THE PARADOX OF INTENSIFICATION

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Abstract

Urban intensification as part of a smart growth strategy can facilitate low energy transport modes and reduce overall car use, with benefits to the global environment but evidence suggests the effect will be less than proportional. Hence, in locations where intensification occurs, greater concentrations of traffic tend to occur, and this worsens local environmental conditions. This phenomenon is defined below as the 'paradox of intensification'. The consequent challenges for planners and policymakers which arise are considered. The analysis suggests that a compromise involving limited intensification would merely redistribute the balance between the two sets of problems: global and local. It is concluded that urban intensification should be accompanied by more radical measures to constrain traffic generation within intensified areas.

1. Introduction

One of the longest-running debates in built environment studies concerns the relationship between urban form and transport outcomes, measured in a variety of ways. Within that debate much attention has focussed on the influence of population density, and by extension, the effects of urban intensification as a planning policy. For its advocates, intensification promotes modal shift and restrains travel by car, with benefits to the urban and global environments (Litman, 2008, Newman and Kenworthy, 2000). Amongst various critiques of this view – some value-based, some empirical – opponents have argued that intensification causes local concentrations of traffic (Cox, 2003) which suburbanisation can help to disperse (Gordon and Richardson, 2000, Echenique and Homewood, 2003).

Although they differ in their recommendations, both sides in this debate accept, explicitly or implicitly, that concentrations of traffic and motor vehicles in urban areas cause negative externalities, including congestion, air pollution and a range of health and social problems. Most would also accept that rising levels of car use cause problems at a national and global level, including a significant contribution to climate change, and depletion of resources. How intensification affects local concentrations and aggregate use of private motor vehicles is the subject of this article. It will review the above debate and associated evidence, suggesting an underlying principle: the paradox of intensification, with significant implications for transport and planning policies.

1. The Problem – Urban Intensification and Traffic Generation

Urban intensification – increasing the density of dwellings within existing built areas – has become a principle of planning policy and practice across many developed countries. It is usually accompanied by a range of other policies, some transport-related (e.g. public transport improvements), some related to other aspects of the urban environment. Terms such as 'smart growth' and 'the compact city' (both variably defined) generally encompass intensification alongside a number of these other measures. This article focuses on outcomes related to personal travel and use of private motor vehicles, whilst recognising that other outcomes may be at least as important for policymakers. It will also consider how additional measures alongside intensification can influence those transport outcomes.

The evolution of policy towards intensification has been influenced by a substantial literature on the relationships between the urban form and transport outcomes. Most of this literature draws on cross-sectional data, to draw conclusions about the relationships between built environment factors including density, and travel behaviour. Whether those findings can be used to predict the effects of intensification (i.e. changes in density) is a disputed point. Relatively little direct evidence is available on the effects of urban intensification in practice: the few exceptions cited in this article leave many unanswered questions.

Average household sizes have been falling across many developed countries in recent years. A distinction should be drawn therefore between intensification which increases the population density of an area, and a limited intensification of dwellings which serves only to attenuate a decline in population density. In seeking to identify an underlying principle, this article will define urban intensification as an increase in the density of both dwellings and population. The principle will have slightly different implications for the other, more limited, form of intensification.

Within the literature, there is one example of a city where urban intensification has been practised, and where some evidence is available on its effects over time. Portland, Oregon has sought to limit sprawl since the 1970s by concentrating development within an urban growth boundary.

Jun (2008), in analysing US Census data, conducted logistic regressions for the 1990 and 2000 datasets, but found no significant relationship between the density of housing at the residence block level and mode choice. The modal share of driving by commuters fell by just 2.4%. Jun's study did not measure vehicle miles travelled (VMT). Some North American studies including one using data for Portland (Sun et al, 1998) have shown a stronger relationship with density for VMT than for vehicle trips.

	Portland		Large Urban Areas	
	2000	Change	2000	Change
Population Density (per sq. mile)	3,059	8.0%	2,100	-6.2%
VMT on freeways & arterials (1000s)	24,065	30.7%	26,688	38.2%
Peak Travellers (1000s)	749	52.5%	757	38.9%
Public transport miles (millions)	394	83.3%	195	31.8%
Total Delay (1000s of peak hours)	28,237	154.0%	25,706	99.0%
Delay per peak traveller (hours)	38	65.2%	34	41.7%

Table 1 Portland and Average for US Large Urban Areas, Changes 1990 - 2000. Source: (Schrank, Lomax 2009)

Table 1 (drawn from Schrank and Lomax, 2009) shows a clear divergence between Portland and other large urban areas (population between 1 and 3 million), which reduced population density over the decade (a trend which has begun to reverse more recently). Portland's upward trend in VMT was less than average, whereas the number of peak travellers (by all modes) increased considerably more than average. As the modal share fell only slightly, as expected, congestion increased more rapidly than average.

The traffic and congestion data in Table 1 refers only to freeways and arterial roads. For Portland as a whole, between 1990 and 2002, VMT increased by 36% (Oregon Metro, 2010) – twice the national increase for all urban roads over the same period (AAA, 2005).

The Portland example is interesting because the intensification was accompanied by a concentration of activities in the city centre, traffic restraint and expansion of public transport. Indeed, Portland has been described as a "poster child for 'smart growth' policies" (TRB, 2009) Although these policies have contributed to the substantial increase in public transport shown above, and a decline in per capita VMT, against the national trend (TRB, 2009) this has been insufficient to counteract the increase in traffic volumes and congestion, partly due to increasing population density, and partly due to other factors.

Apart from congestion, there is little direct evidence of the effects of intensification on other externalities such as air quality, health and social capital. Indirect evidence suggests concentrations of traffic are deleterious to all three. On social capital for example, Hart (2008) has provided a recent corroboration of Appleyard's (1980) findings about the correlation between traffic volumes and social contact between neighbours. It cannot necessarily be deduced from this that intensification causes a worsening of these externalities, however, as other factors such as increased walking and cycling to local facilities might exert a countervailing influence. To assess the net effects would require a longitudinal study, examining multiple factors.One such study was conducted in the UK from the late 1980s until the late 1990s, including a national survey of all planning authorities and 12 case studies of areas subject to intensification (Entec and Oxford Brookes, 1996). The findings suggested that worsening of congestion, noise and air pollution were all consequences of intensification as practised in the UK at that time, although much of the additional traffic was generated outside the areas under study. The study was mainly qualitative and did not provide any comparison with other areas not subject to intensification.

Although the evidence reviewed in this section is not sufficient to generalise to all other contexts, it suggests that urban intensification tends to increase concentrations of traffic in those areas where it is practised. Indeed it could be argued that increasing traffic generation is a normal corollary of building at higher densities. Amongst transport planners who use models such as the one described in Section 4 to estimate the trips generated by new developments, this proposition would be considered uncontroversial.

In the light of this, it may seem strange that some writers have advocated urban intensification as a means of reducing the negative externalities of car use. The next section will examine those claims in the context of the wider debate about the relationships between transport and the built environment. Section 3 will propose a new concept, the paradox of intensification, to explain some of the principal relationships between intensification and transport outcomes. Section 4 will examine the different implications of intensification at the level of the individual development compared to city-wide intensification. The final sections will consider the implications of the paradox for transport policy.

2. Density and Intensification within the Wider Debate

At the aggregate level, an inverse relationship can be observed across the developed world between the density of urban areas and the use of motor vehicles, measured in different ways. This applies both within countries and between them. Across the UK, the average 'exurbanite' drives 25% more miles per year than the average suburbanite and 44% more than the average urbanite (Independent Transport Commission, 2004). The same relationship, measured in slightly different ways, has been observed across the USA (Giuliano and Narayan, 2003) and the Netherlands (Schwanen et al, 2004) amongst others. Although the methodology and conclusions of Newman and Kenworthy's (1989) study have been criticised (Glaeser and Kahn, 2003, Gomez-Ibanez, 1991), the overall inverse relationship between area per person and gasoline consumption per person is undisputed. The relationship is particularly clear at the extremes: American levels of car use would be physically impossible in a city as dense as Hong Kong, just as Hong Kong levels of public transport accessibility would be economically impossible in the suburbs of American cities. Within countries or regions where the conditions are more homogenous, the two issues which remain most strongly disputed concern, first, the causality in this relationship and, from a policy perspective, whether urban intensification does or does not reduce car use and the externalities associated with it.

These questions are part of a wider debate concerning the relationship between the built environment and travel outcomes. Apart from population density, the vast literature in this area has suggested many other built environment variables associated with a range of travel outcomes. Litman (2008) surveyed the literature, mainly relating to North America. Some of the principal relationships he found are summarised in Table 2:

Factor	Associated With
Population Density	Lower Vehicle Miles Travelled (VMT) but not necessarily fewer trips
Proximity to an urban centre	Lower VMT
Land use mix	Shorter travel distances, and increased use of alternative modes
Concentration of activity in Centres	Lower modal share of commuting by car, more frequent use of public transport and car sharing
Connectivity of routes	Lower VMT, particularly if layout discriminates in favour of non-motorised modes
Transit Accessibility (proximity to a rail station)	Higher modal share for rail and fewer vehicle trips
Parking Constraints (residential or destination/employment)	Lower share of commuting by car

Table 2: Summarised from Litman (2008)

The list is not exhaustive: the factors are selected to illustrate the principles in this article. Studies of other developed countries have identified similar relationships and several other relevant built environment factors. Hickman and Banister (2008) for example, studied cross-sectional data for Surrey in England. They found similar associations with density, connectivity, accessibility to public transport and proximity to central London. They did not assess parking constraints, and used jobs/housing balance within the settlement as a measure of land use mix (negatively associated with energy weighted VMT). Stead (2001) also found a negative association between settlement size and travel distance for the UK. Several studies of the Netherlands have found significant associations between composite measures of urbanisation and different measures of travel behaviour, similar to the above (e.g. Schwanen et al, 2004, Susilo and Maat, 2007).

There is often a high degree of correlation between the above factors, at the regional and neighbourhood level, and policies of urban intensification often aim to increase several or all of them. The effects, Litman argues, tend to be cumulative: residents of high density urban areas in the U.S., which generally exhibit all the other factors, make about 25% fewer car trips and twice as many pedestrian and transit trips than the national average.

Most of the studies reviewed by Litman controlled for socio-economic factors in reaching the conclusions shown in Table 2. A few also incorporated measures of attitudes or preferences. The vast majority of the literature in this area relies on cross-sectional studies, however, from which causality can not necessarily be inferred. If the built environment factors do not cause the differences in the second column, then it cannot be assumed that promoting those factors will produce such changes.

One potentially confounding mechanism is the question of ‘self-selection’: the tendency of people to choose neighbourhoods which facilitate their preferred mode of travel. Several studies have sought to address this question by controlling for attitudes, typically finding these to be more important than built environment factors (Schwanen and Mokhtarian, 2005). These studies also used cross-sectional methods and as a result may have underestimated the importance of the built environment factors, since the attitudes measured at a single point in time may have been influenced by the local built environment. So, for example, a cross-sectional study which finds that city centre dwellers prefer to walk and cycle, and controls for these factors, may wrongly conclude that living in a city centre exerts no influence on rates of walking and cycling.

As suggested by Handy et al. (2005), to address this problem would require either a longitudinal study (which are rare for cost and resource reasons) or a combination of quantitative and qualitative methods which sought to explore the evolution of attitudes.

Two recent studies have done this, both reaching similar conclusions. Based on quantitative data for Copenhagen, and qualitative interviews in Copenhagen and Hangzhou, Næss (2009) found that significant relationships between residential location and travel exist regardless of travel-related residential preferences. He also concluded that previous studies had underestimated the influence of the built environment, for the reasons outlined above.

On a smaller scale, a recently completed study by the authors (Melia, 2010) included a survey of a ‘low car’ development in Dorset (UK), seeking to explore similar issues. Poole Quarter is a recently built development of apartments and town houses with a residential travel plan and one parking space per dwelling. Its density of dwellings – around 100 per hectare – was significantly higher than elsewhere in the town.

Of the 97 households surveyed during 2007, 26 had reduced their car ownership on moving there and 32 reported lower car use (4 reported higher use). The reductions were partly explained by proximity to the town centre, bus and rail stations but parking limitations also contributed. Telephone interviews revealed some evidence of self-selection: some people who moved there were seeking greater accessibility. Others moved there for other reasons, but still reported a change in their travel behaviour. Several reported that their attitudes towards travel by alternatives to the car had become more positive following their moves, consistent with the arguments above about attitudes and the built environment.

Overall, the findings reported in this section support the view that redeveloping inner urban areas with high density housing of this nature can help to reduce travel by car at the individual and national levels, though this does not imply any overall reduction in traffic surrounding the development. As the rest of this paper will argue, an increase in local traffic is more likely.

3. The Paradox of Intensification

Notwithstanding self-selection and other confounding factors, all other things being equal, Section 2 suggests that urban intensification does cause a reduction in per capita VMT and the modal share of private motor vehicles in those areas where it is implemented. Whether this implies a reduction or increase in traffic within and surrounding intensified areas depends upon the elasticity of vehicle use with respect to population density.

So is vehicle use elastic or inelastic with respect to population density? Studies of this question have been based on cross-sectional data, again, with the limitations that implies. Newman and Kenworthy’s interpretation of the international data implied an inelastic relationship at the highest levels of density in Asian cities, but a relatively elastic relationship at the lower levels of density encountered in North America and Australia.

Cross-country comparisons, reflecting a range of cultural and other differences, may be misleading when considering intensification within a country. Studies within countries have consistently shown that vehicle use measured in different ways is highly inelastic in respect of density.

Zhang (2004) estimated probability-weighted average elasticities for mode choice in Boston and Hong Kong. Their findings with respect to driving are shown in Table 3.

	Work Trips	Non-Work Trips
Boston	-0.044	-0.04
Hong Kong	-0.039	-0.11

Table 3 Elasticities of driving against population density, Zhang (2004)

This implies that all other factors held constant, doubling the population of Boston would reduce the probability of driving for each trip by around 4%. It should be noted that these are net elasticities, controlling for a range of other social, economic and built environment variables.

The appropriate measure of ‘driving’ for these purposes would vary according to circumstances. If a single development is considered in isolation *vehicular trip generation* (i.e. the number of vehicle movements) would be the most appropriate measure, since the only change in traffic levels would be caused by journeys originating (or terminating) in that development. If intensification is practised across a city (or any area wider than the individual development) then journey *distances* would also influence the volume of traffic in and around the intensified areas.

Elasticity with respect to VMT appears greater than that of trip generation, but it is still highly inelastic. Using data for California, Brownstone and Golob (2009) estimate that a household in a neighbourhood 40% denser than the average will drive 4.8% fewer miles than an identical household in an average neighbourhood – an elasticity of –0.12.

In a study using Census data for England, Gordon (1997) found that a doubling of densities was associated with a 7% reduction in energy-weighted miles of travel to work. Based on a range of studies using U.S. data, Ewing et al (2008) estimate that a doubling of local density would reduce both VMT and trips by around 5%.

Different data and methods will produce different estimates, but none of the studies suggest that doubling population density would halve trips per person or VMT. This suggests:

> Ceteris paribus*, urban intensification which increases population density will reduce per capita car use, with benefits to the global environment, but will also increase concentrations of motor traffic, worsening the local environment in those locations where it occurs.*

The *ceteris paribus* qualification is necessary to draw the above conclusion from cross-sectional data. It implies a number of caveats relating to changes in other factors. These may be entailed by intensification, or they may be exogenous, including additional policy measures aimed at restraining car use in intensified areas. The predicted transport outcomes of the paradox are illustrated in Table 4:

	Per capita (by residents of the intensified area)	**Within the Intensified Area**	**Globally**
Vehicle Miles Travelled	↓	↑	↓
% of trips by car	↓	↓	↓
Traffic volumes		↑	↓

Table 4 Transport Effects of Urban Intensification as Predicted by the Paradox

The intensified area in Table 4 may refer to a city, a neighbourhood, or a smaller development. The fourth column reflects the small differences in global car use and traffic volumes implied by the behavioural change in the second column, assuming either:

a) the additional residents have moved from lower density areas, or
b) a comparison between higher and lower density scenarios for accommodating population growth

The relationship between these factors and global environmental factors such as energy use and CO_2 emissions are not straightforward. Increased emissions and fuel consumption due to worsening congestion in and around the intensified area may offset the gains from behavioural change.

The paradox defines density in terms of population. As discussed in Section 1, average household size has been falling in many developed countries. So in some circumstances, intensification of dwellings accompanies and only partially offsets a fall in population density. In these circumstances, the principle behind the paradox still applies, but rather than increasing concentrations of traffic, intensification will attenuate the traffic *reduction* which would otherwise occur, all other things being equal.

Although the scale of the intensified area will not affect the direction of the relationships illustrated in Table 4, it will affect their nature and magnitude, as discussed next.

4. Gross and Net Relationships, Micro and City-wide Intensification

The paradox does not imply that intensification will produce the predicted results in all circumstances. Many other local circumstances and changes in exogenous factors over time will complicate each individual situation. Clearly, in practice, other factors do not remain constant following intensification. Returning to the factors in Table 2, higher population densities may entail greater accessibility to public transport and parking constraints. They are also likely to facilitate greater mixture of land uses in any given area. Whether intensification will reduce distances to the nearest urban centre depends upon the context in which the comparison is made. Intensification of an existing suburb will not alter its distance from the city centre. But in a context of household growth, a city-wide policy of intensification will restrain the increases in distances which would otherwise result from the alternative of lower density expansion beyond the limits of the built area.

In addition to these built environment factors, density is also associated with socio-economic differences. Income exerts a strong influence on vehicle use, directly and indirectly through its influence on car ownership. In the USA, where higher income groups generally prefer suburban living, there is a strong negative correlation between income and population density (Brownstone and Golob, 2009, Horning et al, 2008). In England and Wales, as illustrated below, the pattern is more complicated, producing a weak overall negative correlation. For these reasons, the gross relationship between density and vehicle use will typically be stronger than the net relationship (i.e. controlling for other factors) described in the previous section. Even the gross relationships within countries and regions still tend to be inelastic, however

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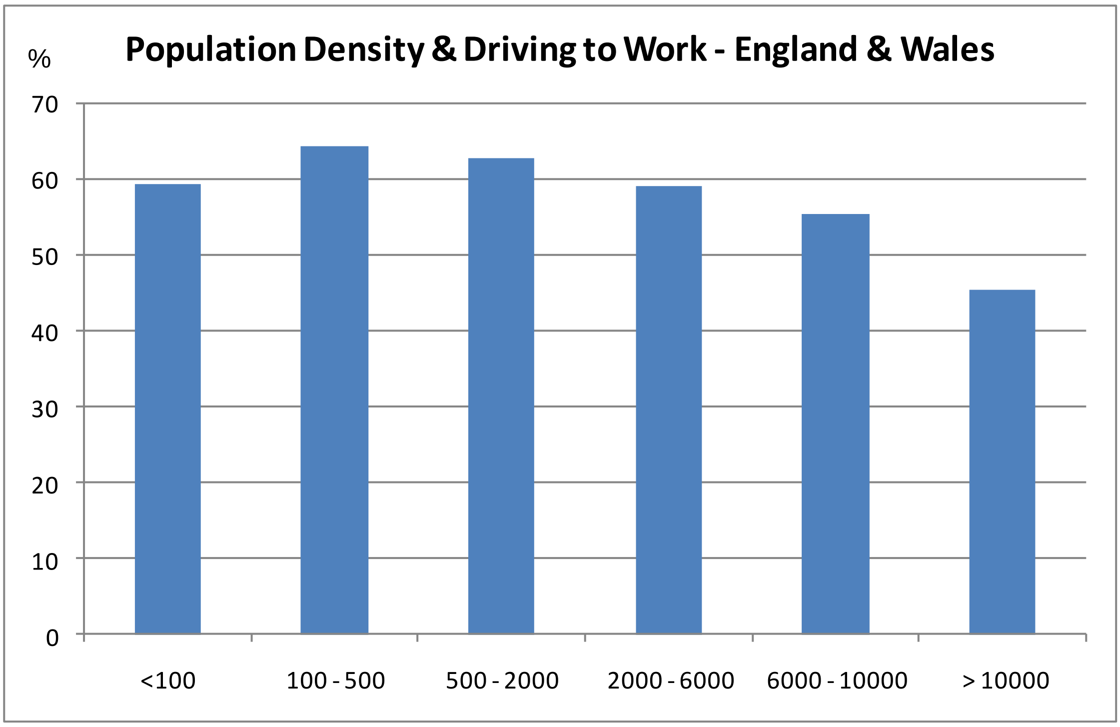

Figure 1 Density in Persons/Mile^2 against modal share – UK 2001 Census

Figure 1 uses 2001 Census data for local electoral wards in England and Wales, using similar bands relating to population density rather than dwelling density (assuming two persons per household – slightly less than the average). Three simple linear regressions were performed on this data, to estimate the gross relationships between population density and: income, modal shares for driving to work, and average distance travelled to work. It was also possible to obtain the statistics on density and modal share for the smaller Lower Super Output Areas (LSOAs – usually with a population between 1000 and 2000).

Compared to the net elasticities from the studies cited in the previous section, Table 5 shows a stronger but still inelastic relationship between density and commuting distances, and a weak relationship with modal share. These relationships are stronger than the relationships with electoral wards illustrated in Figure 1 presumably because the smaller LSOAs are more homogenous.

	Coefficient	**R^2**
Household Income (by ward)	- 0.028	0.002
Average distance to work (by ward)	- 0.310	0.448
Modal share for driving to work (by ward)	- 0.099	0.268
Modal share for driving to work (by LSOA)	- 0.238	0.415

Table 5 Gross Relationships between Population Density (persons/hectare) and other factors (2001 Census data)

The previous section cited Ewing et al's (2008) estimate of elasticities with respect to local density – one of the 'four Ds' shown in Table 6:

	Vehicle Trips	Vehicle Miles Travelled
Local Density	- 0.05	- 0.05
Local Diversity (Mix)	- 0.03	- 0.05
Local Design	- 0.05	- 0.03
Regional Accessibility	-	- 0.20

Table 6 Typical Elasticities of Travel from US data (Ewing et al 2007)

The authors maintain that the four elasticities are additive: doubling all four would be expected to reduce VMT by about a third, vehicle trips by 13%. This would only apply in circumstances where it is possible to vary all four factors. As the strongest effect, regional accessibility, relates to the position of the intensified area in relation to its conurbation, this factor may be difficult to change at the level of the individual development although it has significance for the choice of development locations.

The databases used by transport planners to estimate the traffic generation of new developments illustrate a similar pattern to the one above. One commonly used database, TRICS®, contains data from a wide range of surveys conducted over the past 20 years in the UK and Ireland. Some of the residential developments surveyed include information on the density of dwellings, from which the average vehicular trip rates shown in Figure 2 were calculated.

Figure 2 is based on 79 developments of privately owned houses and 34 developments of privately owned flats. The flat developments were all built at densities of over 50 dwellings per hectare; the average density of the flats was 241 dph, compared to just 65 dph for the band 'Houses > 50'. When this is taken into account, Figure 2 clearly illustrates the same pattern of inelastic negative correlation between densities (of dwellings in this case) and vehicle use. The flats, for example, are 16 times denser on average than the least dense band of houses, but the latter generate only 3.4 times the vehicle movements per dwelling than the flats. As above, this is a gross relationship reflecting differences in many other factors besides the density of dwellings.

It may be inferred from these inelastic relationships that, where intensification replicates *all* the conditions of denser areas – socio-economic and attitudinal as well as built environment – the paradox will still hold, but the additional traffic generated will be less extreme than the *ceteris paribus* condition would imply.

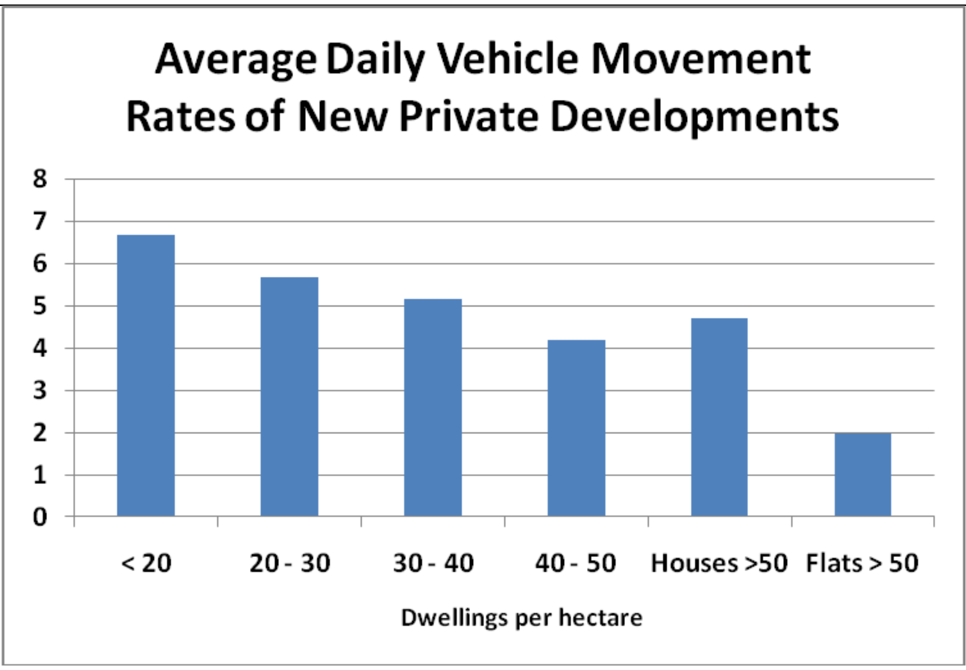

Figure 2 Average Daily Vehicle Movement Rates of New Developments from TRICS®

Reality is likely to resemble the *ceteris paribus* condition more closely where a small area is selected for intensification in isolation (assuming that the socio-economic characteristics of the residents do not change). Where intensification is practised across a city or region, other factors such as concentration of activities, parking constraints and road capacity limitations are all likely to restrain some, but not all, of the increased traffic generated. In extreme cases, where the road network is already very congested, it is possible that no additional traffic may be generated. At both levels, but particularly at the city-wide level, additional policy measures may help to constrain or suppress the increase, as discussed below.

5. Policy Implications of the Paradox

From a policy perspective, a key question which emerges from this analysis is whether, through additional measures it is possible to intensify without significantly increasing local concentrations of traffic. At the city-wide level one example suggests that in at least some circumstances, it may be.

Freiburg in Germany is one example visited and studied by the authors. Between 1990 and 2006 the population of the city rose by 13.9% (Stadt Freiburg, 2009), partly due to intensification and partly due to two compact urban extensions, one of them (Vauban) substantially carfree. The fall in per capita vehicle use on residential roads was sufficient to keep traffic levels roughly constant, although total traffic levels still rose slightly (Pucher and Buelher, 2009). The specific influence of intensification and other factors, such as rising incomes has not been studied, but some of the factors which helped to constrain the growth in motor traffic can be identified. They have included: subsidised all-mode public transport season tickets, expansion of the tram and cycle networks to cover nearly all the city, pedestrianisation of the city centre and concentration of activities there, channelling of through traffic, speed reduction and traffic calming in residential areas. None of these policies is unique but their consistent and coordinated application distinguishes Freiburg from most other European and North American cities. Litman's observation about the cumulative effect of factors is certainly relevant in this context. Several aspects of national transport and planning policy have clearly been more helpful in Germany (CfIT, 2000), but why Freiburg has been more successful than Portland in restraining traffic growth is a question which would merit further research.

At the level of the individual development, the analysis in the previous section suggests it would generally be difficult to overcome the effects of the paradox. Where two options are considered for developing a site, one at low density, the other at significantly higher densities, the latter will, under most circumstances, generate more local traffic, which it would be difficult to overcome with the normal range of mitigating measures available at that level. This is a theoretical rather than an empirical statement. Barton et al (2010) set out a range of design principles and other measures which can help to reduce traffic generation at the neighbourhood level. What range of measures would be necessary to mitigate what level of traffic induced by intensification is an area where more research is needed.

Policymakers may consider local concentrations of traffic an acceptable side-effect where intensification of that site forms part of a strategy aimed at achieving modal shift and other objectives at the city-wide level – although residents of surrounding areas are unlikely to share that view. One obvious context is intensification around public transport routes, where population density around stops exerts a strong influence on ridership and the financial viability of the service (TRB, 2009).

Alternatively more radical measures may be considered to overcome the traffic effects of intensification. Whereas positive measures, such as improvements in public transport and land use changes, are unlikely, in most circumstances, to overcome these effects on their own, direct constraints on car use can be more effective, where these are acceptable to residents and policymakers (to illustrate the point, consider the extreme option of a total ban on motor vehicles).

Reductions in residential parking provision can be one of the most effective tools, provided effective controls exist to prevent overspill parking and reduce levels of car ownership. Melia (2010) found that the environmental improvements from the removal of traffic can help to offset the perceived disadvantage of parking restrictions for some home buyers and tenants, particularly in the inner areas of larger cities, or other centres well served by public transport including rail. As a policy response, carfree development has the advantage that it is most likely to be feasible in areas where the benefits of traffic and parking reduction are most needed.

Non-residential parking restrictions – often part of ‘smart growth’ policies – can reduce inward vehicle trips to mixed use areas, although these are unlikely to have much effect on traffic generated by households within the area, unless they are accompanied by residential parking restrictions.

Physical restrictions on the circulation of motor vehicles have also been effective in certain city centres such as Groningen in the Netherlands, where population has increased in an area from which private motor vehicles have been largely removed, through a combination of pedestrianisation and closure of roads to through traffic (Melia, 2010).

Some commentators from a libertarian perspective have used the example of Portland as an argument against the principle of intensification (e.g. Cox, 1999). From a different perspective, giving greater weight to sustainability, we would challenge this conclusion. Focusing solely on the transport factors (others relating to land use may be at least as important) intensification of cities is justified partly for the benefits to the global environment even though these are currently small, partly for the public health benefits of increases in walking and cycling (Butland et al, 2007), but particularly because higher density cities will find it easier to adapt to a future less dependent on private motor vehicles. In addition, where average household size is falling, to maintain existing population densities, around public transport corridors, for example, will require intensification of dwellings.

Some writers, particularly associated with the Town and Country Planning Association in the UK (TCPA, 2007, Breheny, 1997) have argued that planning policy should steer a middle course of limited urban intensification accompanied by more rapid decentralisation using green field sites (in the UK context, where the number of households is rising rapidly). The analysis here suggests a compromise involving limited intensification would merely redistribute the balance between the two sets of problems: local and regional/global. A policy of sustainable development, which aimed to address both, would embrace urban intensification accompanied by more radical policies at the national, city and local levels to combat the negative externalities arising from the concentration of cars and traffic.

6. Conclusions

Although the evidence on the specific outcomes of intensification is currently limited, the weight of evidence reviewed here suggests that an inelastic negative relationship between population density and vehicle use is common, across several developed countries. This implies that planning policies which increase population densities will, under 'normal circumstances' reduce overall vehicle use, but increase its concentration in the intensified areas, causing a range of local environmental and social problems, unless significant steps are taken to constrain the generation of additional traffic. It is important that this paradox of intensification is recognised, to avoid false expectations and focus attention on the other policies which must accompany intensification if environmental and social goals are to be achieved.

At the level of the city or region it may be possible to prevent a significant rise in traffic volumes through a combination of measures related to: land use, public transport, walking, cycling and traffic restraint. Freiburg provides one successful example, although a combination of such measures in Portland has not proved sufficient. At the level of the individual development, the range of available measures is likely to be more limited. Even where policy at the city level succeeds in restraining traffic growth, the effects of intensification will be uneven. At the level of the individual development higher densities will, under most circumstances, generate more traffic: positive measures to promote modal shift are unlikely to counteract this on their own. At this level policymakers face two choices: accept the local consequences as the price of wider progress, or take more radical measures to constrain traffic growth in intensified areas. These measures may include closing roads to through traffic, reducing residential parking and, where feasible, carfree development.

The range and level of measures needed to counteract the effects of intensification in different circumstances is an area where current knowledge is surprisingly limited, given the prevalence of intensification policies across the developed world. More detailed research in this area could help policymakers to make better choices than urban sprawl or conventional intensification where global gains entail local sacrifice.

A longer version of this article will be published in Transport Policy Volume 18(1) 2011.

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