overall, the population of metropolitan areas increased from 93 million to 160 million during this time; since the population of central cities only increased from 45 to 51 million, and cities on average gained 2.6 new highways, a third of the relative decline in central city populations was caused by the highway building programme. He further analysed the effect of highways on the location of jobs, noting that in 1950, 20 million out of 40 million urban centre jobs were in central cities, whereas in 1990 only 27 million out of 87 million jobs were located there. Cities with more highways had greater job decentralisation: an extra highway led to an 18% reduction in the number of people living and working in central cities, and a 25% increase in the number of people living and working outside central cities. In a strongly worded conclusion, he observed:

> The evidence is clear that the primary way highways serving central cities caused declines in central city populations was by inducing those who had lived and worked in central cities to live and work in suburban

> areas instead. … Estimates indicate that had the urban highway systems not been built, the total number of within-city commutes would be about double its 2000 number, and the total number of within-suburb commutes would be cut by about one half. (Baum-Snow, 2010, p.382)

Related evidence from Duranton and Turner (2008) shows that road building increases the population of cities as well as reduces their density. They demonstrated that a new road, built for reasons independent of a city's economic performance, tended to increase the population of the city, because it lowered transport costs in the city and for that reason made it a more attractive place to live. They estimated a 10% increase in a city's stock of major roads led to a 20% increase in population over a 20-year period. But they questioned the cost-effectiveness of road building as a strategy for reducing transport costs, noting that the provision of bus services increased the population at far lower cost.

While Baum-Snow's evidence is clear that highways induce sprawl, it should not be concluded that the highways were bad. Many people and firms are obviously happy to move to low-density housing far from the city centre if transport systems are sufficiently efficient that it is not too inconvenient to locate there. Indeed, from the data assembled by Kenworthy and Laube (1999), it is clear that people are prepared to pay high private transport costs in order to live in these low-rent, low-density areas. From the evidence compiled by Duranton and Turner (2008), it appears many people are prepared to migrate to these cities from elsewhere because of the transport network. This is not to say that people would not use inexpensive public transport if it were convenient. But revealed preference indicates that, when faced with the relative costs and benefits of high-density city or low-density suburban living, in many cities a large majority of people has chosen the latter.

The second question is whether the construction of private transport infrastructure makes public transport less efficient. Here the evidence is indirect. Nonetheless, combining the analysis of Baum-Snow and Newman, Kenworthy and others, it appears that (a) constructing a highway reduces the population density of a city and (b) cities with lower densities have less efficient public transport. The inefficiency can occur for two reasons. First, the population close to each bus or rail route is smaller in less dense cities, meaning that a given route is likely to have lower utilisation because it is conveniently located to fewer residences. Secondly, since people, their jobs and the amenities they wish to use are widely dispersed across space, any route is less likely to go directly to a desired destination than when a city is densely populated. While it may be possible to go between any two points in a city indirectly, by transferring between public transport lines, this can be excessively time consuming and unattractive compared to private transport.

While there is clear evidence from Newman and Kenworthy and others that cities with low population density have little public transport, the argument that low density reduces the utilisation and efficiency of public transport is difficult to prove. First, the cross-city evidence analysed by Kenworthy and Newman can be criticised because, rather than analyse the history of a city or cities through time, they analyse a cross-section of cities at a single point in time. This type of analysis can be misleading if city transport patterns evolve through time and cities differ in terms of their development stage, or if the transport arrangements in each city are dominated by idiosyncratic factors that are correlated with density, but that are not caused by density (Hensher, 2000). Secondly, within-city evidence that public transport is more efficient in densely populated areas than in low-density areas suffers from selection issues: often people who frequently use public transport have characteristics that attract them to high-density areas. Nonetheless, the weight of evidence strongly suggests that density and city form have a large effect on the use of public transport, and there is no evidence that reductions in population density increase public transport use. For instance, a study of commuting patterns across 114 urban areas in the United States shows that cities with less dispersed populations have lower car ownership rates, and that the combination of population density, public transport supply and road density explains a large fraction of the difference in commuting patterns across cities (Bento et al., 2005).

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If, as theory suggests and evidence corroborates, low-density cities are less suited for public transport than high-density cities, transport infrastructure choices can have long-term and potentially irreversible effects on city form. A city that chooses to invest in roads rather than public transport infrastructure to improve its transport system is likely to reduce the efficiency of any subsequent public transport investments, by causing population and employment in the city to disperse widely over space. When making decisions to build roads, therefore, the city planners need to take into account the way roads affect the operation of subsequent transport infrastructure investment choices. Once people and firms take advantage of highways and other roading investments to locate in dispersed regions far from the city centre, public transport becomes increasing irrelevant to city operation.

It is important to emphasise that the overall operation, income and welfare of a city is not necessarily affected by its population density or public transport use. Both low-density and high-density cities can have and do have high productivity

and high incomes. Moreover, it appears that city highways enable many firms to leave the central city area to obtain cheap land without losing the agglomeration benefits usually associated with central cities (Moses and Williamson, 1967; Glaeser and Gottlieb, 2009). Traditionally, firms have clustered together to reduce the cost of doing business with each other, or to share a common input or customer; this cost can be minimised by lowering transport costs, or, for a given level of transport costs, by lowering the distance between businesses – that is, by increasing density. The fact that many firms leave central business areas when road transport costs decline suggests that firms can obtain agglomeration benefits over a large area if transport costs are sufficiently low, as well as obtain benefits from not being in the central city.

Transport infrastructure in New Zealand: an historical perspective

By world standards, New Zealand's cities, particularly Auckland and Christchurch, are characterised by low density and extremely low public transport use (Bachels, Newman and Kenworthy, 1999). Like many other Australian and American cities, these cities have always had low population densities, for reasons that can be traced back to a coincidence in their initial histories: not only did they develop at a time when streetcars made it possible for people to live in suburbs and commute to the central city, but their incomes during this phase were sufficiently high that a large fraction of their populations could afford to make this commute (LeRoy and Sonstelie, 1983; Frost, 1991; Frost and Dingle, 1995). It helped that New Zealand, like Australia, was largely populated by English settlers who had a preference for living in leafy suburbs rather than compressed cities (Frost, 1991). Note, however, that this history means that while New Zealand's cities have always had low density, they have not always been dependent on the car for transport. Rather, until the 1950s, urban dwellers in New Zealand cities intensively used public transport for commuting purposes.

The transport history of Auckland is particularly interesting. In the early 1950s, 58% of motorised trips were by public transport, or 290 trips per resident per year. This is similar to the number of trips in contemporary European cities (Kenworthy and Laube, 1999.) In the mid-1950s, however, it was decided that Auckland's transport future would be based on private transport, and several highways were constructed, using the US interstate highway model as inspiration (Mees and Dobson, 2001; Harris, 2005; Mees and Dobson, 2007.) Auckland had a highway system one or two decades before comparable Australian cities, and switched away from public transport to private transport much faster than these cities, despite having similar levels of car ownership. By 2000, only 2% of motorised trips, or 33 trips per resident per year, were by public transport, the largest decline in any major city during this period around the world. The decline of public transport was much faster in Auckland than in Wellington, where a significant public transport infrastructure system had been constructed between 1937 and 1955 (Harris, 2005). Consistent with the history of US cities, the population of Auckland grew rapidly, far faster than Christchurch or Wellington, with the growth concentrated in new suburban regions south and north of the central city. In short, after the construction of the highway system, Auckland grew, decentralised and gave up public transport.

If Aucklanders wish to reduce the amount of private transport use, not only will they need to increase the provision of public transport ... but they will need an urban plan that reverses population and employment dispersal.

Since the middle of the 1990s, Auckland has made several new investments in public and private transport infrastructure, in part because of growing traffic congestion. For example, a dedicated bus-way has been constructed to the north of the city, and the train system to the south and the west of the city has been upgraded and partially double tracked. It is also upgrading its road network, and considering several large-scale developments such as a new harbour bridge. While public transport use has nearly doubled in response, it remains at very low levels (Wang, 2009). It appears that Auckland citizens, spread over a wide urban area, still find it more convenient to travel by car than to use public transport. It seems likely that the reluctance to use public transport is because many of their trips could not be easily made by public transport. If this is the case, it suggests that, for the time being at least, Auckland's public transport has been locked out by historic decisions to build a highway system, and the subsequent geographical dispersal of the city.

US evidence suggests it is very difficult to increase public transport use, and that to increase its use requires careful planning. It also requires a clearly stated objective. If Aucklanders wish to reduce the amount of private transport use, not only will they need to increase the provision of public transport (which, as Duranton and Turner (2008) suggest, can be considerably more cost effective than constructing new roads), but they will need an urban plan that reverses population and employment dispersal. This is not easy to do, given the lifespan of residential and commercial building. But it is not impossible either, as several overseas examples demonstrate, and such plans are being considered and adopted by major Australian cities (Mees and Dobson, 2007). However, this is not the only possible goal. If Aucklanders merely want to improve transportation speeds, and don't mind private transportation remaining the dominant transport form, new road and bridge construction is a means to achieve this goal. But Aucklanders should not expect this to be inexpensive, or to revitalise the central

city. The US evidence, and Auckland's own history, suggest that new roads cause population dispersal and employment decentralisation, as firms and citizens flee the central city in search of desirable locations with easy city access located slightly further out of town.

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