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# Investigating relationships between road freight transport, facility location, logistics management and urban form

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ABSTRACT

This paper examines road freight transport activity and its relationship with facility location, logistics management and urban form through an analysis of 14 selected urban areas in the UK. Improved understanding of this relationship will assist planners when making transport and land use decisions. The findings suggest that several geographical, spatial and land use factors have important influences on freight activity in urban areas. Commercial and industrial land use patterns affect the types and quantities of goods produced, consumed, and hence the total quantity of freight transport handled. This also influences the distances over which goods are moved and by what specific mode. There has been relatively low growth in warehousing in many of the selected areas over the last decade compared to the national average as well suburbanisation of warehousing in some locations. This affects the origin and destination of journeys visiting these facilities and typically increases the distance of such journeys. A greater proportion of road freight has been shown to be lifted on internal journeys in large urban areas than in smaller ones. Journeys within urban areas have been shown to be less efficient than journeys to and from the urban area in the 14 locations studied due to the much smaller average vehicle carrying capacities and lower lading factors for journeys within urban areas. The length of haul on journeys to and from urban areas studied was found to be greatest for those areas with a major seaport and/or which were geographically remote. This affects the road freight transport intensity of goods transport journeys.



## 1. Introduction

There has been much discussion since the mid-1980s about the relationship between transport and urban form (Banister, 2005; Breheny, 2001; ECOTEC, 1993; Newman and Kenworthy, 1988; Stead and Marshall, 2001; Taylor and Sloman, 2008). However, much of this body of research has concerned itself with passenger transport (i.e. the movement of people). There has been no comparable consideration of the interactions between the various features of urban areas and freight transport activity.

While there has been a sizeable body of planning and engineering research into freight transport (especially in urban areas), the study of freight transport and logistics as a geography remains relatively under researched (Hesse and Rodrigue, 2004; Rodrigue, 2006a). Some recent research has begun to address this imbalance by considering how logistics developments are affecting urban land use patterns (Bowen, 2008; Cidell, 2010; Hesse, 2004, 2008; Woudsma et al., 2008). However this work focuses primarily on developments in the location and use of logistics facilities (e.g. warehouses, distribution centres, and fulfilment centres) in urban areas rather than on the relationship between land use, urban form and goods vehicle activity patterns.

This paper investigates relationships between road freight transport activity, urban form, land use, facility location and logistics management. It discusses whether the urban form factors related to passenger transport are likely to also have a relationship with freight transport activity, and considers the differences between freight and passenger transport. It then considers evidence for changes in warehousing patterns in urban areas and discusses the potential relationship between urban land use patterns and specific freight transport activity through a study of fourteen urban areas in the UK using warehousing and freight transport activity data.

## 2. Transport and urban form

Research into the relationships between passenger transport and urban form has covered a range of different geographical

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scales and has investigated many different characteristics of urban form. The major focus has been to try to determine whether transport growth can be affected by promoting particular forms of urban development – i.e. whether particular designs and layouts of urban areas can help to limit increases in traffic.

This body of research ranges in consideration of urban form from the regional strategic planning level to local planning issues at a neighbourhood level (Stead and Marshall, 2001). The aspects of urban form that have been considered in relation to transport activity levels and patterns include (Stead and Marshall, 2001; Banister, 2005): settlement size, intensity of land use, mixing of land uses, provision of local facilities, accessibility to local transport infrastructure/networks, availability of parking facilities, road network type and neighbourhood type. Elements of transport activity that have been considered in relation to these aspects of urban form in this body of research include: travel distance, journey frequency, mode of travel, travel time and energy consumption (Banister, 2005).

There is no consensus between researchers about whether some of these relationships exist or not. Banister (2005) argues that this lack of consensus is due to a general lack of detailed analysis due in the main to deficiencies in the quantity and quality of data available and incompatible research approaches used (especially in terms of the geographical unit of analysis – such as region- or city-wide studies compared with neighbourhood studies). Also, it can be argued that planners often have limited land use policy tools at their disposal especially at the local, neighbourhood level.

Passenger journeys and freight journeys in urban areas are very different in nature. While passenger journeys are decided on (in terms of origin and destination, mode, timing and frequency of travel) by individuals for a multitude of different reasons, freight journeys have a single purpose of transporting goods from one point in the supply chain to another. At each of these points in the supply chain, goods are either worked on, stored, or sold. Decisions about the nature of these freight journeys are made by the owners of these goods, the customers they do business with, and the freight transport companies that carry them. While passengers can make multiple journeys in a single urban area each day, and thousands of journeys per year, this is not the case for goods, which are often delivered into an urban area from outside (as many urban areas are net importers of goods) and then are usually only transported to, at most, one or two additional locations in the urban area before being consumed.

Although freight journeys are likely to be influenced to some degree by factors including the size, density and layout of the city, these influences are likely to be less important than for passenger transport for reasons including: (i) fewer modal options exist for freight than for passengers (with the vast majority of urban freight transported by road), (ii) the demand for freight transport is more inelastic with respect to price than for passenger journeys (and therefore less likely to alter or stop than passenger journeys when transport prices change), and (iii) most goods are transported along major roads rather than residential neighbourhoods (which have distinctive development patterns and road layouts).

This is not to say, however, that freight journeys are unaffected by urban form. Clearly, factors such as settlement size, density, and commercial and industrial land use patterns are likely to influence the extent and location of urban freight activity as well as the operating patterns and types of vehicles used for freight work that takes place to and within the urban area (Cherrett et al., 2009). Other important influences on freight activity in urban areas are likely to be the strategic organisation of product supply chains (in terms of the location of warehousing facilities within the chain), and the logistics management of road freight transport operations to meet these goods requirements.

## 3. Developments in commercial land use and warehousing in urban areas

Prior to the 1970s, stockholding in supply chains was relatively decentralised with warehouses positioned at various points in the chain – often at the manufacturing site as well as at the receiver's premises, with other intermediate warehouses between these two locations. This resulted in many relatively small warehouses being located in urban areas, often in the inner city adjacent to industrial areas. Factors determining warehouse location included the proximity to production and market areas, suitable access to the road network and modal interchanges, land costs, and availability of workers (McKinnon, 1989). Three major trends have been observed in recent decades that have fundamentally changed the warehousing land use patterns in urban areas in the UK and other developed countries:

(i) **De-industrialisation** has resulted in a major decline in industrial land use (which is a major generator of freight activity) and has led to a decline in the demand for industrial warehousing space in urban areas (Hesse, 2008). Much industrial activity that previously took place in urban areas in developed economies has now been relocated to countries in eastern Europe and Asia where lower labour costs can be exploited. In some cases, companies (especially multinationals) have relocated their facilities, while smaller indigenous manufacturers have often gone out of business as a result of competition from producers in these countries. A relocation of the manufacturing process also results in a relocation of the warehousing needs to these countries, with the imported goods passing through western European and American ports, with storage either taking place in large modern warehouses capable of handling major flows of goods located either near the ports or at regional and national distribution centres located on major road networks outside of urban areas (Bowen, 2008; Cidell, 2010; Woudsma et al., 2008).

(ii) **Spatial centralisation of stockholding** has been adopted by manufacturers and retailers in order to achieve cost savings in their supply chains. As a result, there has been a shift away from warehousing at both producers' and receivers' sites and an increase in the use of fewer, large-scale national and regional distribution centres that serve a far larger geographical area. This centralisation has been made possible by the development of the motorway network, which allows companies to have fewer stock holding points by locating extremely large warehouses at strategic points with good accessibility to their hinterlands. By using this approach companies have been able to benefit from the 'square root law' of stockholding and economies of scale which results in the need to hold less stock in the supply chain in total (McKinnon, 1989, 2009). Although freight transport costs may increase as a result of these location decisions, these cost increases are more than offset by the cost savings resulting from the centralisation of stock. Many of these supply chains operate hub and spoke networks with regional and national warehouses being used in conjunction with local urban depots where goods can be transhipped between vehicles for local delivery.

(iii) **Rapidly rising land prices and increasing traffic congestion** in urban areas have forced companies to relocate warehouses to locations with relatively lower prices (Hesse, 2008) which are often not hindered by planning law. In addition, high urban land prices have encouraged retailers and other users of commercial floor-space to limit storage space in their premises, converting for activities which will provide better financial returns (e.g. increased sales areas). This has led to the suburbanisation of warehousing, being relocated to the edge of the urban area or even outside (Cidell, 2010; Hesse, 2008; Dablanc and Rakotonarivo, 2010).

Technological developments in road freight transport have allowed the distance over which goods are transported to and from urban areas by road, to increase substantially over recent decades. This has been achieved due to vehicles being able to carry increasingly heavier loads, and the speed of travel increasing substantially (as a result of improved road engineering and vehicle developments – Boyes, 2003a,b; Storey, 2003). This has helped to facilitate the three land use and warehousing trends discussed above.

## 4. Logistics management of road freight transport operations

The reduction of stockholding space in urban shops, offices and factories in developed economies has resulted in an increasing demand for reliable, regular, flexible delivery of relatively small quantities of products. This has led to the adoption of just-in-time transportation systems in which goods supply to urban premises is geared more closely to demand (Rodrigue, 2006b; Taylor, 2001). It has also resulted in goods being held in warehouses for shorter periods of time and in some operations, not stored at the warehouse at all, but simply unloaded from vehicles, sorted by destination and loaded immediately onto other vehicles (i.e. 'cross-docked') for onward transport to the customer (Bowen, 2008). In some supply chains the transport system itself (i.e. modes, vehicles and terminals) is used to hold inventory, especially in chains that source products internationally and make use of containerisation. In addition, continued and growing demand for goods from businesses and residents in urban areas that are expanding in population has resulted in increased urban road freight vehicle activity.

The service sector, which has often replaced industrial activities, has different but substantial goods requirements. The relocation of warehousing to the edge of, or outside, the urban area has resulted in greater journey distances when delivering from these facilities to inner and central urban areas (Dablanc and Rakotonarivo, 2010). Freight journeys to, from and within urban areas are likely to differ in terms of the sizes and weights of vehicles used and their operational performance as reflected by the lading factor (i.e. how well the vehicle payload is utilised) and the degree of empty running (i.e. the extent to which the vehicle travels empty or not). These operational performance issues are influenced by factors such as the commercial land use and warehousing patterns in the urban area, the location of the urban area, its geographical size and layout, and will determine the total amount of freight vehicle activity required to deliver a given quantity of goods.

## 5. Research approach and data used

Fourteen urban areas in the UK were selected for analysis; the intention was to include areas of varying geographical areas, population sizes, economic composition and population densities (Table 1). The urban areas included range in population size from Greater London to Milton Keynes and in geographical area from West Yorkshire to Southampton. Population densities range from 705 people per km$^2$ in York to 4,779 people per km$^2$ in Greater London. Some metropolitan counties comprising several contiguous urban areas were included in the analysis (such as West Yorkshire, the West Midlands and Merseyside). A small city with a historic centre (York) and a new town established in the 1960s (Milton Keynes) were included due to their varying urban forms, road layouts.

Commercial and industrial land use data produced by the Valuation Office Agency was analysed for the period 1998–2008 for each of the 14 urban areas studied. These data provided details of the quantity of warehousing, retail, factory, and office floor-space in each location (Office for National Statistics, 2010).

Road freight activity data disaggregated from the Continuing Survey of Road Goods Transport (CSRGT) was obtained for the period 2005–2007 for these 14 urban areas from the Department for Transport. The CSRGT is a statutory survey of British-registered goods vehicles over 3.5 tonne gross weight (i.e. heavy goods vehicles or 'HGVs') carrying out domestic operations which is conducted by the Department for Transport. These data were disaggregated into three types of journeys: (i) journeys to the urban area from elsewhere, (ii) journeys from the urban area to elsewhere, and (iii) journeys wholly within the urban area. The following data items collected in the CSRGT were used in the analysis: loaded vehicle kilometres, empty vehicle kilometres, tonnes lifted, tonne-kilometres, and vehicle lading factors. A 3-year average for the period 2005–2007 was used in the analysis using a spreadsheet model.

Using these two sets of data it was possible to analyse the following in each of the selected fourteen areas: (i) commercial and industrial floor-space composition, (ii) warehousing floor-space and changes over the decade, (iii) road freight transport activity patterns including its efficiency and intensity. In this way it was possible to investigate the extent to which these 14 urban locations in the UK bear out the issues discussed in the earlier sections, namely: the extent to which the commercial and industrial land use patterns influence the amount, pattern and intensity of road freight transport activity, and whether the suburbanisation of warehousing has been occurring.

## 6. Commercial and industrial land use in the urban areas studied

Table 2 shows the total commercial and industrial floor-space in each of the 14 urban areas, together with the commercial and industrial floor-space per capita and per square kilometre of land.

Fig. 1 shows the proportion of total commercial and industrial floor-space accounted for by warehousing, retail, office, factory and 'other bulks' in 2008 across the 14 urban areas and nationally. In 10 of the 14 urban areas, warehousing accounted for between 21% and 30% of total commercial and industrial floor-space in 2008, retailing, 14–23% of total floor-space in 11 out of 14 urban areas, offices accounted for 12–25% in 11 out of 14 areas, and factories 28–43% of total floor-space in 10 out of 14 urban areas. "Other bulks" accounted for 2–4% of total floor-space in all 14 urban areas.

The commercial and industrial land use patterns of the 14 urban areas can be seen to be broadly similar in many of the urban areas with a few notable exceptions. Brighton and Hove has a greater proportion of retail and office space than most other locations but a lower proportion of factory and warehousing space, Milton Keynes has a far greater proportion of warehousing space than elsewhere (due to its central location in the country and its proximity to the motorway network), and London has a preponderance of offices but relatively little factory space. Meanwhile factory space was the most important category of land use and accounted for more than 35% of the total in eight of the areas (Greater Manchester, Merseyside, West Yorkshire, West Midlands, Tyne and Wear, South Yorkshire and Leicester).

Fig. 2 shows the changes in commercial and industrial floor-space between 1998 and 2008 in the 14 urban areas. This indicates the rise of the service sector in the UK, with both office and retail space rising in England and Wales as a whole (and in most of the selected areas), while factory space has fallen as a whole (and in 10 of the 14 selected areas). Warehousing space increased by

**Table 1**
Population and geographical size of the urban areas.

| | Population | Area (sq km) | Population density (pop./sq km) |
|---|---|---|---|
| Greater London | 7,512,000 | 1572 | 4779 |
| West Midlands | 2,600,000 | 902 | 2884 |
| Greater Manchester | 2,554,000 | 1276 | 2001 |
| West Yorkshire | 2,161,000 | 2029 | 1065 |
| Merseyside | 1,354,000 | 645 | 2099 |
| South Yorkshire | 1,293,000 | 1552 | 833 |
| Tyne and Wear | 1,088,000 | 540 | 2014 |
| Bristol | 411,000 | 110 | 3745 |
| Cardiff | 318,000 | 140 | 2268 |
| Leicester | 290,000 | 73 | 3951 |
| Brighton & Hove | 251,000 | 83 | 3041 |
| Southampton | 229,000 | 50 | 4587 |
| Milton Keynes | 225,000 | 309 | 728 |
| York | 192,000 | 272 | 705 |

Source: Office for National Statistics, 2008.

**Table 2**
Commercial and industrial floor-space per capita and sq km of area.

| | Commercial and industrial floor-space (000 sq m) | Commercial and industrial floor-space per capita (sq m) | Commercial and industrial floor-space per sq km (000 sq m) |
|---|---|---|---|
| Greater London | 71,089 | 9.5 | 45.2 |
| West Midlands | 35,370 | 13.6 | 39.2 |
| Greater Manchester | 34,285 | 13.4 | 26.9 |
| West Yorkshire | 30,140 | 13.9 | 14.9 |
| Merseyside | 13,765 | 10.2 | 21.3 |
| South Yorkshire | 15,630 | 12.1 | 10.1 |
| Tyne and Wear | 13,077 | 12.0 | 24.2 |
| Bristol | 4857 | 11.8 | 44.2 |
| Cardiff | 3813 | 12.0 | 27.2 |
| Leicester | 4404 | 15.2 | 60.3 |
| Brighton & Hove | 1639 | 6.5 | 19.7 |
| Southampton | 2047 | 8.9 | 40.9 |
| Milton Keynes | 3961 | 17.6 | 12.8 |
| York | 1958 | 10.2 | 7.2 |

Source: Calculated from data in Office for National Statistics, 2008 and 2010.

22% in England and Wales. This suggests that the growth in the demand for goods by businesses and households and their related handling and storage requirements more than offset any reduction in warehousing space that occurred as a result of the spatial concentration of warehousing in England and Wales.

As the warehousing data in Fig. 2 only shows results for the entire urban area, it does not reflect whether suburbanisation of warehousing was taking place over the period in question.

## 7. Warehousing in the urban areas studied

Fig. 3 shows the change in total warehousing floor-space between 1998 and 2008 which increased over the decade in 12 of the 14 urban areas but at varying rates. Fig. 3 shows that the growth rate in 8 of the 14 urban areas was lower than the overall rate in England and Wales, and that total warehousing actually fell over the decade in Bristol and Southampton. This implies that the majority of national growth in warehousing may have been taking place outside urban areas (close to the motorway network). Strong growth was recorded in York, Milton Keynes, South Yorkshire and the West Midlands over the decade and with the exception of York, these urban locations are well situated for motorway access.

Much of the weaker growth and reductions in warehousing space have taken place in inner urban and higher density areas while stronger growth has occurred in less central and dense locations. This is likely to reflect relative land values within urban areas and is consistent with the suburbanisation of warehousing discussed earlier. In Greater Manchester, warehousing floor-space in Manchester fell by 13% between 1998 and 2008, but increased in Wigan by 46%, Thameside by 26% and Trafford by 22% over the period. Similarly in Merseyside, warehousing floor-space in Liverpool fell by 12% between 1998 and 2008, while it rose in Knowsley by 65% and St Helens by 27%.

In Greater London, warehousing floor-space fell in all central London boroughs over the decade (by 82% in the City of London, 51% in Westminster, 37% in Camden, and 22% in Kensington and Chelsea), and also fell in many other inner London boroughs (by 42% in Hackney, 31% in Islington, and 24% in Southwark for instance). Meanwhile growth in warehousing floor-space was strong in many outer London boroughs over the same period (49% in Bexley, 34% in Enfield, 26% in Barking, 28% in Sutton and 21% in both Havering and Waltham Forest).

Fig. 4 shows the change in total warehouse floor-space, number of warehouses, and average floor-space per warehouse over the period 1998–2008. In all of the 14 urban areas (as in England and Wales as a whole) the change in the number of warehouses has been less than the change in total warehouse floor-space,

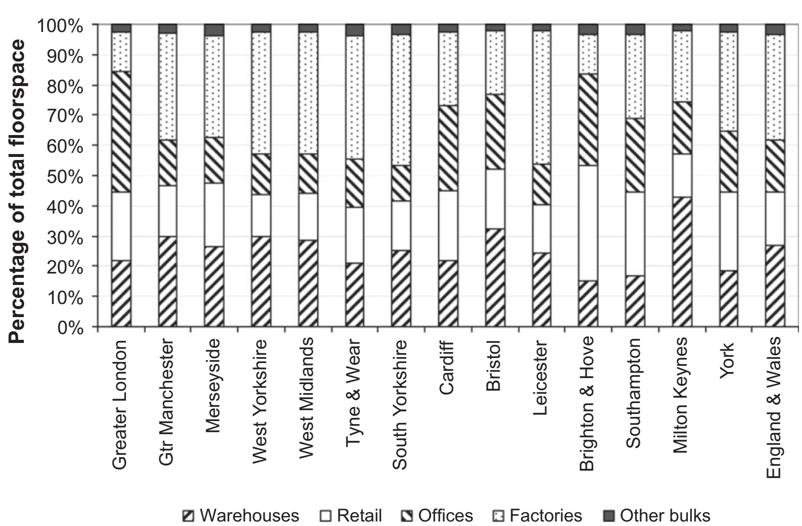


**Fig. 1.** Commercial and industrial floor-space by land use in 2008 (percentage), *Note*: "Other bulks" is a miscellaneous group which consists mainly of halls, social clubs and garden centres, Source: Calculated from Valuation Office Agency (VOA) data in Office for National Statistics, 2010.

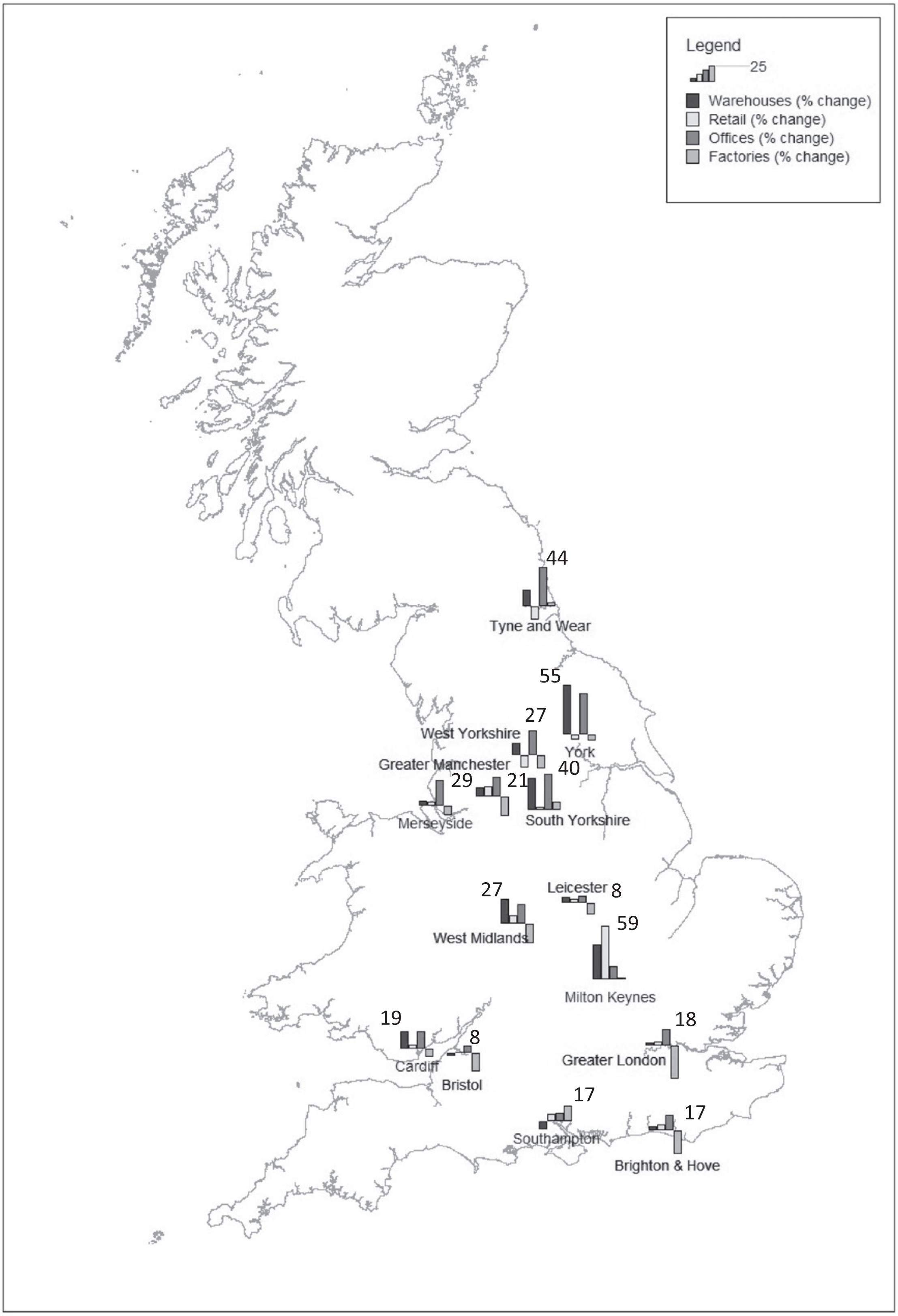


**Fig. 2.** Change in commercial and industrial floor-space by land use, 1998–2008 (percentage), Source: Calculated from VOA data in Office for National Statistics, 2010.

and in 7 areas the total number of warehouses has fallen over the period. This reflects an increase in the average floor-space per warehouse which has increased in all of the 14 urban areas (between 3% and 30%). Increases in total warehouse floor-space that are greater than growth in the number of warehouses (and hence an increase in average warehouse size) are consistent with

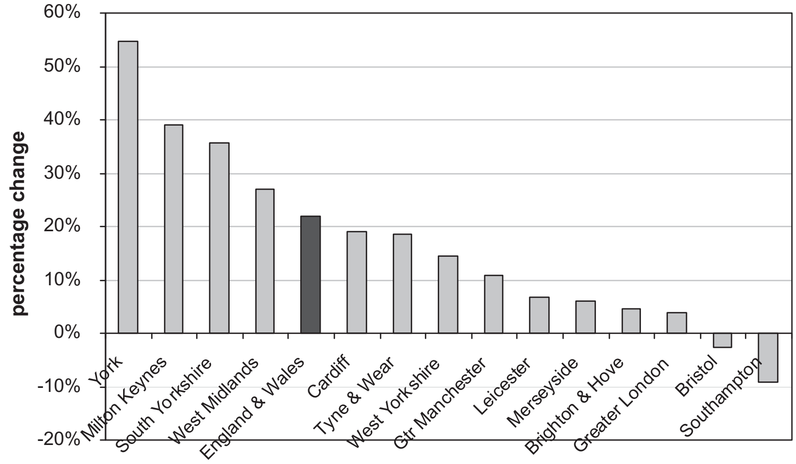


**Fig. 3.** Change in total warehousing floor-space, 1998–2008 by urban area (percentage), Source: Calculated from VOA data in Department for Communities and Local Government, 2009 and Office for National Statistics, 2010.

efforts to centralise stockholding in the supply chain (and thereby reduce supply chain costs through the square root law as previously discussed).

## 8. Road freight transport operations in the urban areas studied

### *8.1. Quantity of goods lifted*

Fig. 5 shows the goods lifted by HGVs on journeys to, from and within each urban area per square metre of commercial and industrial floor-space in 2008. The data shows that London and Brighton and Hove generated the least freight lifted by road per square metre of commercial and industrial floor-space. This is likely to be related to the relatively low proportion of factories and warehouses and the high proportion of office space in these two urban areas. Meanwhile, Southampton and Bristol both generated substantially more freight lifted by HGVs per square metre of commercial and industrial floor-space than the other urban areas which could be related to the freight flows generated by their sea ports.

The proportion of freight lifted by HGVs on journeys that take place within the urban area is generally greater in the larger urban areas than the smaller ones (Fig. 6). This is likely to be due to two factors: (i) larger urban areas typically contain more production and logistics facilities and hence generate more internal journeys to service businesses and residents than smaller ones, and (ii) larger urban areas are likely to have several urban centres between which goods are moved (i.e. they are usually polycentric).

The CSRGT data indicates that 12 of the 14 urban areas studied are net importers of goods by road with more tonnes flowing in than out on HGV journeys, ranging from 5% per annum in the case of Merseyside to 65% in the case of Brighton and Hove (Fig. 7). Urban areas with relatively high proportions of factory floor-space appear to generally have lower rates of net importation. The two urban areas in which the tonnes lifted on journeys from the urban area slightly exceed the tonnes lifted on journeys to the urban area are Southampton and Bristol (both of which have major cargo ports).

### *8.2. The efficiency and intensity of road freight transport in the urban areas studied*

Fig. 8 shows the relationship between key variables and outputs in the CSRGT data – this analytical framework has been adapted from one originally proposed by McKinnon (2007) which illustrates the links between freight transport and the economic activities that it serves. The key variable 'length of haul' (the distance over which goods are transported) determines how goods lifted by HGVs ('road tonnes lifted') are converted into tonne-kilometres. Three key variables ('vehicle carrying capacity' – the maximum quantity of goods that HGVs can carry, 'vehicle lading factor' – the extent to which the carrying capacity is used, and the 'proportion of empty running' – the extent to which vehicles are carrying no goods when travelling) determine the relationship between the tonne-kilometres performed and the vehicle kilometres travelled by HGVs.

### *8.3. Ratio of tonne-kilometres to vehicle kilometres*

The ratio of tonne-kilometres to vehicle kilometres performed by HGVs reflects the efficiency of HGV operations (Fig. 8) with higher numbers indicating more efficient operations. The ratio reflects the average vehicle carrying capacity, lading factor on laden journeys and the extent of empty running by HGVs. Journeys within urban areas are least efficient (Fig. 9) in terms of the ratio of tonne-kilometres to vehicle kilometres (ranging from 2.3 in Brighton and Hove to 4.5 in Merseyside). The ratio on journeys to and from urban areas ranged from 7.2 in Brighton and Hove to 10.2 in Merseyside). Key factors in this difference between journeys within and those to and from urban areas are the much smaller average vehicle carrying capacities and lower lading factors for journeys within urban areas. In all but one of the 14 urban areas (South Yorkshire), journeys from urban areas are less efficient than journeys to urban areas in terms of the ratio of tonne-kilometres to vehicle kilometres. This is related to the higher proportion of empty running and lower lading factors on these journeys from urban areas. The ratio of tonne-kilometres to vehicle kilometres for all journeys to, from and within the urban area ranged from 6.3 in the case of London to 9.2 in the case of Merseyside. This compares with a national average for all journeys (urban and non-urban) of 7.0.

Vehicle carrying capacities and lading factors were far higher in each of the 14 urban areas for journeys to and from the urban area compared with journeys within the urban area. This is likely to be due to several factors including: (i) urban areas are typically busy, congested environments in which vehicle manoeuvrability is relatively difficult, (ii) urban areas can be subject to weight and size restrictions in some locations, (iii) journeys within urban areas may involve a higher proportion of goods with low bulk densities

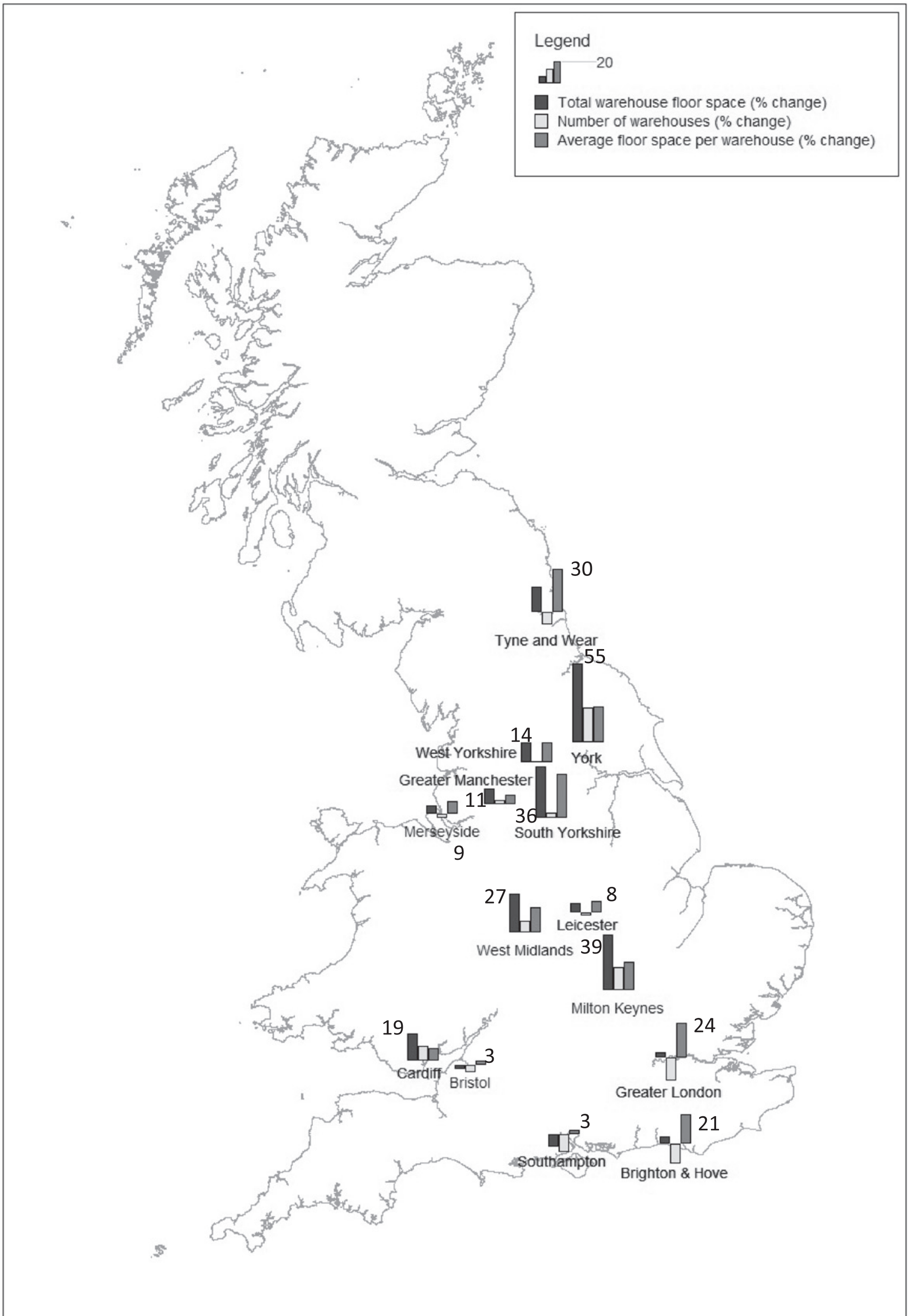


**Fig. 4.** Changes in warehousing floor-space and numbers, 1998–2008 (percentage), Source: Calculated from VOA data in Office for National Statistics, 2010.

than on journeys to the urban area (such as parcels and courier flows), and iv) the higher costs of journeys to/from urban areas (given their relative length and hence journey time) can result in the decision to move larger quantities per journey.

The analysis shows that for London and Brighton and Hove journeys to and from urban areas were made by HGVs with lower carrying capacities than in the other 12 urban areas. This could be a reflection of the types of product flowing to and from these

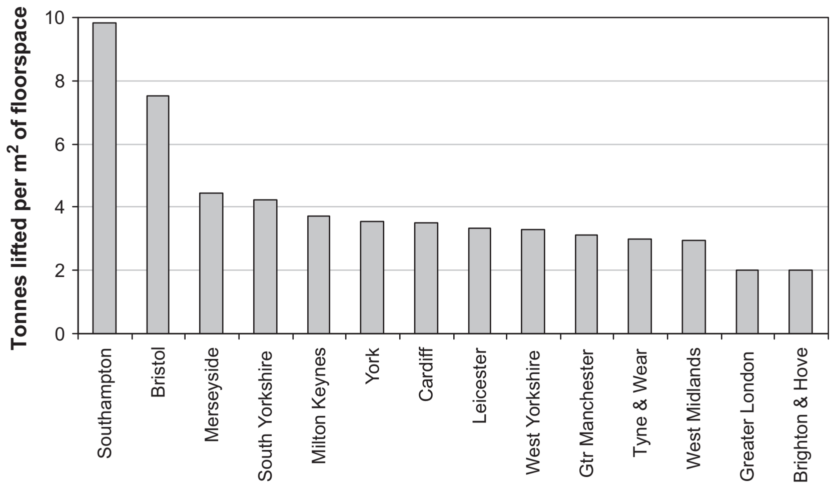


**Fig. 5.** Goods lifted by road on journeys to, from and within each urban area per square metre of commercial and industrial floor-space, Source: calculated from VOA data in Office for National Statistics, 2010; Department for Transport, 2009.

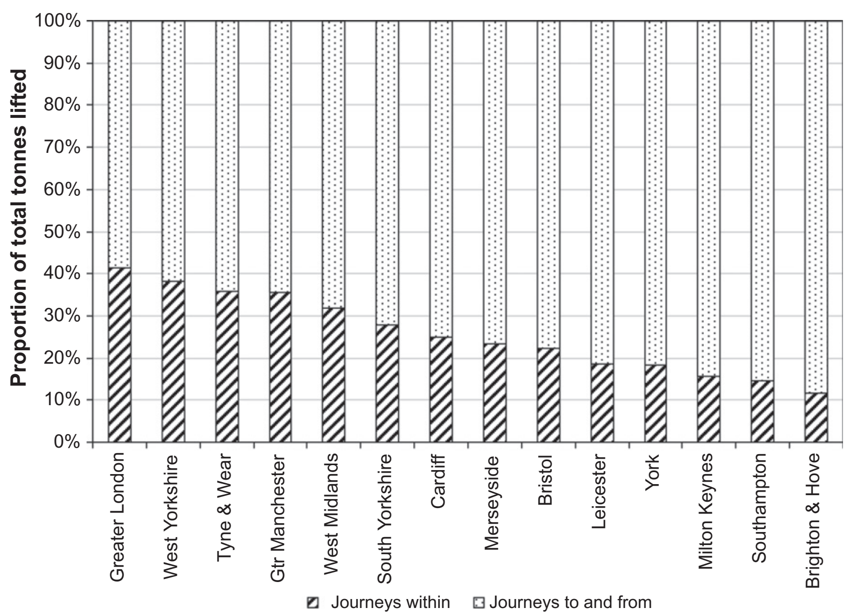


**Fig. 6.** Proportion of tonnes lifted on journeys to, from and within each urban area (2005–2007 average), Source: Calculated from data in Department for Transport, 2009.

cities with service-based economies. With the exception of London, lighter HGVs were used to transport goods to and from smaller urban areas than within them. In Brighton and Hove, Southampton and Milton Keynes, vehicle lading factors on journeys within the urban area were considerably lower than for the other urban areas, resulting in lower efficiency rates. Similarly, in Leicester, Southampton and Milton Keynes vehicle lading factors on journeys to and from the urban area were lower than for the other urban areas. Lighter HGVs were used on journeys within York were lower than journeys within the other 13 urban areas. This is likely to be related to the prevalence of narrow streets in this historic city.

### *8.4. Average distance travelled per tonne lifted*

The transport intensity of goods vehicle operations is reflected in the relationship between the quantity of goods lifted by HGVs and the total vehicle kilometres performed by these vehicles (Fig. 8). The distance travelled per tonne lifted is determined by the length of haul, the vehicle carrying capacity, the vehicle lading factor, and the proportion of empty running. The greater the distance travelled per tonne lifted, the greater the intensity of road freight activity. This intensity level is closely related to the environmental sustainability of road freight as the distance travelled by HGVs has a major impact on fuel consumed, greenhouse gas emissions, local air pollutants, and accident levels.

The results (Fig. 10) indicate that journeys within urban areas are generally less transport intensive in terms of vehicle kilometres performed per tonne lifted (ranging from 8.1 vehicle kilometres per tonne lifted in London to 17.2 km in Bristol) than journeys to and from urban areas (which ranged from 11.9 kilometres per tonne lifted in the case of Brighton and Hove to 17.0 km for Southampton). This is due to their far shorter average length of haul, despite the fact that the vehicle operation is far less efficient in terms

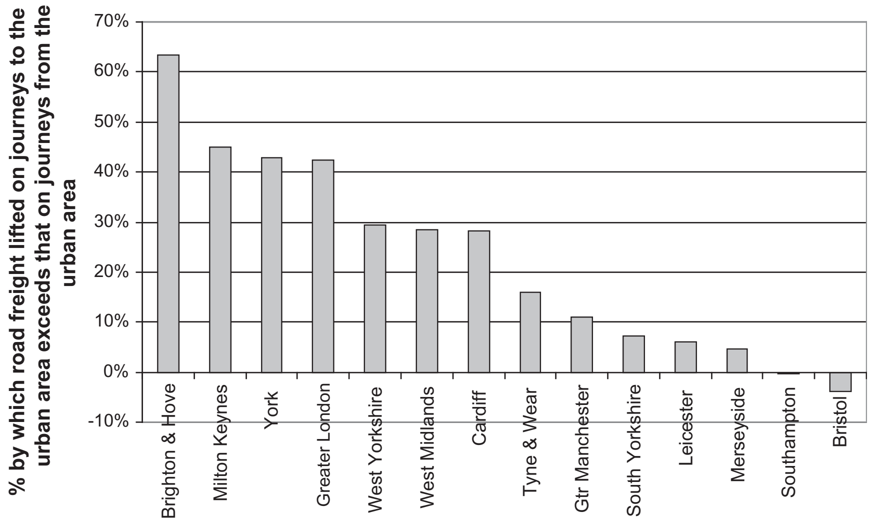


**Fig. 7.** Comparison of tonnes lifted on journeys to and from urban area (2005–2007 average), Source: Calculated from data in Department for Transport, 2009.

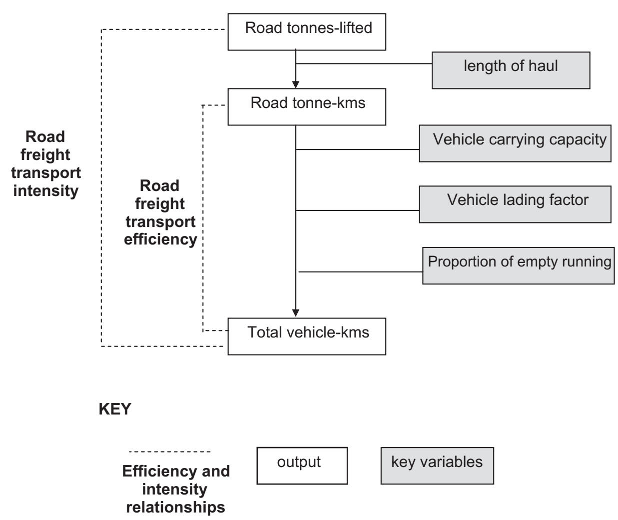


**Fig. 8.** Relationship between key variables, outputs and the efficiency and intensity of road freight transport, Source: Adapted from McKinnon, 2007.

of average vehicle carrying capacity and lading factors (see Section 8.3). Only in 2 of the 14 urban areas (Bristol and Brighton and Hove) were vehicle kilometres per tonne lifted higher on journeys within the urban than on journeys to and from the urban area.

Further analysis shows that journeys from urban areas were more transport intensive than journeys to urban areas in terms of the vehicle kilometres performed per tonne lifted in all 14 urban areas except Bristol. This is related to the higher proportion of empty running and lower lading factors on these journeys leaving urban areas (as the average length of haul and average vehicle carrying capacities are similar for journeys to and from urban areas). This is explained by the fact that the majority of the urban areas studied are net importers of goods by road, and therefore HGVs departing from the urban area typically have a smaller load (or no load) than HGVs destined for the urban area.

Vehicle kilometres per tonne lifted for all journeys to, from and within the urban area ranged from 11.3 in the case of Merseyside to 16.6 in the case of Milton Keynes. The national average for all journeys (urban and non-urban) was 12.3 vehicle kilometres per tonne lifted.

The difference between the efficiency of road freight transport (examined in Section 8.3) and the road freight transport intensity is the average distance over which goods are transported between links in the supply chain as reflected by the length of haul (Fig. 11). As would be expected the length of haul is far greater on journeys to and from the urban areas than on journeys within the urban areas. For journeys within the urban areas, the average length of haul varied from 25 km in London to 53 km in Bristol.

The length of haul for journeys to and from the urban areas ranged from 86 km for Brighton and Hove to 157 km for Southampton. This indicates that there are major differences in the hinterlands of some of the urban areas. The average length of haul on journeys to and from an area are dependent on factors including: (i) trading links that exist between the urban area and other centres of supply and demand, (ii) the location of the urban area in relation to other centres and production and warehousing facilities, and (iii) the type of economic activity that takes place in the urban area (for instance a port city may have a larger hinterland than other urban areas). Both Bristol and Southampton generate sizeable road freight flows to and from their sea ports which are likely, in many cases, to have lengthy origins and destinations within the country. This may account for the relatively high average length of haul on journeys to and from these two areas. Tyne and Wear is relatively remote from other settlements in the country, which may explain the high average length of haul for journeys to and from it.

These variations in the average length of haul explain why some urban areas (especially London and Brighton and Hove) have among the lowest levels of road freight transport intensity for all journeys to, from and within the urban area despite having the least efficient transport. Conversely it also explains why some urban areas with among the best utilised road freight transport operations (including Bristol and Southampton) have some of the highest rates of transport intensity (compare Figs. 9 and 10).

### *8.5. Vehicle activity and floor-space*

London and Brighton and Hove generated the least vehicle kilometres per square metre of commercial and industrial floor-space (Fig. 12), while Southampton and Bristol generated the most. This is similar to the order of results for the quantity of goods lifted per square metre of commercial and industrial floor-space (see Section 8.1 and Fig. 5) but the difference between the highest and lowest is

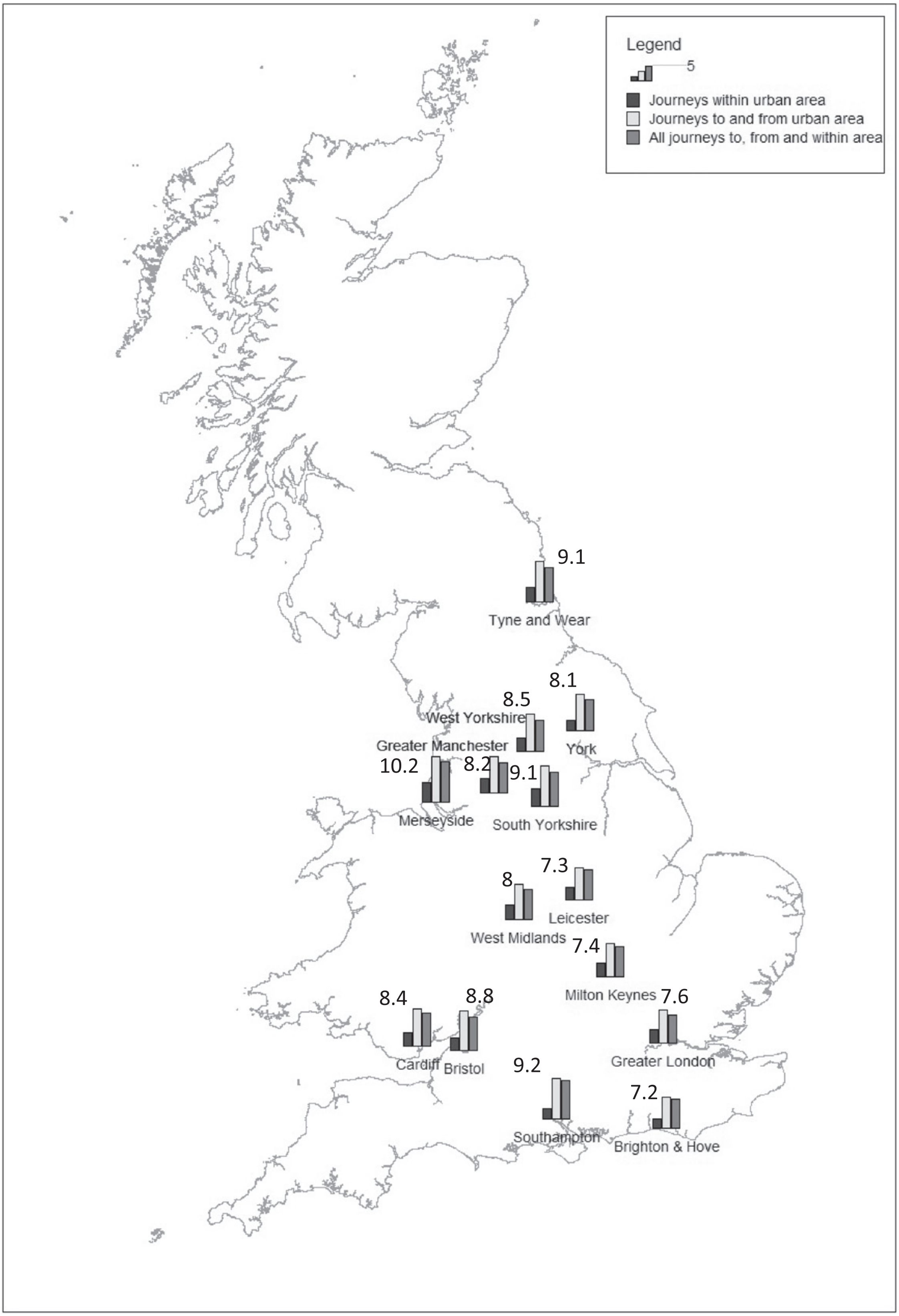


**Fig. 9.** Ratio of tonne kilometres: vehicle kilometres by road on journeys to, from and within each urban area (2005–2007 average), Source: Calculated from data in Department for Transport, 2009.

greater when expressed in vehicle kilometres as it takes into account the efficiency and intensity of freight transport (based on vehicle carrying capacity, lading factor, empty running and length and haul – see Sections 8.3 and 8.4).

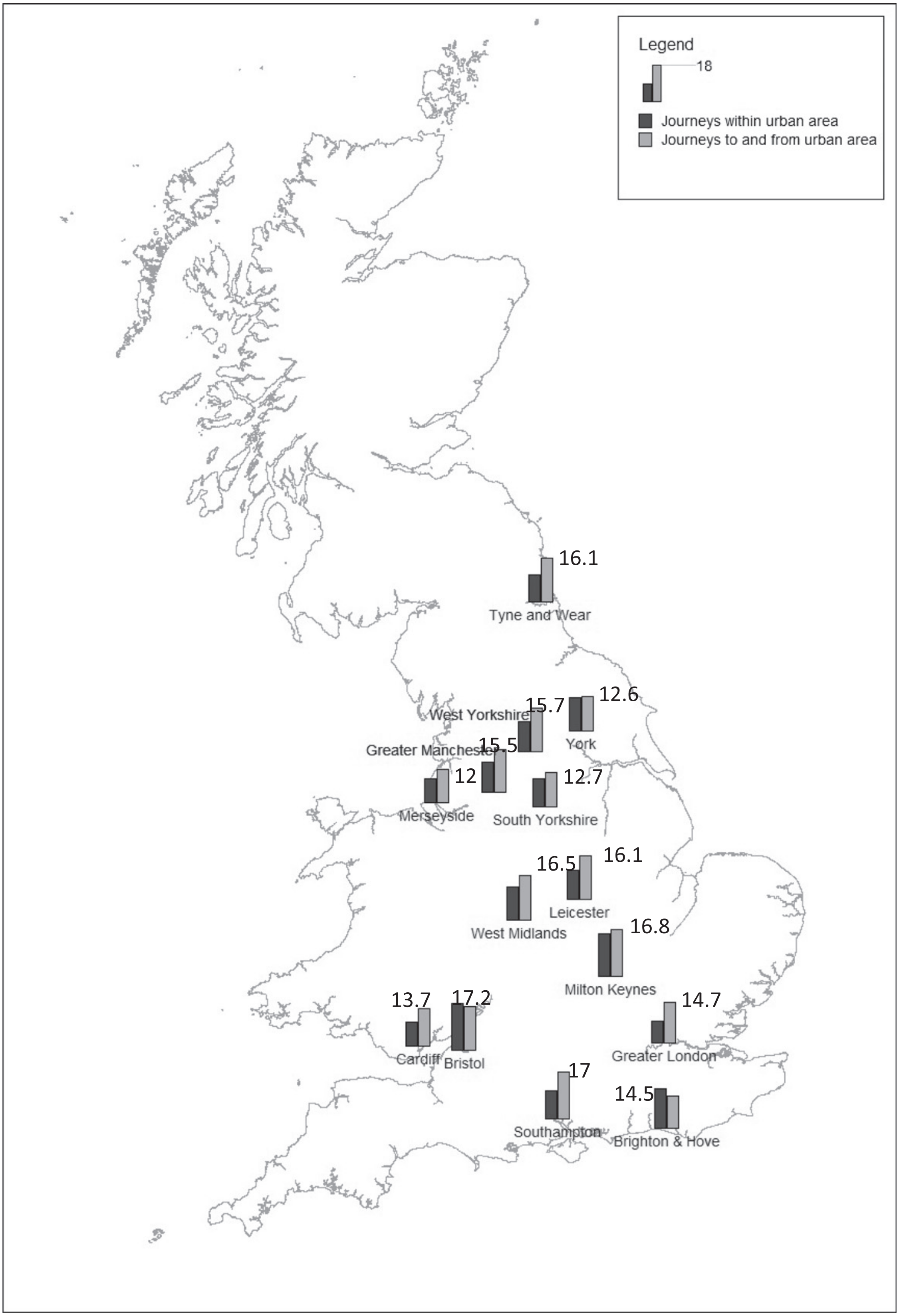


**Fig. 10.** Average vehicle kilometres travelled per tonne of goods lifted by road on journeys to, from and within each urban area (2005–2007 average), Source: Calculated from data in Department for Transport, 2009.

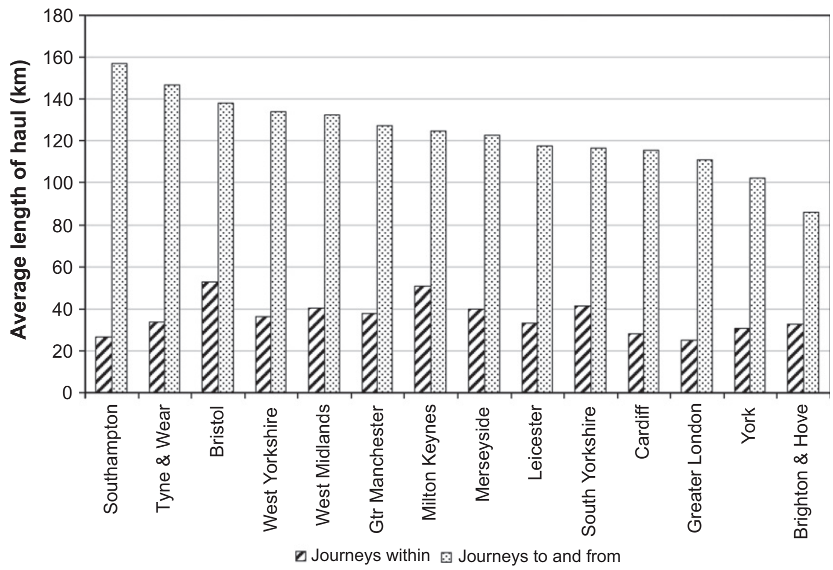


**Fig. 11.** Average length of haul on journeys within and to/from each urban area (2005–2007 average), Source: Calculated from data in Department for Transport, 2009.

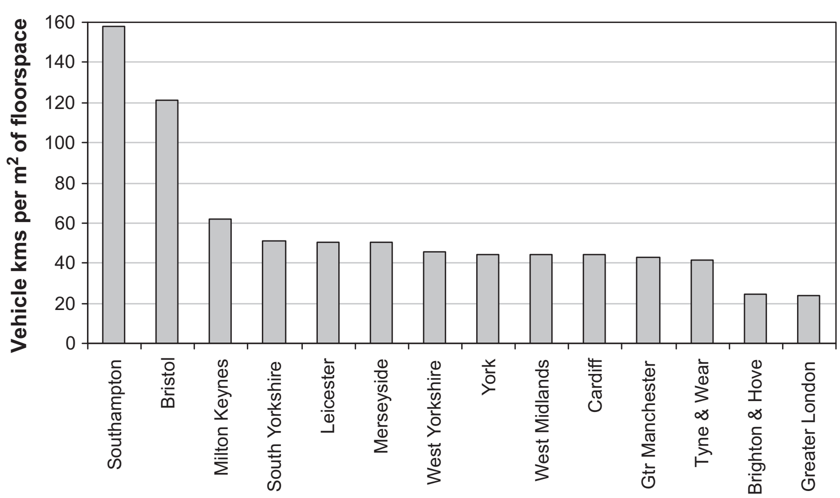


**Fig. 12.** Vehicle kilometres by road on journeys to, from and within each urban area per square metre of commercial and industrial floor-space, Source: calculated from VOA data in Office for National Statistics, 2010; Department for Transport, 2009.

## 9. Conclusions

The findings suggest that several geographical, spatial and land use factors have important influences on freight activity in urban areas. First, commercial and industrial land use patterns within an urban area affect the types and quantities of goods produced and consumed, and hence the total quantity of freight transport handled. Due to the demise of much industrial production in urban areas in the UK, the majority of the urban areas studied have been shown to be net importers of goods by road. Only 2 of the 14 urban areas studied were net exporters of goods and both of these contained seaports through which major flows of goods destined for other locations entered the country. Urban land use patterns and the location of the urban area in relation to other centres of production and consumption as well as warehousing facilities have been shown to affect the distances over which goods are transported to and from urban areas which in turn has an important bearing on total road freight activity and intensity. The existence of a major freight generating or transshipment point located within the urban area (such as a large freight-handling sea port in the case of Bristol and Southampton) can result in an urban area attracting HGV movements from remote locations. The importance of maritime shipping in an increasingly globalised production system has resulted in a growth in port-centred logistics activities in the UK. This can lead to the development of warehousing facilities that are co-located with port terminals in such supply chains. The size of the urban area (in terms of its geographical area and population) also appears to have a bearing on the relative importance of internal goods movements by road, with the larger urban areas studied exhibiting higher proportions of internal road freight journeys than the smaller ones. Similarly, the urban road layout may well have an influence on the size of HGVs operated in the urban area (as suggested by the case of York with its many narrow streets).

Second, the strategic organisation of product supply chains in terms of the location of warehousing facilities within the chain has been shown to have altered over the last decade in the urban areas studied, with relatively lower growth in warehousing in many of the areas than the national average as well as a suburbanisation of warehousing in some locations over the period. This is likely to be due to changes in urban land values as well as shifts in the importance of different industries resulting in changes in land use.

Third, the results suggest that the logistics management of road freight transport operations are affected by geographical location, land use patterns and trade imbalances, and this in turn influences the efficiency of road freight journeys (i.e. the ratio of tonne-kilometres to vehicle kilometres) to, from and within urban areas (due to impacts on carrying capacities of vehicles used, the vehicle lading factors and levels of empty running). Journeys within urban areas have been shown to be less efficient than journeys to and from the urban area in the 14 locations studied. This is due to the much smaller average vehicle carrying capacities and lower lading factors for journeys within urban areas. Journeys from urban areas were found to be less efficient than journeys to urban areas in terms of this ratio. This is related to the higher proportion of empty running and lower lading factors on these journeys from urban areas resulting from net imbalances in urban goods flows. In terms of the transport intensity of road freight journeys (measured by the vehicle kilometres performed per tonne lifted) the results indicate that journeys within urban areas are generally less intensive than journeys to and from urban areas. The lower intensity of journeys within urban areas is due to the shorter transport distances involved.

These urban freight journeys are only one part of a wider set of related journeys in the supply chain of a product from its point of production to point of consumption (and the various stages, modes, vehicles and transport networks that these goods pass through). This relative complexity results in a potentially far greater set of factors that influence urban freight activity than passenger transport.

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