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Density and the built environment ☆

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ABSTRACT

The densities with which urbanised regions are occupied can have a significant impact on energy use and emissions, via the patterns of personal mobility that are enabled and encouraged. The potential for using this variable as a tool for environmental regulation is limited, however, for two inter-related reasons. One is that actual densities are an outcome of complex processes of individual choice over which planners have little direct control. The other is that planning operates only at the margins of physical development, with much slower and more modest impacts on the behaviour of the population as a whole than would changes in relative transport costs, in particular.

1. Background: density, location choices, travel behaviour and planning

Density is an intuitively simple concept, representing both the intensity with which an area is used or occupied and how limited the available local space is for an average resident or worker. In practice, however, neither the measurement of population or job densities, nor an assessment of their relevance to the scale of human impacts on the natural environment, is so simple.

There are two main reasons for this. One is that densities of occupation vary greatly both between types of occupier and between localities, even within a region or settlement. This is both a matter of circumstance and of preference. Survey evidence shows that some people will be as happy living at high densities as others would be only with access to more space (Burdett et al., 2004). The other reason is that the appropriate area over which to measure densities of occupation, from the room up to the region or nation, itself varies according to the purpose for which the measures are to be used, and the types of spatial behaviour relevant to it.

In market economies such as the UK, densities vary as a reflection of what occupiers can afford their weighting of the value of extra space relative to accessibility, local constraints on land supply, and the pressure of demand in alternative locations. The appropriate area to consider varies because occupiers' location decisions and subsequent behaviour are affected by their proximity to space, facilities and opportunities outside their own premises. The impacts of urban form on the natural environment may depend on the configuration of densities across broad economic regions as well as those within immediate residential or commercial neighbourhoods.

Because individuals and firms ignore the impact of their own location decisions on the welfare of others, density levels in particular areas may be either too high or too low from a social or environmental perspective. But corrective physical planning measures need to be based on an understanding of the diverse preferences and complex interactions underlying market outcomes if they are to improve on these results and avoid negative effects from unanticipated reactions. The risk of such effects is well illustrated by the outcome of post-war urban containment policies in the UK, which effectively if unintentionally secured higher-density residential development as a reaction to rocketing land prices, but only at the cost of extended commuting patterns in regions where homeowners in search of affordable space had to 'leapfrog' the new green belts (Evans, 1998; Hall et al., 1973).

A useful framework for understanding the development of density patterns in the urban regions of market economies is in terms of a trade-off that both firms and households have to make between the amount of space (in terms of land area) that they would like to occupy and the level of accessibility they would like to opportunities (for jobs, work, recreation, etc.) within the region. These are both derived demands. This means that the demand for land space that emerges is a composite of preferences in relation to household size, internal and external spaces, privacy, etc., which may be satisfied in different ways, for example by combinations of garden and public space. But overall, the greater the priority given to accessibility (relative to space), and the more concentrated the relevant opportunities are, the higher

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both peak and average densities will be. These higher densities would involve some combination of reduced internal spaces (and therefore higher floor space densities), and more storeys in the development, plus reduced external space associated with it, together yielding higher plot ratios.

Anglo-American observers have concluded that demands for accessibility are less elastic than those for space. They vary little if at all as incomes grow, and have more the character of needs than of luxuries. This means that densities across a region will tend to fall continuously as average incomes rise; while richer groups will locate at the fringe of the region, the poor will locate in the centre together with those businesses that require face-to-face interaction.

In the UK these patterns have broadly prevailed, though they are complicated by the impacts of sizeable social and public housing sectors and of post-war physical planning policies, and are intensified by the rise of private car ownership.

Different patterns have prevailed elsewhere in Europe. There, the rich are generally more residentially centralised than the poor. This exemplifies the fact that such patterns rest on cultural and lifestyle values, which can vary from place to place, and may be subject to change over time. Within the UK, there are groups—including people not living in family-based households, university graduates and some ethnic minorities—who seem to attach relatively more value to centrality and live at higher densities than would be expected from their incomes. These groups have been growing as a proportion of the population over recent decades, contributing to the repopulation of central areas in cities such as London and Manchester. There are indications for some of these that higher incomes may actually have a stronger effect on the demand for accessibility than on that for space.

More generally, it is important to recognise that demands for both accessibility and actual interaction (involving trips to opportunities) are elastic and not simply matters of 'need' that can be satisfied by the provision of economic or social opportunities close to places of residence. At the regional scale, affluence and economic dynamism are both linked to increasing diversity and specialisation of opportunities, with residents and business people valuing the chance to patronise those which are closest to their preferences rather than simply closest to their base. People travel further (for work and pleasure) within the region, as well as outside, than would seem 'necessary' to planners or uninformed observers of their behaviour, to a degree depending essentially on the cheapness, quality and availability of transport.

Density patterns have evolved and become much more complex, with the emergence of discontinuous and poly-centric regions over the past half century. This has happened through the interaction of market forces, underpinned by economic, social and technological trends, and public policy interventions of various kinds, including the statutory planning system. This process will undoubtedly continue. But there are limits on how much change can be secured, and it is difficult to ensure that the pattern of change both reflects policy intentions and secures significant improvements in environmental outcomes.

One reason is that policies operate only at the margin represented by new construction, which is limited both by the durability of buildings and their high cost of replacement. A second is that, as we have seen, patterns of density in a market economy are the complex outcome of very large numbers of personal and commercial choices, and of the diverse values and circumstances underlying them. These need to be understood if planning policies are to yield desired effects rather than undesired and unexpected adjustments of behaviour. In any case, the final implementation of planning policies, in terms of actual patterns of development and investment on the ground, will inevitably diverge from expectations, as a result of continuing interaction with market forces and local politics (Breheny and Archer, 1998) in ways that need to be better understood.

2. UK densities in an international perspective

At the national scale, the UK is one of the most densely populated of advanced economies. Its population density is more than double the EU average, behind Belgium and the Netherlands and similar to that of Germany. These comparisons are somewhat arbitrary, depending on historical accidents of national boundaries, and on how much more-or-less empty peripheral space is included within them. When local densities are aggregated using population or worker numbers as weights rather than land area—to approximate the density at which the average person lives and works—a much higher and less variable number is produced. But the UK still emerges as a country of high densities, since it has a large proportion of its population in major cities, each of which has relatively high densities. The internal denseness of those cities, compared with those in culturally similar nations in North America and Australasia, reflects the much tighter physical constraints in the UK on the amount of developable lowlands available.

At the scale of continuously built-up 'urban areas', average UK densities are rather high even by European standards. Across the ten UK urban areas with more than 500,000 inhabitants, population densities average 41/ha, half as high again as in the rest of Western Europe, equal to those in Japan, and almost four times those in the USA. Densities in smaller urban areas average 36/ha for England and Wales, also high by the standards of high-income countries outside Asia. Among leading European cities, London's average density at 51/ha is slightly below those of Athens and Madrid, but is at least 50% above those for Paris, Frankfurt, Rome, Milan and Amsterdam. It is also above the average density in Tokyo/Yokohama and very much higher than that of the New York urban area (Demographia, 2007).

At a wider metropolitan scale, the picture can be somewhat different, because of the role of British green belts, which have served both to make urban areas more compact and functional urban regions less so. But even on the basis of Eurostat et al. (2006) 'Larger Urban Zones' (LUZs), the largest British cities are all denser than the European average of just 5/ha for LUZs with over a million residents. In fact it is probably only in the central areas of cities such as London that British urban densities are significantly below those in their counterparts abroad (e.g. comparing central London with Manhattan, central Paris or Berlin, cf. Burdett et al., 2004).

Since there is substantial evidence that larger and denser agglomerations contribute positively and significantly to productivity levels, the UK's relatively high density should be seen as an economic asset. In global environmental terms it could be seen more negatively if limitations on the land available for agriculture were a binding constraint on self-sufficiency, adding substantially to the transport cost of meeting UK consumer demands. But this appears not to be the case. The crucial consideration appears to be the level of energy use and the consequent carbon emissions, notably from personal transport within the urban region, where the strong presumption is that higher urban densities can reduce both.

Emissions from buildings themselves are an important concern, with a clear need to improve standards of insulation. But in this case links between energy use and development density are less clear, and the empirical evidence points to significant but mixed effects (Mitchell, 2005). On the one hand, the least dense residential forms (bungalows) show twice the rate of heat loss per unit area as apartments, the most dense. But for offices, the densest forms in terms of plot ratios are associated with rates of

energy use half as high again as in the least dense. Arguments about the potential for modifying densities are relevant to impacts both from buildings and from transport, but the focus here will be on emissions generated by personal travel.

3. Trends in urban densities

From the 1950s until at least the 1970s, urban densities in Britain tended to fall significantly. In part this was the consequence of massive job losses from some major industrial and port city-regions in the north, stimulating out-migration to places whose area expanded, while reducing pressure on space in the cities they had left. But primarily, in the north as well as the south, it was a consequence of increasing demands for residential space, whether in the form of larger properties or smaller household sizes. In aggregate this required the urbanised area of the country to grow.

In the 1980s, there were some signs of a slowing in this process, perhaps partly as a reaction to an extended economic recession. In the 1990s, however, densities seem to have stabilised, with just a 1% fall across urban areas outside London, and a quite large increase there (of about 8%), between the 1991 and 2001 Censuses. The London increase seems largely or wholly to reflect the emergence of high rates of international immigration, primarily of people from poor countries, who at least initially occupy properties at much higher densities than the settled population (Gordon et al., 2007).

4. Implications of density and density mix for transport

Density of development affects transport in two ways:

- Closer proximity of people and businesses to each other stimulates more demand for travel (i.e. more trips), but over shorter average distances. This means that denser urban and metropolitan regions will generate rather fewer trip miles of personal travel, and maybe of local goods transport too.
- Urban or metropolitan regions containing a number of dense local concentrations of populations and jobs increase the viability of more energy-efficient forms of public transport. The effect is stronger where urban form allows efficient network links between residential areas and centres of business and social activity. Denser regions could thus achieve significantly lower emissions levels per trip mile.

The one well-known international comparison appears to provide strong support for these hypotheses, with a graphic correlation of per capita energy use in personal travel against metropolitan densities. It suggests a pattern in which a doubling of densities could bring a halving of energy use, and thus of greenhouse emissions from this source also (Newman and Kenworthy, 1989a, b). It should be noted that though the observations are of cities, the contrasts are essentially between four or five broad national groupings (cf. Kenworthy, 2003) in quite distinct situations. Within any of these regional groups the correlations between density and energy use are much weaker, and in the case of the European cities, which comprise a third of the observations, there is no sign at all of a relationship.

This simple correlation of these two variables is quite misleading because other factors need to be controlled for, which actually have a much larger impact on travel behaviour. In particular, the high-density cases tend to be in nations of the developing world, where low incomes currently depress demand for travel by private motor vehicles. Conversely, the low-density cases come from countries (notably the USA and Australia) where expectations of cheap petrol prices have stimulated demand for car travel. Over the long run these price and income factors are themselves important influences on density levels, as well as having direct effects on travel behaviour. But, when their influences are controlled for, the apparent impact of density on emissions is greatly reduced. Rather than a doubling of densities being associated with a halving of energy use in personal travel, the corrected estimates implied a reduction of just 15%. A similar cross-sectional analysis based on commuting patterns for all the English functional urban regions found another significant, but even weaker, effect—a doubling of densities being linked to a 7% reduction in energy-weighted miles travelled (Breheny and Gordon, 1997; Gordon, 1997). Various kinds of analysis in other countries, with differing strengths and limitations, have generated qualitatively similar kinds of conclusion, implying that higher densities of occupation could probably reduce levels of energy use in personal travel somewhat, though the implied elasticities are low (e.g. Golob and Brownstone, 2005; Schwanen, 2002).

The key point in relation to the practical application of these results is that the overall density of a city-region is not amenable to much influence except over the very long term. References to a 'doubling of densities' are purely notional even in relation to the densities, that might otherwise have been expected. The only exception is in areas where the present trend is for unchecked market forces to produce very substantial 'sprawl' at the perimeter of the city-region, continuously extending its area. This is now far from being the case in the UK. Even in the USA, where the concept of sprawl has more relevance, remotely sensed data for the period from the mid-1970s to the early 1990s indicate no tendency towards more discontinuous patterns of expansion (Burchfield et al., 2006).

Manipulation of urban density patterns is only likely to make a substantial difference to emissions—via restraint of travel demand and a shift towards modes other than the private car—if it is especially sensitive to aspects of urban form that are more susceptible to change. Little systematic work has been done on this, but examination of a variety of simple statistical indicators of form for the English functional regions revealed a single important association. This involved the job-weighted workplace density, a measure of the concentration of employment in a few small areas, which was correlated with a more energy-saving mix of travel-to-work modes. There was no such evidence of particular effects from more space-saving forms of residential development, though the spatial mismatch between jobs and residences was associated with longer average distances of travel to work (Breheny and Gordon, 1997). Another British study does report significant effects of residential densities *within* neighbourhoods on distances travelled by local residents (Stead, 2001). Some part of this apparent relationship is, however, likely to reflect differences in attitudes to travel between those choosing to live in different types of locality within a functional region. Other local design features might be more important than density per se, for example those favouring slower modes of travel (Maat et al., 2005).

Urban forms have a range of other effects, though these are not well understood. An example on which work is under way (referred to above) concerns the levels of energy use in buildings and the resulting emissions levels. There are also complicated issues about how urban form affects levels of travel congestion, and thereby localised pollution, as well as time wastage. Outside the environmental domain, there is increasing economic evidence for the significance of agglomeration economies at various spatial scales in the productive economy. There has also been much speculation about potential positive effects of urban density on

social integration, equality and social capital as factors reinforcing the case for more compact cities made in Rogers et al. (1999). Little systematic evidence has been gathered about these, but a first study at neighbourhood scale, distinguishing five dimensions of 'social sustainability,' finds that higher density has only negative effects (on local pride, environmental quality and use of local facilities), when the local social mix is controlled for (Bramley et al., 2006).

5. Influences on future trends

Rising personal incomes: The general expectation remains that increasing real personal incomes will continue to boost the demand for space both inside and outside the home, and on average will do so faster than they boost demand for accessibility and centrality, thus leading to lower densities.

Planning policy: Planning policies of the past decade have been geared to the compact city goal, for reasons at least partly linked to global environmental concern. They have tended to slow the decline in urban densities, by encouraging reuse of brownfields in cities, including disused industrial sites, playing fields and suburban gardens, and especially by increasing resistance to greenfield development outside the cities. How far this will continue is uncertain. The easier and more economic brownfield opportunities in areas of potential demand are being used up, while the Barker review has highlighted the relation between controls on greenfield development and house price inflation. On balance, the new sustainable communities may raise densities modestly, and might also reduce longer-distance commuting, although the precedent of New Towns is not encouraging in this regard.

Immigration: Future levels of net immigration into the UK are uncertain, and the great increase over the past 20 years was generally unpredicted. However, there seems no good reason to believe either that demand to come here from (mostly skilled) workers in poorer countries will diminish, or that policies will more effectively abate the inflow. The immediate effect of such migration is to raise densities in the destination regions (notably London). This effect is substantially reduced, however, by an increase in outmigration—equal to about half the immigrant inflow—to surrounding areas as a consequence of displaced demands for space. Unless the scale of immigration flows continues to increase, convergence in space aspirations would mean that density levels in the receiving regions should peak within 20 years. It should be noted that density increases due to population growth do not actually reduce travel demands, though they may marginally improve the viability of public transport unless they are concentrated in areas where capacity is already stretched.

Lifestyle changes: Trends in household structures, participation in higher education and the higher number of the foreign-born are among the factors favouring higher-density urban lifestyles. Each has a good prospect of continuing for at least the next 10–20 years, but the implications beyond that, as current younger generations pass into middle age, are not at all clear.

Economic competitiveness and workplace changes: The shift toward a more flexible, market-oriented economy, first noted about 20 years ago, still has quite a way to go, and could continue to 2050. It increases the competitive advantages of concentrating at least key functions in denser urban environments. But these locations will remain relatively expensive sites for any function that does not need face-to-face interaction outside the organisation, and pressure can be expected to continue for all other activities to be hived off as and when they can be routinised. The gradual but much-hailed trend to home-based working will continue. It has more of an effect on the frequency of travel to work than on numbers working primarily from home. Home working depends on people having space available to do it. So it is more likely to feed demand for lower densities and facilitate decentralisation than the reverse. Its net effect could thus actually be to increase, rather than decrease, travel for all purposes by the least energy-efficient modes.

Fuel costs: For market reasons and because of policy concerns over transport's role in greenhouse gas emissions, fuel costs can be expected to rise substantially over the period to 2050. In part this increase will no doubt be absorbed through induced improvements in vehicle technology. But, in so far as they impact on transport costs, fuel prices can be expected to have a continuing impact on residential choices, favouring significantly higher densities in the long run, as well as strong short- to medium-term impacts on fuel consumption in personal travel (Graham and Glaister, 2002a, b). A key challenge for planning—playing with, rather than against, market forces—will then be to design urban forms at both neighbourhood and city-region scale, which respond most effectively to residents' shifting demands for space, accessibility and quality of life.

New forms of transport provision: The relationship between densities and the quality of public transport provision is a two-way one. Better provision will encourage higher densities, as well as increased density making such provision more viable. Growing demand can be expected for more flexible and efficient ways of meeting private mobility demands on a collective basis—both technologically and through better integrated land use transport planning. These could have a significant impact on densities, as well as more directly on energy consumption and emissions. Their effectiveness will depend on how far they actually offer more attractive compromises between demands for access to space and for accessibility than are currently available.

6. Priority areas for future research

From existing research it is clear that action to raise urban densities (or slow their decline) is not a realistic substitute for more direct fiscal measures to discourage extended travel by inefficient forms of personal transport (Evans, 1998; Wegener, 1998). This is because of the low elasticity of travel demands in relation to density variations, and because the rate of change of densities is inevitably slow, except in the face of a rapid acceleration in population growth. The social and political implications of sustained efforts to promote higher densities by means of severely restricting greenfield development, which would raise dwelling prices and restrict access to housing, would also be unacceptable. If the key environmental issue is carbon use in transport, rather than land use, it is only efficient to address the main concern.

More refined analyses of different contexts, activities and urban forms are extremely unlikely to alter these basic findings. They could, however, be vital to understanding how locational preferences are likely to shift as and when such fiscal incentives exert a substantial impact on travel behaviour, and how urban and transport planning can most efficiently respond to the opportunities and pressures that this shift will create (Wegener, 1998).

In particular, we need to know more about:

- The future pattern of employment location within urban regions, across the spectrum of more or less routinised kinds of activity, and how this is likely to be altered by a substantial increase in the cost of travel by private motor vehicles.
- The dynamics of shifts in lifestyle values, particularly those associated with the interaction between household composi-

tion and ageing. This is needed to understand, for example, how much further the trend towards non-couple-based households and delayed child-bearing can go, and how far its locational implications may extend beyond the normal time of transition to nuclear familyhood.

- How the locational preferences of those currently making extensive use of private motor vehicles would be altered by a substantial increase in its cost, and how change could most effectively be satisfied and encouraged by sensitive forms of urban and transport planning.
- How far, in a less car-intensive era, alternative forms of urban development and alternative transport networks, including selective radial extensions of major urban areas, could provide more efficient ways of meeting the desires of residents and businesses for access to opportunities and space.

Work on several of these areas is currently under way within EPSRC's Sustainable Urban Environment Programme.

More generally, it is clear that debate on these issues has relied too heavily up to now on cross-sectional analysis. This needs to be complemented by carefully designed studies of change in the relationships between demographic and social change, incomes, prices, planning and transport policies, density and urban form and travel behaviour, to identify more confidently where the effective levers for change are and how they can be used.

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