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Urban logistics—how can it meet policy makers' sustainability objectives?

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Abstract

This paper discusses how urban freight activity can function such that it meets the urban sustainability objectives policy makers are now beginning to implement. It considers: the importance of urban freight transport in maintaining the economic vitality of the city; the negative impacts that it imposes; the concept of urban sustainability and the development of sustainability strategies; and the means and measures by which freight transport could be made more sustainable. It presents results from a project that investigated the current freight transport operations of seven different companies in three urban areas in the UK. The potential operational, financial and environmental effects of four policy measures on these operations are considered.

Keywords: Urban; Freight transport; Logistics; Sustainability; Policy measures; Research approach

1. Introduction

The overall aim of this paper is to consider how urban freight activity can function in a manner such that it meets the urban sustainability objectives policy makers are now beginning to implement. It opens by considering the importance of urban freight transport in maintaining the economic vitality of the city, and the negative impacts that it imposes. The concept of sustainability and the development of sustainability strategies are then discussed before it addresses the means and measures by which freight transport could be made more sustainable. The paper then continues by presenting a project that has investigated the current freight transport operations of seven different companies in three urban areas in the UK. The potential operational, financial and environmental effects of four policy measures on these operations were investigated by obtaining each company's expected response to these policy measures and applying these changes in their behaviour to their current operational vehicle data. The results suggest that the policy measures will vary in their operational and financial impact on the distribution companies and also in terms of the change in vehicle pollutant levels.

2. The importance of urban freight transport

Traffic levels and their impacts in British towns and cities have received growing attention in recent years, much of this has been directed at public transport and private car traffic while relatively little consideration has been paid to road freight transport.

However, urban freight transport is important for many reasons (Meyburg and Stopher, 1974; Hasell et al., 1978; Ogden, 1992). Among the most significant are:

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- It is fundamental to sustaining our existing life style.
- The role it plays in servicing and retaining industrial and trading activities which are essential major wealth generating activities.
- The contribution that an efficient freight sector makes to the competitiveness of industry in the region concerned.
- The effect of freight transport and logistics costs on the cost of commodities consumed in that region.
- The total cost of freight transport and logistics is significant and has a direct bearing on the efficiency of the economy.
- The environmental effect of urban freight movements (in terms of energy use and environmental impacts such as pollution, noise, visual intrusion etc.).

2.1. Impacts of urban freight transport

Road freight vehicles operating in an urban environment generally emit a greater proportion of certain pollutants per kilometre travelled than other motor vehicles such as cars and motorcycles. This is due to their higher fuel consumption per unit of distance travelled and the fact that many of them use diesel as a fuel.

Existing freight and passenger transport systems in urban areas create a variety of economic, environmental and social impacts. These include (UK Round Table on Sustainable Development, 1996):

Economic impacts: (i) congestion, (ii) inefficiency and (iii) resource waste.

Environmental impacts: (i) pollutant emissions including the primary greenhouse gas carbon dioxide, (ii) the use of non-renewable fossil–fuel, land and aggregates, (iii) waste products such as tyres, oil and other materials and (iv) the loss of wildlife habitats and associated threat to wild species.

Social impacts: (i) the physical consequences of pollutant emissions on public health (death, illness, hazards, etc.), (ii) the injuries and death resulting from traffic accidents, (iii) noise, (iv) visual intrusion, (v) the difficulty of making essential journeys without a car or suitable public transport, and (vi) other quality of life issues (including the loss of greenfield sites and open spaces in urban areas as a result of transport infrastructure developments).

However, as Plowden and Buchan (1995) note "Freight transport is essential to the modern economy. An efficient system must provide the customer with a good service at a reasonable cost." However, increasing congestion in urban areas has called into question our ability to achieve high levels of efficiency and as the Freight Transport Association have observed: "While industry has achieved significant success in improving vehicle productivity and utilisation, urban congestion imposes major constraints on further improvements" (Freight Transport Association, 1996).

3. Developing a sustainability strategy

The concept of "sustainability" and "sustainable development" has become increasingly influential in policy considerations in recent years. The most widely accepted definition of sustainable development is "development that meets the needs of the present without compromising the needs of future generations to meet their own needs" (World Commission on Environment and Development, 1987). This was the definition used by the World Commission and then endorsed by the United Nations at the Earth Summit in Rio in 1992. This conference led to a focus on the policy action required to bring about sustainability, known as Agenda 21, which, whilst having no force in international law, has been adopted by many national governments (Mazza and Rydin, 1997). In the UK, as a result, many local authorities have been preparing environmental strategies.

A key problem to implementing an achievable sustainable strategy is determining the parameters of measurement (e.g. geographical scale, environmental and social impacts, etc.), and not surprisingly it is extremely difficult to achieve a workable, acceptable set of targets, actions and measures which will result in more sustainable cities, and a more sustainable urban freight transport system within that city.

3.1. Sustainability strategies for urban freight transport

The aim of a sustainable transport strategy is "to answer, as far as possible, how society intends to provide the means of opportunity to meet economic, environmental and social needs efficiently and equitably, while minimising avoidable or unnecessary adverse impacts and their associated costs, over relevant space and time scales" (UK Round Table on Sustainable Development, 1996). Since freight transport is part of the transport system it follows that the issue of sustainability must be addressed with regard to freight transport.

Urban freight movement can be improved so as to make it more sustainable in various ways. It is important to distinguish between two different groups who are capable of changing the urban freight system and the rationale for their doing so:

- *Changes implemented by governing bodies*—i.e. the introduction of policies and measures that force companies to change their actions and thereby become more environmentally or socially efficient (e.g. changing the way in which they undertake certain activities) (Ogden, 1992).

- *Company-driven change*. Companies implementing measures that will reduce the impact of their freight operations because they will derive some internal benefit from this change in behaviour—i.e. companies can achieve internal economic advantages from operating in a more environmentally or socially efficient manner, either through improved economic efficiency or through being able to enhance market share as a result of their environmental stance. Company-led initiatives include increasing the vehicle load factor through the consolidation of urban freight, making deliveries before or after normal freight delivery hours, the use of routing and scheduling software, improvements in the fuel efficiency of vehicles, in-cab communications systems, and improvements in collection and delivery systems (including materials handling technology, unitisation of loads and co-ordination between shipper, carrier and customer). As this list illustrates, some of these initiatives are technology related, some are concerned with freight transport companies reorganising their operations and some involve change in the supply chain organisation.

Although, in several instances, efficiency in operations and reduced environmental impacts go together, it must also be recognised that individual freight transport operators will not, by themselves, be able to achieve adequate system-wide improvements in urban freight efficiency. In some instances there may be a lack of concern about freight costs by the customers of the distribution companies since these costs may be only a small proportion of total product cost. In other cases there may be a reluctant acceptance by the freight industry of current levels of congestion, since there is no competitive advantage to any one firm as a result of a lower congestion level. This implies that a combination of company initiatives and government policies will be necessary in developing a sustainable urban freight system.

Given that the demand for freight transport is a derived demand, in order to consider how freight transport can be made more sustainable it is also necessary to understand the nature of commodity and goods flows. The driving forces behind these flows are factors such as the geographic location of activities, the costs of transport and related activities, land prices, customer tastes and required service levels and existing policies governing freight transport and land use. Therefore, in order to change freight transport patterns and reduce their impacts it is necessary to influence some of these factors that determine goods flows as well as simply focusing attention on goods vehicle movements.

Sustainable development strategies are likely to require national policies together with measures taken at a more local level. A national sustainability strategy could help to ensure that urban sustainability policies do not result in some urban locations becoming less economically attractive than others. It will be necessary to find suitable measures for the town or city in question and these are likely to vary from one urban area to another.

4. Urban freight study

Over the past few years the University of Westminster has carried out two specific research projects addressing urban freight transport. The two research projects were funded by the UK's Engineering and Physical Sciences Research Council (EPSRC). In this section of this paper the most recent project, which was completed in January 2003, is described and discussed.

The project was carried out in collaboration with three local authorities, Birmingham City Council, Hampshire County Council, Norfolk County Council and several distribution and logistics companies. It was concerned with the sustainability of current urban freight operations and the ways in which this would potentially be altered by company responses to policy measures. Importantly, it was also trying to show policy makers how the measures that they implement can influence and/or change the costs and operations of urban deliveries activities.

In the following sections of this paper we describe the context in which the project took place, the project methodology and presents results of the analysis of current urban freight operations. Finally, the policy measures investigated and the results of the companies' likely reactions to these policy measures are discussed.

4.1. Background to the project

While the recent growth of research into urban distribution is encouraging (see e.g. Ambrosini et al., 2001; Kohler, 1999; Meimbresse and Sonntag, 2000; Thompson and Taniguchi, 1999), little of this work has been concerned with examining the likely impact of policy measures on distribution operations. Few previous studies have attempted to understand the relationship between: (i) policy measures, (ii) likely company action in response to the measure (in terms of distribution activity), (iii) the effect on operating costs, and (iv) the change in environmental impact. The intention of our project was to:

- Illustrate patterns of current urban distribution operations of different companies and the variation between them.
- Show the extent to which distribution operations vary for the same company in three different urban areas studied.

- Quantify the likely direction and scale of change in distribution operations, vehicle operating costs and environmental impacts for different patterns of distribution if new policy measures were introduced in urban areas.
- Indicate whether the policy measures are likely to result in the same or different outcomes in the three urban areas studied.

The main aim of the project was to investigate the ways in which policy measures are likely to result in changes in goods vehicle activity for different types of urban distribution operation, a critical point if sustainable urban freight operations are to be achieved. Policy measures tested include Low Emissions Zones, congestion charging, and weight and access time restrictions. Changes that companies could make to their operations in order to improve efficiency while at the same reduce environmental impacts were also considered in the project, but are not reported on in this paper. This project has built on our earlier work, further developing our work into the sustainability of urban distribution (Allen et al., 2000).

4.2. Research approach

The research approach comprised the following four main components:

(i) Devising a suitable assessment approach to examine the relationships between policy measures, companies' distribution operations, and financial and environmental impacts of these operations.
(ii) Development of a database model to reflect the relationships noted in (i) above. This model was used to calculate operational, financial and environmental indicators of companies' current distribution operations. The database model was also used to reflect the change in these indicators caused by likely alterations to distribution operations resulting from the introduction of various policy measures.
(iii) Working closely with distribution companies that carry out urban collections and deliveries in order to firstly, understand and document their existing goods flow and vehicle activity patterns in the three urban areas studied. And secondly, to ascertain how these companies and their customers would expect these patterns of operation to change as a result of the introduction of specific policy measures.
(iv) Evaluation of the similarities and differences between the distribution operations and the three urban areas studied in the project in terms of: (a) the current pattern of goods collections and deliveries of the distribution companies, (b) the likely change in the goods collection and delivery operations in response to potential policy measures, and (c) the extent of change in the operational, financial and environmental indicators as a result of the new pattern of goods collection and delivery operations.

Urban distribution operations were studied in Birmingham, Basingstoke and Norwich. These locations were chosen due to their differences (in terms of scale, age, urban form, and geographical location), and also because of the enthusiasm of these local authorities to participate in a project that would help them to better understand current patterns of operation, and the relationships between policy measures, distribution operations, and environmental impacts.

We studied seven distribution operations in detail. This allowed us to reflect several major patterns of urban distribution operation in the project including parcels delivery, general haulage, the distribution of drinks, and dedicated contract distribution for retail stores. Fig. 1 shows the different activities in the project and how they relate to each other.

The project involved collecting a significant amount of data from the distribution companies. This included: (i) a detailed three-day survey of vehicle rounds in the three urban areas, and (ii) a more general survey of the total distribution activity taking place at the depots from which these vehicles operate. Detailed information on 120 vehicle rounds carried out by the companies was collected. In total, 2286 collections and deliveries were made on these rounds.

The database developed and used in the project had to be capable of handling all the distribution data collected. It also had to be designed to allow manipulation of this data to reflect operational changes resulting from policy measures in accordance with the views expressed by companies (Allen et al., 2003). Fig. 2 shows the data inputs and outputs, and how they were used.

A set of indicators was selected to reflect the sustainability of these current vehicle rounds (centre column in Fig. 2). These included: (i) operational indicators (including 'time taken', 'speed', 'distance travelled', 'vehicle fill', and 'proportion of on- and off-street deliveries'), (ii) financial indicators (based on the cost of making deliveries and collections to the distribution company) and (iii) environmental indicators (including CO, CO_2, NO_X and PM_{10} emissions). Although 'time taken', 'speed' and 'distance travelled' are shown as operational indicators in the list below, they also obviously influence the environmental impact of distribution activities.

4.3. Policy measures investigated

The task of determining which policy measures to test in the project was carried out in conjunction with the

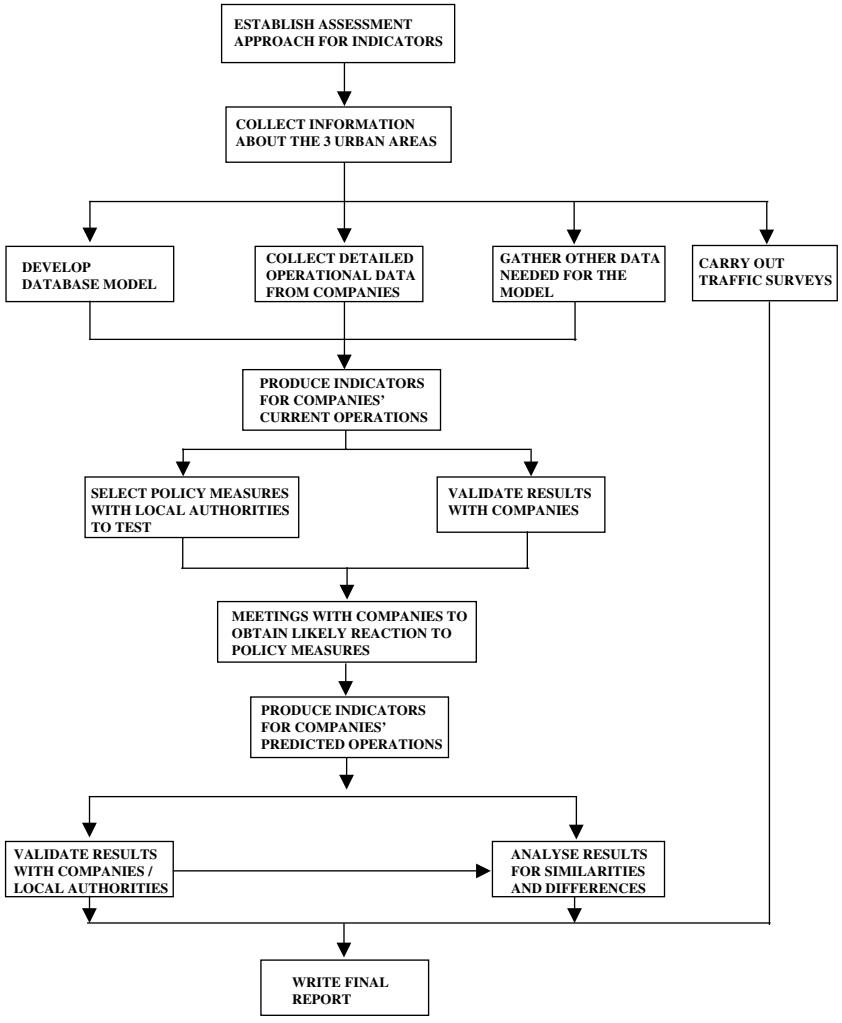

Fig. 1. The project activities.

local authority partners from Birmingham City Council, Hampshire County Council, and Norfolk County Council. Three basic principles were used to guide the selection process:

- To assist in making comparisons it was agreed that the same policy measures would be tested in each urban area.
- Policy measures selected should be area-wide approaches to goods vehicle management in an urban area, rather than localised measures in a particular street.
- Measures selected were thought to be the types of approach that policy makers may take with respect to UK urban areas in the next five years (i.e. policy measures that may be implemented in the medium term).

Four policy measures were selected for detailed analysis:

- Low emission zones—the aim of a low emission zone (LEZ) is to improve air quality by excluding older, high-polluting goods vehicles from certain urban areas and encouraging the faster take up of more modern, cleaner vehicles. Such zones do not currently exist in UK towns and cities.
- Congestion charging—this refers to a scheme in which vehicle drivers (or the companies responsible for the vehicles) have to pay a charge in order to enter a particular geographical area at a particular time. The aim of such a scheme is to reduce road traffic levels in the urban area and also to reduce traffic pollutant emissions. Such a scheme may also generate a profit which can be used to provide improved public transport services. Congestion charging was introduced in London in February 2003 but does not exist in any other UK urban area, apart from the historic core of Durham city.

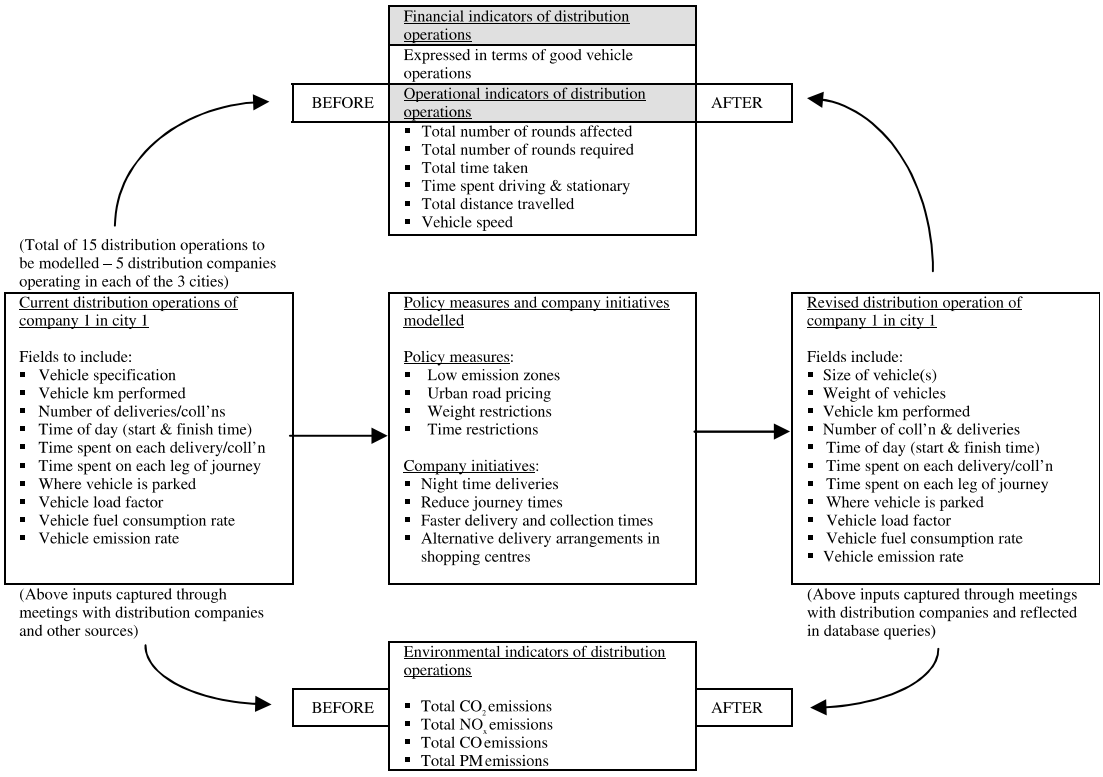

Fig. 2. Data handling in the database.

- Vehicle weight restrictions—in this policy measure only vehicles up to a certain gross vehicle weight would be allowed to enter a specific geographical area within the urban area to make collections and deliveries during a large period of the working day (10:00 to 16:00). The aim of such a measure would be to reduce the number of large goods vehicles entering the chosen area when pedestrians and other road users are present and thereby overcoming the impacts that it is commonly perceived that these vehicles cause, such as pollution, intimidation, safety concerns, vibrations and noise.
- Vehicle access time restrictions—in this policy measure no goods vehicles would be permitted to enter a specific geographical area within the urban area to make collections and deliveries during a large period of the working day. The aim of such a measure would be to prevent goods vehicles of any weight entering the chosen area when pedestrians and other road users are present. This could help to reduce the impacts that it is commonly perceived that goods vehicles cause, such as pollution, intimidation, safety concerns, vibrations and noise.

Several scenarios were tested for each policy measure. For example, congestion charge remains at £5, but drive time reduces by 15%; no vehicles with a gross weight of more than 12 tonnes allowed in inner urban area between 10:00 and 16:00. The next stage involved determining how the distribution companies expected these policy measures to affect their operations in the three urban areas. To achieve this a meeting was held with the companies at which their representatives were presented with an explanation of the policy measures and the different scenarios for that measure, and then asked to comment on and discuss the likely company response to the scenarios for each policy measure. Detailed discussions enabled the representatives to describe likely changes that the company would make in order to meet the specific scenarios put to them. Companies were also given the opportunity to explain initiatives they could implement that would result in operational, financial and environmental benefits.

The companies' responses to the policy measures were modelled by applying queries to current distribution data in the database using relationships derived from company interviews. Each scenario was treated in this way, allowing revised distribution data to be calculated for each vehicle round studied. The difference between the current and revised indicators was then calculated for each scenario. Fig. 3 shows the relationship between data items in the database used for producing these indicators.

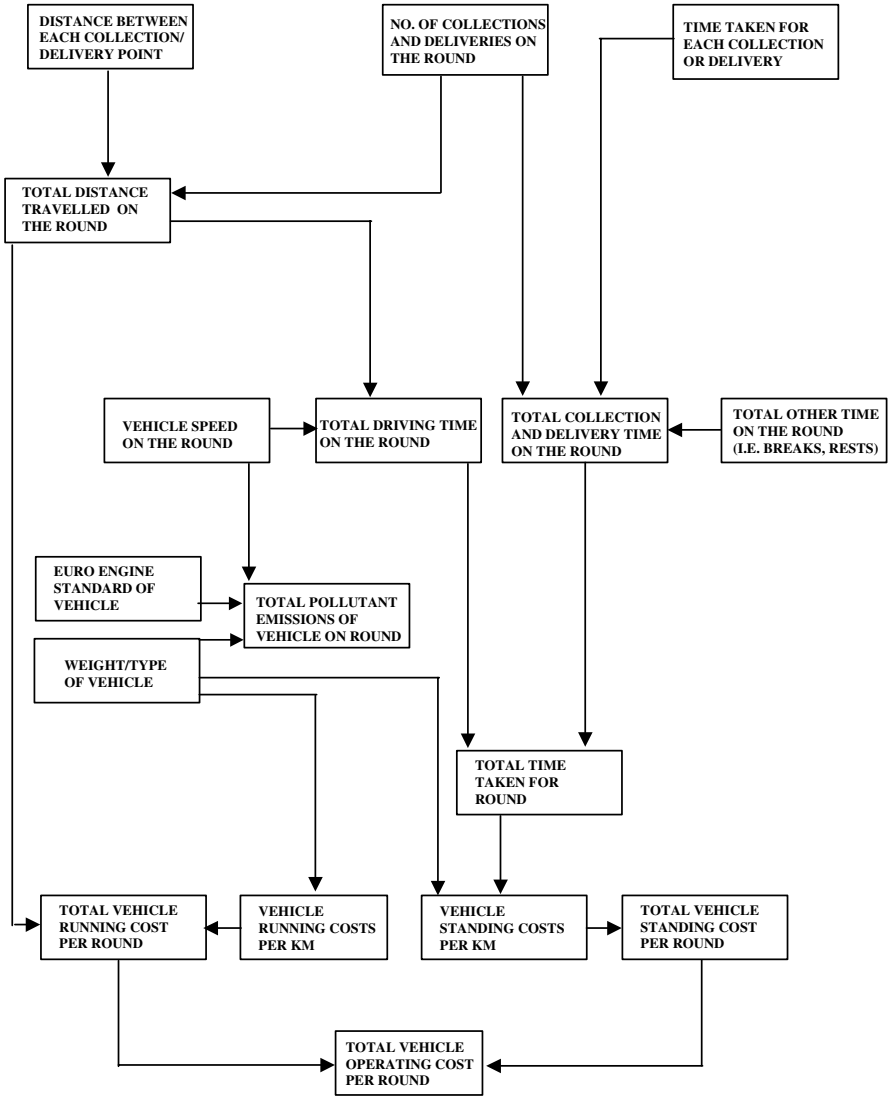

Fig. 3. Relationships between data in the database.

4.4. Results

4.4.1. Current operations

The operations studied ranged from multi-drop work with some 100 deliveries per round made using light goods vehicles from a depot located within the urban area (e.g. parcels deliveries), to full-load single drop work on large articulated (semi-trailer) vehicles made from a single national distribution centre. The project has quantified key differences in the current urban distribution operations of the companies taking part in the project.

A range of local, regional and national vehicle round patterns were observed among the seven distribution companies studied in the project. These are listed below:

- **Urban distribution operation** (i.e. vehicle rounds operated from depot located in urban area):
  - Collections/deliveries wholly within city centre.
  - Collections/deliveries wholly within rest of urban area (i.e. not in city centre).
  - Collections/deliveries in city centre and rest of urban area.
  - Collections/deliveries in urban area and outside urban area.
- **Regional distribution operation** (i.e. vehicle rounds operated from depot located in same region as urban area):
  - Collections/deliveries wholly within one urban area.
  - Collections/deliveries in more than one urban area.
- **National distribution operation** (i.e. vehicle rounds operated from national depot to the urban area):
  - Full load delivery for one destination in urban area.

– Collections/deliveries wholly within one urban area.
– Collections/deliveries in more than one urban area.

The work has demonstrated that there are important differences between current urban distribution operations that need to be understood when considering urban distribution policy measures and their likely effects.

4.4.2. Potential impact of the four policy measures

The four policy measures analysed were found to have differing effects on distribution operations in terms of: (i) impact on the distribution operation and its cost, and (ii) on the environmental impact of the distribution activity. In addition, results varied by type of distribution operation and by urban area. Unfortunately, too many scenarios were modelled to include detailed results in this paper, however the findings for each policy measure and differences between companies and urban areas are summarised in Section 4.4.3. An example of the database output is shown in Table 1, which contains the results by urban area for the weight restriction policy measure applied to the seven companies' vehicles operating in the inner urban area.

4.4.3. Operational, financial and environmental impacts

- **Low emission zones**

The results indicate that low emission zones will have the least impact of the four policy measures on the organisation and operation of distribution activities, but would have a potentially significant impact on pollutant levels (e.g. a LEZ based on Euro III engine standards could lead to reductions in particulate matter of up to 50% for the companies studied). However, three of the seven companies would be expected to experience vehicle operating cost increases of up to 5% due to the need to acquire compliant vehicles. Operating costs and environmental impacts will depend on two main factors (i) the company's vehicle replacement cycle and (ii) the geographical profile of a companies delivery and collection work compared with the geographical coverage of a LEZ scheme. A range of LEZ scenarios has been investigated and their effects assessed for different types of distribution operation.

- **Congestion charging**

Our work has demonstrated that the effect of congestion charging will differ between companies, depending on: (i) the level of the charge, (ii) the geographical area in which the scheme is implemented, and (iii) whether or not the scheme results in speed improvements. The results suggest that improvements in the average speed of goods vehicles (as a result of reductions in traffic levels) can reduce, and in the case of some companies outweigh, the congestion charge (depending on the level of the charge). The findings indicate that a 15% reduction in driving time in the congestion charging area, would more than offset a daily congestion charge of £5 per vehicle for some companies. However a daily charge of £15 would lead to increased operating costs for all companies. The work has highlighted the importance of generating time savings to ensure that congestion charging does not have a detrimental economic effect, in helping to increase acceptability among companies, and for pollution reduction to be achieved.

Table 1
Results of weight restriction scenario by urban area (No vehicles over 7.5 tonnes (gvw) allowed in inner area between 10:00 and 16:00)

	Basingstoke	Birmingham	Norwich
Total number of rounds	Was: 20 rounds	Was: 57 rounds	Was: 43 rounds
Total number of rounds	Now: 27 rounds	Now: 75 rounds	Now: 59 rounds
Number of round affected	4/20	10/57	8/43
Total time taken	+13%	+6%	+4%
Orig. driving time as % of total	Was: 54%	Was: 46%	Was: 43%
Orig. stationary time as % of total	Was: 46%	Was: 54%	Was: 57%
New driving time as % of total	Now: 56%	Now: 49%	Now: 44%
New stationary time as % of total	Now: 44%	Now: 51%	Now: 56%
Speed per round (incl. stops)			
Speed per round (excl. stops)			
Total distance travelled	+23%	+14%	+7%
Total vehicle operating cost	+11%	+4%	n/c
Total CO emissions	+12%	+6%	+3%
Total CO_2 emissions	+7%	+4%	n/c
Total NO_x emissions	+8%	+4%	n/c
Total PM_{10} emissions	+32%	+14%	+8%

The results suggest that the weight restriction scenarios would results in some differences in the three urban areas in terms of: (i) the proportion of vehicle rounds affected by each scenario, (ii) the proportional increase in vehicle rounds that would be necessary to carry out the same amount of collection and delivery work, and (iii) the effect of each scenario on the total distribution costs, time taken, distance travelled and pollutant emission levels. The scenario regarding 7.5 tonnes vehicles in inner areas would affect approximately the same proportion of vehicle rounds in all three urban areas (approximately 20%).

- **Weight restrictions**

The companies studied would be affected very differently by weight restriction policy measures. In the scenarios we have examined, those companies operating light goods vehicles would be completely unaffected, while those companies operating heavy goods vehicles with a gross weight of 12 tonnes or more would have to make significant changes to their distribution patterns in order to comply (i.e. operating a greater number of vehicle rounds using lighter vehicles) These changes would result in increases in total vehicle operating costs of as much as 30% for some companies depending on the weight restriction. The environmental impact of the vehicle rounds performed by those companies worst affected by the weight restriction scenarios would increase significantly as a result of increases in total distance travelled (calculated to double for one company if a 7.5 tonnes gross vehicle weight limit was introduced), which would lead to increases in total fuel consumption and pollutant emissions. The increase in the total time taken to complete the same quantity of collection and delivery work would require an increase in total time taken (which is expected to rise by as much as 50% in the case of one company) and would also lead to negative impacts (see Table 1).

- **Time restrictions**

Time restrictions could lead to distribution activities being compressed into a shorter period at the start or end of the working day. If this were to happen the results suggest that, like weight restrictions, there would be negative impacts on the distribution operations of companies affected in terms of increases in vehicle rounds, total distance travelled and could lead to more queuing at receivers' premises. The environmental impact of vehicle activity would also increase if companies responded to time restrictions in this manner.

However, if time restrictions resulted in more distribution companies operating at night then the results indicate that this could be beneficial from both a commercial and environmental perspective. The commercial benefits would depend on the trade-off between improved driving speeds and higher drivers' wages. The results indicate that improved driving speeds due to night working could result in vehicle operating cost reductions of between 1% and 4% for the companies studied, as well as reductions in pollutant emissions. Though it must be recognised that there may be noise implications for local residents. However, 20% higher drivers' wages for night working would outweigh the value of improved driving speeds and lead to operating cost increases of 1–4% for the companies studied. For night delivery and collection to become more commonplace it would be necessary for senders and receivers of goods to accept night work. They will potentially experience higher reception/despatch costs and may have concerns about the safety of their premises if staff were not present. Therefore negotiations between supply chain partners would be necessary to make night collections and deliveries in urban areas possible for more distribution companies.

4.4.4. Impact of policy measures on different companies/types of operation

The results indicate that the four policy measures (and the scenarios modelled for each) will not result in uniform effects for all urban freight transport operations. Differences between companies for each policy measures are presented below.

- **Low emission zones**

The LEZ policy measures tested in this project are not expected to affect the vehicle operating costs of companies in particular sectors of the distribution market more than others. The impact on vehicle operating costs will depend on two main factors: (i) the company's vehicle replacement cycle, and (ii) the geographical profile of a company's collection and delivery work compared with the geographical coverage of a LEZ scheme.

However, if LEZ schemes were only implemented in a small number of urban areas in the UK, large companies with a national fleet may be able to redeploy their newer vehicles to these urban areas and use the older vehicles in areas without a LEZ. Locally-based companies with small fleets and long vehicle replacement cycles would be unable to redeploy their vehicles in this way. The latter may therefore be disproportionately affected by a LEZ scheme in terms of the fleet changes they will have to make in order to comply.

- **Congestion charging**

The results suggest that some of the companies in the project will be worse affected than others by particular congestion charging scenarios. Very few of the vehicle rounds we studied avoid the congestion charge due to completing their work in the congestion charging area before, or starting their work after, the charge comes into force. However, like the LEZ policy measures, differences in the impact on companies are due to the proportion of a company's vehicle rounds that take place in the geographical area in which the scheme is implemented.

A congestion charging scheme that was implemented in the central/inner area may disproportionately affect distribution companies delivering to the city centre such as parcels carriers, and companies delivering to high street shops and to pubs, bars and restaurants. If the congestion charging scheme covers both the inner and outer urban area then many companies would be expected to have a high proportion of affected vehicle rounds.

- **Weight restrictions**

The results indicate that the weight restriction policy measure would be expected to affect the companies studied in the project very differently. Some would be totally unaffected while others would have to make significant changes to their operation, and would experience sizeable cost increases.

The primary factor in determining how severely distribution companies would be affected by such weight restriction measures is obviously the weight of vehicles currently operated by companies. Other important factors are the geography of vehicle rounds compared with the area covered by the weight restriction, and the times at which vehicle rounds take place compared with the times at which restrictions are in force.

- **Time restrictions**

Three of the companies studied would have a greater proportion of vehicle rounds that are affected by the time restriction scenarios modelled in the inner area than the other companies. This is due to two facts: (i) that they have a high proportion of rounds that enter the inner area, and (ii) that their many of their rounds take place during the restricted times of 10:00–16:00.

4.4.5. Differences in current and predicted operations in the three urban areas

The project has demonstrated that the size and form of the urban area has an important bearing on the distribution operations that serve that area. For example, average speeds in Basingstoke are higher than in Birmingham and Norwich, and the proportion of off-street and shopping centre deliveries are higher in Basingstoke (which was designed in the 1950s and 1960s to segregate and improve much of the distribution work for the city centre). Multi-drop vehicle rounds serving Basingstoke also cover greater distances than in Norwich and Birmingham as, given the population size and density, it is necessary to travel further to carry out the same amount of collection and delivery work.

Discussions with the companies together with our own analysis of each urban area has shown that existing distribution problems (both in terms of problems caused and experienced by goods vehicle) are far more acute in Birmingham and Norwich than in Basingstoke.

The work has also shown that in some cases the policy measures studied would be likely to either: (i) affect a different proportion of vehicle rounds in the three areas, or (ii) result in different company reactions in the three areas, thereby resulting in different environmental outcomes.

4.4.6. Value of the adopted research approach

The research approach adopted for project has helped in providing a better understanding of the:

- Different patterns of urban distribution operations currently taking place.
- Likely effect of different policy measures on various distribution operations.
- Relationship between policy measures and their environmental and commercial/operational impact on these various distribution patterns.
- Impact of policy measures on distribution activities in three different urban areas.
- Possible environmental and commercial benefits that could be achieved through company actions to reduce distance travelled and time taken.

The analysis of the likely effects of four policy measures on urban distribution operations has demonstrated:

- The impact of several scenarios for each policy measure considered (the results reflect that the various scenarios modelled for each policy measure could produce very different outcomes).
- The extent to which the vehicle rounds of the seven companies participating in the project would be affected differently by these four policy measures in terms of: (i) distribution operations, (ii) vehicle operating costs, and (iii) environmental impacts.
- The extent to which the companies' operations would be affected differently in the three urban areas.
- The overall effect on the total distribution activities carried out by the seven companies in each of the urban areas (i.e. comparisons of results between the three urban areas).
- That an understanding of different patterns of urban distribution is necessary when investigating the likely effect of policy measures intended to bring about sustainable urban distribution.

Even with the relatively small number of companies participating in the project and the amount vehicle round data that we were able to capture, it has been possible to obtain much insight into the likely company reactions to, and effects of, different policy measures and company initiatives. This work will add to the current discussion about policy making for urban distribution.

The database developed and used in the project proved to be a very effective tool for analysing the distribution data collected. It was also suited to the task of applying changes to this data to reflect how operations may change as a result of policy measures and company initiatives in accordance with the views expressed by companies. The use of a database also made the task of producing results in several ways relatively straightforward (e.g. by company, by urban area, by company by urban area).

By developing a set of indicators it was possible to reflect the sustainability of these distribution operations

before and after the application of the policy measures and company initiatives in operational, financial and environmental terms.

The involvement of local authorities and distribution companies in the project has helped to ensure that the policy measures selected for investigation and the likely responses of companies to these measures are as realistic as possible.

5. Conclusions

Freight transport is an important component of urban environments and without effective freight delivery systems the vitality of urban areas can be disadvantaged, both in terms of their economic and environmental states.

The urban freight transport operations that take place do not conform to any one system or pattern and if policy makers are to implement measures that aim to meet sustainability objectives they must take into account these variations.

Policy measures will impact upon freight transport companies in different ways. As our research revealed, even with the relatively small number of companies participating in the project and the amount of vehicle round data captured, it has been possible to obtain much insight into the likely company reactions to and effects of different policy measures.

This work will add to the current discussion about policy making for urban distribution.

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