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FURTHER STUDIES OF THE DISTRIBUTIONAL EFFECTS OF ROAD PRICING

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ABSTRACT

MAY, AD, MILNE, DS (1994). Further studies of the distributional effects of road pricing. *ITS Working Paper 417,* Institute for Transport Studies, University of Leeds.

This Working Paper extends the study reported in Working Paper 400, which used the MVA START model for London, disaggregated into three income groups for each of car owners and non car owners, to investigate the distributional effects of road pricing in London. At the time of that study, it was not possible to obtain, from the disaggregate model, output on trips, flows and speeds. The further work reported in this Working Paper has involved extending the evaluation procedures to provide output on trips, flows and speeds; assessing the results from the previous study in terms of these indicators, and testing a fourth charging structure. In all, four charging structures were tested. It is concluded that the additional charging structure tested here, with the original LPAC charging structure, but with charging extended to the off peak in inner London, is by far the most effective in terms of overall benefits, and is similar in its distributional effects to the original LPAC structure.

KEY-WORDS: Road pricing; distributional impact; public transport; traffic management policies.

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FURTHER STUDIES OF THE DISTRIBUTIONAL EFFECTS OF ROAD PRICING

1. Introduction

1.1 In 1991, LPAC commissioned The MVA Consultancy, with support from the Institute for Transport Studies (ITS) at The University of Leeds, to construct a new strategic transport model of London, based on MVA's START software. The results and greater detail of the START model were reported to LPAC in July 1992 (LPAC, 1992).

1.2 In the original study LPAC only contributed £24,000 of the total cost of around £60,000, with both MVA and ITS bearing the remainder. The study has provided useful general confirmation of the robustness of LPAC's Transport Strategy, which has been reflected in the work of the Review of Advice and Guidance. However, at the time of the original study there was insufficient money to enable the development of an evaluation module to provide detailed cost benefit data on the effects of the strategies considered. Since then MVA have developed such an evaluation module and have made it available to ITS, who also have a copy of both the model and previous results.

1.3 ITS subsequently developed a disaggregate version of the model, which identified the responses of, and impacts on car owning and non-car owning households, each within three income groups. That model was used in a study, funded by ESRC, of the distributional effects of alternative road pricing strategies in London (WP400: Fowkes et al, 1993). The study indicated that road pricing restricted to entering Central London was likely to have a more adverse impact on low income households, while schemes which extend charging to Inner London, and thus have lower charges per cordon crossing, have a greater impact on middle and high income car users.

1.4 Unfortunately, at the time that these results were reported, it was not possible to use the evaluation module to study the impact on trip-making by each group of travellers, or the changes in traffic flows and speeds. The current contract with LPAC was designed to provide the further analysis necessary to investigate these issues and, within the resources available, to investigate the distributional effects of alternative strategies.

1.5 More specifically, the objectives were:

(1) to investigate in more detail the changes in travel patterns which lead to the distributional effects predicted by our ESRC work (as summarised in WP 400); and
(2) to identify and assess the distributional effects on other road pricing and complementary strategies.

1.6 The work programme involved the following five stages:

(1) development of the facility in the disaggregated START model to determine changes in the disaggregate trip matrix;
(2) reanalysis of the existing (WP 400) tests based on the facility in (1) to understand the predicted impacts on travel patterns, and hence assess the acceptability of the model outputs;
(3) introduce any necessary modifications to the model or the WP 400 tests, as a result of (2);

(4) within the remaining resources available, conduct tests of a wider range of road pricing and road pricing with public transport strategies to assess their distributional impacts;
(5) prepare a final report on the work in (1)-(4).

2 Extension of the Evaluation Module

2.1 The START model is fully described elsewhere (LPAC, 1992), and the principles on which it is based in an earlier paper (Bates et al, 1991). In brief, its characteristics are:-

- representation of car owning and non-car owning households separately and, in the disaggregate version developed by ITS, three income groups for each:-
- four journey purposes (home based work, education and other, and non home based), and a separate freight matrix;
- choice among four modes (car, bus, train and walk);
- some choice of frequency and destination of journeys;
- spatial disaggregation into 13 zones within the study area and four external zones (as shown in figure 1);
- no formal networks for road and rail, but with road network supply represented by radial and orbital area speed flow relationships in each zone, and with rail represented by access and in vehicle times;
- interaction between demand and supply represented through the area speed-flow relationship for roads, through overcrowding on bus and train, and through search time, searching traffic and access time for parking.

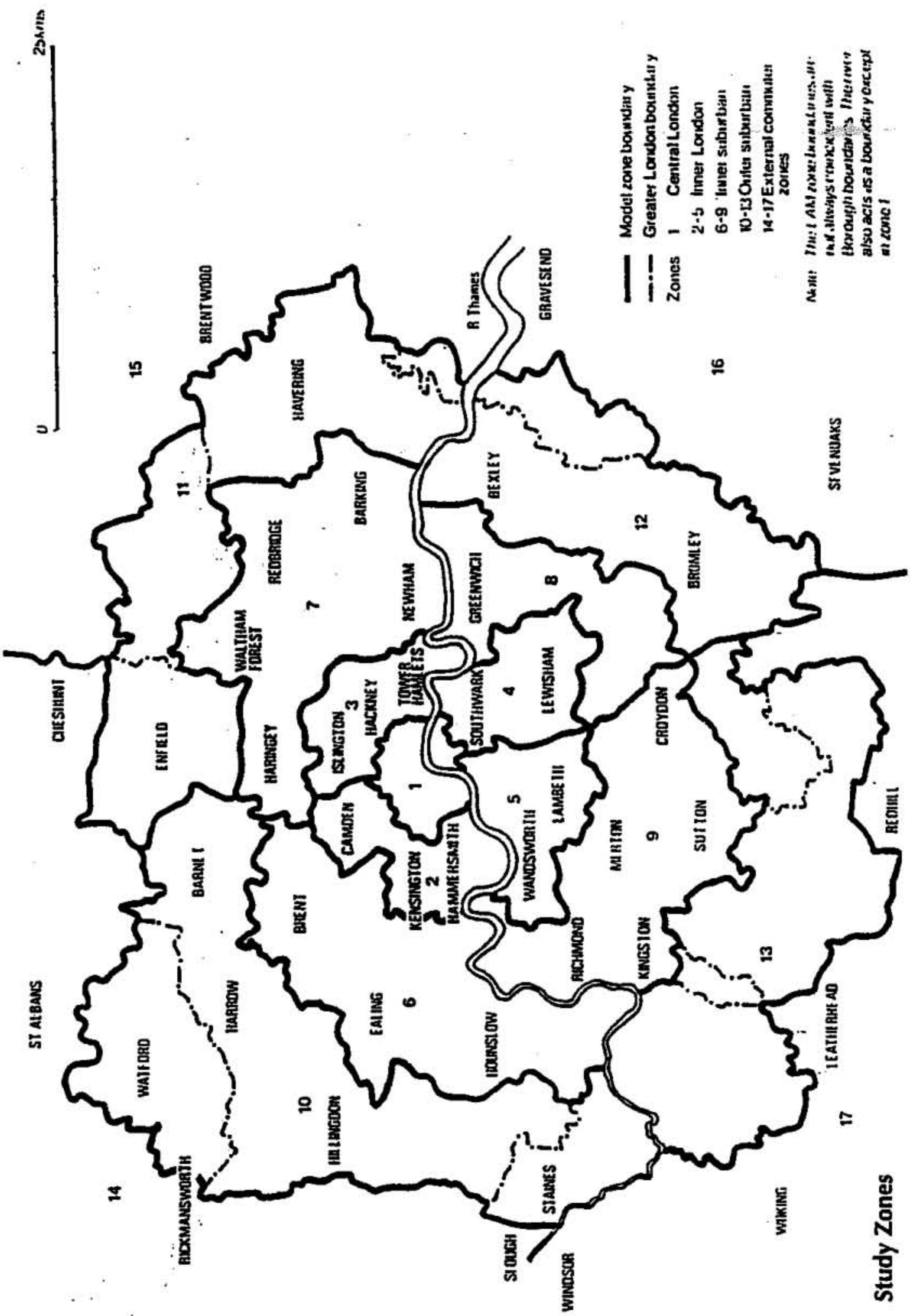
2.2 The evaluation model developed by MVA provided a combined economic (cost benefit) and financial appraisal for a specific modelled year, providing information on time and money costs and benefits for households, freight, operators, local and central government. These evaluation procedures have since been incorporated into the Common Appraisal Framework, and are described, together with their underlying principles, in that report (MVA, ITS, OFTPA, 1994). The subsequent modification for the ESRC - funded study enabled the results for households to be split between the six household types.

2.3 Additional software has been written, by The MVA Consultancy, to enable the following data to be output:

(1) an aggregate economic evaluation for transport users and non-users;
(2) absolute and relative changes in accessibility for each journey purpose and mode, for journeys starting and ending in each of the 17 zones;
(3) parking utilisation, search and egress times in Central London;
(4) numbers of trips by each mode for each purpose in each of three time periods for each of the six types of user;
(5) numbers of trips and trip-kilometres by each mode in each of three time periods for each of the six types of user;
(6) numbers of trips to Central London by each mode in each of three time periods for each of the six types of user;
(7) flows and speeds in each of the 17 zones for each of the three time periods.

Figure 1

Zone System



Study Zones

2.4 Of these (1) provides confirmation of results reported earlier, and (2), (3) and (4) are additional items of information available for future use by LPAC. The analysis in this report has concentrated on items (5) - (7).

3 The Impacts of Alternative Road Pricing Strategies

The Strategies Tested

3.1 In the original work for LPAC (LPAC, 1992) one road pricing strategy was tested. This involved three concentric cordons, the outermost inside the North and South Circulars and the innermost inside the Inner Ring Road, with six screenlines within Central London. An identical charge was levied for cars to cross each cordon or screenline in either direction. No charges were imposed on freight. While the two outer cordons operated only in the morning and evening peaks, the inner cordon and screen lines operated throughout the day. This fairly complex system is referred to as Structure A. For the ESRC study, two simpler systems were also tested. Structure B excluded the screenlines, and Structure C simply employed the innermost cordon.

3.2 A total of three charge levels were tested for Structure A, with the maximum benefits achieved by a one way charge of 50p. For Structure B five charge levels were tested, with the optimum at 100p. For Structure C, six charge levels were tested, with the optimum at £5. Rather than repeat all 14 tests, we have concentrated on 10 which include the optima and charge levels either side of the optima. The 10 are specified in Table 1, which also indicates the benefits from adding road pricing to the LPAC Preferred Strategy, measured in £m for 2001. These values are consistent with WP 400 (Fowkes et al, 1993).

3.3 Subsequently, in stage (4) of the study, it was decided to test a fourth system, based on Structure A, but with the two outer cordons also operating throughout the day, denoted as Structure D. A total of nine charging levels were tested for this but those above 100p failed to converge. The remaining five are shown here. For ease of comparison, the results for Structure D are presented alongside those for the other three Structures in the tables which follow. The performance of this structure, and its distributional impact, are discussed in the final section of the report.

3.4 The LPAC Preferred Strategy (without road pricing) used as the base for the benefits, shown in Table 1, includes:

- rail capacity increases and the Heathrow Express, Crossrail, Chelsea - Hackney, Jubilee Extension and orbital rail lines;
- a 20% increase in bus services;
- bus fares kept constant in real terms;
- rail fares increased by 30% in real terms;
- capacity increases derived from SCOOT allocated to environmental improvements;
- an improvement in parking enforcement (LPAC, 1990).

Table 1: Road pricing schemes tested, and benefits compared to the LPAC Preferred Strategy, in £m for 2001

Scheme Code	Crossing Charge	Additional Benefit (£m)
A25	25p	30.7
A50	50p	38.4
A100	100p	19.0
B50	50p	24.8
B100	100p	29.3
B200	200p	11.7
C200	200p	5.1
C500	500p	20.4
C600	600p	14.5
C800	800p	-2.1
D25	25p	99.0
D37.5	37.5 p	149.5
D50	50p	164.7
D75	75p	197.0
D100	100p	243.9

Note: the scheme code A25 denotes
A: the charging structure (A)
25: the charge per crossing (25p)

Changes in Overall Travel

3.5 Table 2 indicates the percentage change from the Preferred Strategy in the number of trips by mode and time period. Table 3 shows the same information for all day trips for each of the six user groups separately.

3.6 The overall all day changes are small, with a reduction of 5.8% in car trips for the optimal charge for Structure D, 2.6% for Structure A, and 1.9% for Structures B and C. Bus, train and walk trips all increase, but the percentage increases are greatest for bus (at 12.2% for Structure D) and least for walking (at 2.5% for Structure D). It is notable that Structure D has over twice the impact of Structure A.

3.7 The results for different time periods for changes in car trips are broadly as expected, with increases in the inter peak for Structures A and B (which include peak only inner area charges); a reduction in the inter peak for Structures C and D; and reductions in the peaks for all Structures, which are highest for Structure D and lowest for Structure C. It is however surprising that the reductions for the evening peak are typically twice as great as for the morning peak.

Table 2: Percentage change to trips for all segments by mode and time period

Time Period = T1 (morning peak)

	MODE			
Scheme Code	**Car**	**Bus**	**Train**	**Walk**
A25	-3.3	11.5	-1.1	0.7
A50	-3.8	16.9	-1.8	0.9
A100	-6.7	24.9	-2.2	1.5
B50	-1.4	10.5	-1.2	0.2
B100	-2.8	16.1	-1.8	0.4
B200	-4.6	22.1	-2.3	0.6
C200	-0.6	8.1	-1.4	0.4
C500	-1.0	10.5	-1.9	0.3
C600	-0.9	10.4	-2.0	0.3
C800	-0.9	11.1	-2.1	0.0
D25	-1.3	9.9	-0.9	0.7
D37.5	-2.0	12.8	-1.1	1.0
D50	-2.6	15.0	-1.1	1.3
D75	-3.6	18.9	-1.2	1.8
D100	-4.5	21.7	-1.2	2.2

Time Period = T2 (inter peak)

	MODE			
Scheme Code	**Car**	**Bus**	**Train**	**Walk**
A25	3.2	4.9	2.2	0.8
A50	0.9	5.6	2.4	1.2
A100	1.4	5.4	3.5	1.9
B50	0.9	3.4	2.6	0.3
B100	1.0	3.6	2.7	0.5
B200	1.0	3.4	3.5	0.7
C200	-0.5	8.1	0.5	0.8
C500	-1.3	10.6	-0.1	0.8
C600	-1.3	10.7	-0.1	0.8
C800	-1.5	11.1	-0.3	0.6
D25	-1.3	9.1	1.2	0.9
D37.5	-2.3	11.4	0.9	1.2
D50	-3.3	13.3	0.9	1.5
D75	-4.7	16.6	1.0	2.0
D100	-6.1	19.2	1.2	2.5

Time Period = T3 (evening peak)

			MODE	
Scheme Code	**Car**	**Bus**	**Train**	**Walk**
A25	-7.1	-13.7	7.0	0.8
A50	-6.2	-8.3	6.0	1.2
A100	-9.3	-0.3	5.2	2.0
B50	-3.6	-14.5	6.8	0.4
B100	-5.0	-9.1	6.0	0.6
B200	-6.6	-3.0	5.2	0.9
C200	-3.1	-16.6	6.4	0.7
C500	-3.6	-14.2	5.7	0.6
C600	-3.8	-13.8	5.5	0.6
C800	-3.6	-13.3	5.3	0.3
D25	-3.6	-15.7	7.2	1.0
D37.5	-4.0	-13.3	6.9	1.3
D50	-4.5	-11.4	6.9	1.6
D75	-5.7	-8.1	6.8	2.2
D100	-6.4	-5.7	6.8	2.7

Time Period = all day

			MODE	
Scheme Code	**Car**	**Bus**	**Train**	**Walk**
A25	-1.7	0.9	2.5	0.8
A50	-2.6	4.2	1.9	1.1
A100	-4.1	8.6	1.7	1.8
B50	-1.2	-0.3	2.5	0.3
B100	-1.9	2.9	2.0	0.5
B200	-2.9	6.1	1.7	0.8
C200	-1.4	0.6	1.8	0.7
C500	-1.9	3.0	1.2	0.6
C600	-2.0	3.2	1.1	0.6
C800	-2.0	3.7	0.9	0.4
D25	-2.0	1.8	2.5	0.9
D37.5	-2.8	4.2	2.2	1.2
D50	-3.5	6.2	2.2	1.5
D75	-4.7	9.7	2.1	2.0
D100	-5.8	12.2	2.2	2.5

Table 3: Percentage change in trips by mode and segment all day

Segment = CO1 (no car, low income)

Scheme Code	Car	Bus	Train	Walk
		MODE		
A25	-5.6	1.4	0.8	0.7
A50	-9.7	3.4	-0.1	1.2
A100	-14.3	5.8	-0.9	1.6
B50	-3.6	0.6	1.0	0.4
B100	-6.2	2.3	0.0	0.7
B200	-10.0	4.2	-0.8	1.1
C200	-8.4	2.3	0.4	1.1
C500	-12.0	4.5	-0.7	1.5
C600	-12.2	4.8	-1.0	1.4
C800	-12.0	5.2	-1.7	1.3
D25	-7.8	3.1	-0.1	0.8
D37.5	-11.0	4.9	-0.9	1.0
D50	-13.7	6.5	-1.4	1.3
D75	-17.7	9.1	-2.4	1.6
D100	-20.4	11.0	-3.3	1.8

Segment = CO2 (no car, medium income)

Scheme Code	Car	Bus	Train	Walk
		MODE		
A25	-4.5	1.9	1.1	0.5
A50	-7.4	5.1	0.4	0.9
A100	-11.5	9.0	-1.8	1.4
B50	-2.7	0.9	1.2	0.2
B100	-4.8	3.8	-0.2	0.3
B200	-7.7	6.9	-1.5	0.6
C200	-5.8	2.1	0.7	1.1
C500	-8.3	4.7	-0.4	1.4
C600	-8.2	4.9	-0.6	1.3
C800	-7.4	5.4	-1.2	0.9
D25	-5.4	2.9	0.8	0.6
D37.5	-7.6	5.2	-0.1	0.8
D50	-9.6	7.1	-0.6	1.1
D75	-12.6	10.1	-1.5	1.4
D100	-14.8	12.4	-2.3	1.6

Segment = CO3 (no car, high income)

			MODE	
Scheme Code	**Car**	**Bus**	**Train**	**Walk**
A25	-3.9	2.2	0.8	0.3
A50	-6.5	5.8	-0.9	0.7
A100	-10.4	10.2	-2.5	1.2
B50	-2.3	1.2	0.9	0.0
B100	-4.2	4.5	-0.6	0.1
B200	-6.9	8.0	-2.1	0.4
C200	-5.0	2.2	0.5	1.0
C500	-7.6	5.0	-0.7	1.5
C600	-7.5	5.2	-1.0	1.4
C800	-6.9	5.7	-1.5	1.0
D25	-4.5	3.0	0.5	0.4
D37.5	-6.4	5.4	-0.4	0.6
D50	-8.1	7.3	-1.0	0.9
D75	-10.9	10.6	-2.0	1.2
D100	-12.9	12.9	-2.7	1.4

Segment = C11 (car, low income)

			MODE	
Scheme Code	**Car**	**Bus**	**Train**	**Walk**
A25	-1.8	0.7	3.6	1.2
A50	-2.5	4.1	3.4	1.6
A100	-3.8	8.7	3.7	2.5
B50	-1.2	-0.6	3.4	0.6
B100	-1.9	2.6	3.3	0.9
B200	-2.6	5.9	3.3	1.1
C200	-1.1	-0.1	2.4	0.7
C500	-1.3	2.1	1.9	0.5
C600	-1.3	2.2	1.8	0.4
C800	-1.2	2.7	1.6	0.1
D25	-2.1	1.7	3.7	1.4
D37.5	-2.8	4.5	3.8	1.8
D50	-3.5	6.7	4.1	2.3
D75	-4.8	10.7	4.5	3.1
D100	-5.8	13.8	4.9	3.7

Segment = C12 (car, medium income)

Scheme Code	Car	Bus	MODE Train	Walk
A25	-1.6	0.4	3.3	1.0
A50	-2.3	4.0	3.0	1.3
A100	-3.6	9.2	3.2	2.2
B50	-1.1	-1.0	3.3	0.5
B100	-1.8	2.6	3.0	0.7
B200	-2.6	6.3	3.0	0.9
C200	-0.9	-0.6	2.3	0.5
C500	-1.1	1.6	1.8	0.2
C600	-1.1	1.7	1.7	0.2
C800	-1.2	2.2	1.6	-0.1
D25	-1.8	0.9	3.4	1.1
D37.5	-2.5	3.7	3.4	1.5
D50	-3.1	5.8	3.5	1.9
D75	-4.2	9.7	3.8	2.5
D100	-5.1	12.6	4.1	3.1

Segment = C13 (car, high income)

Scheme Code	Car	Bus	MODE Train	Walk
A25	-1.1	-0.1	2.4	0.6
A50	-1.6	3.5	1.9	0.8
A100	-2.8	8.4	2.0	1.6
B50	-0.7	-1.4	2.4	0.2
B100	-1.2	2.1	2.0	0.2
B200	-2.0	5.8	2.0	0.5
C200	-0.8	-0.7	1.9	0.3
C500	-1.3	1.9	1.6	0.3
C600	-1.4	2.0	1.6	0.3
C800	-1.6	2.7	1.6	0.2
D25	-1.2	0.4	2.4	0.6
D37.5	-1.7	3.0	2.2	0.8
D50	-2.2	5.1	2.2	1.1
D75	-3.1	8.7	2.3	1.6
D100	-3.9	11.4	2.5	2.2

3.8 The changes to public transport trips are less straightforward. They show an increase in bus use and a small reduction in train use in the morning peak, and the reverse effect in the evening peak. The morning peak results could conceivably be explained by significant improvements in bus services attracting passengers from rail, but the evening peak results cannot be explained in this way, and require further exploration.

3.9 The changes by user type in Table 3 show some interesting distinctions. For all the non car owner categories, the percentage reduction in car use is greater than for car owners. This is partly because their underlying car use is lower, although it is interesting that even these three groups have greater use of cars than of other modes. The non car owners are also more likely to switch to bus use, and are the only groups which reduce their train use. Between the income groups the differences are quite small, reflecting the fairly small differences in values of time, but they are in the right direction, with low income users more sensitive than high income ones.

Changes in Trip-Kilometres

3.10 Tables 4 and 5 show information similar to Tables 2 and 3, but for trip-kilometres. Walk is omitted, since trip kilometre information is not available.

3.11 The results are generally similar to those summarised for Tables 2 and 3 above. However, the reduction in trip-kilometres for cars is substantially greater than for trips, and this is reflected in the relative increases of trip-kilometres and trips for public transport. This is not the expected outcome, since cordon charges are likely to impact more severely on shorter journeys across the cordon than on longer ones, and would thus be expected to reduce trips more rapidly than trip-kilometres.

Table 4: Percentage change to trip kilometres for all segments by mode and time period

Time Period = T1 (morning peak)

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	-12.6	16.5	0.3
A50	-9.1	24.3	0.1
A100	-14.2	36.5	0.5
B50	-5.9	15.5	0.2
B100	-9.7	23.9	0.3
B200	-14.7	33.8	0.8
C200	-2.3	12.5	-0.3
C500	-4.4	17.0	-0.3
C600	-4.5	17.7	-0.1
C800	-5.5	19.6	0
D25	-4.5	14.2	0.3
D37.5	-6.0	18.2	0.3
D50	-7.2	21.1	0.6
D75	-9.5	26.7	0.9
D100	-11.3	31.1	1.4

Time Period = T2 (inter peak)

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	10.7	7.8	3.9
A50	1.5	8.8	4.5
A100	2.8	8.7	6.0
B50	2.1	5.7	4.0
B100	2.9	6.1	4.7
B200	3.8	5.8	6.0
C200	-1.2	12.9	2.3
C500	-2.7	16.8	3.3
C600	-2.5	16.9	3.4
C800	-3.6	18.0	3.5
D25	-2.1	13.8	3.5
D37.5	-3.6	17.1	3.8
D50	-5.1	19.7	4.1
D75	-6.8	24.5	4.8
D100	-8.7	28.2	5.5

Time Period = T3 (evening peak)

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	-20.3	-28.2	6.7
A50	-12.8	-22.1	6.3
A100	-18.5	-12.4	6.5
B50	-9.8	-28.9	6.5
B100	-13.7	-22.5	6.5
B200	-18.2	-14.8	6.8
C200	-7.3	-31.1	5.6
C500	-8.9	-27.6	5.9
C600	-9.8	-25.8	6.0
C800	-9.5	-25.6	6.1
D25	-8.6	-30.6	6.6
D37.5	-9.6	-27.8	6.7
D50	-10.6	-25.7	6.9
D75	-13.3	-22.1	7.3
D100	-14.7	-19.3	7.8

Time Period = All day

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	-5.8	-3.1	3.4
A50	-6.0	1.3	3.2
A100	-8.8	7.7	3.8
B50	-3.9	-4.5	3.3
B100	-5.9	0	3.5
B200	-8.4	5.0	4.0
C200	-3.6	-3.1	2.6
C500	-5.2	0.8	2.7
C600	-5.4	1.6	2.8
C800	-6.0	2.6	2.9
D25	-4.9	-2.2	3.3
D37.5	-6.2	1.0	3.4
D50	-7.5	3.6	3.6
D75	-9.7	8.1	4.0
D100	-11.3	11.7	4.5

Table 5: Percentage change in trip kilometres by mode and segment all day

Segment = CO1 (no car, low income)

	MODE		
Scheme Code	**Car**	**Bus**	**Train**
A25	-8.9	0.9	2.8
A50	-13.2	3.8	2.9
A100	-18.4	7.3	3.0
B50	-6.4	-0.3	2.8
B100	-10.2	2.3	2.7
B200	-15.0	5.2	3.0
C200	-11.2	2.6	2.7
C500	-15.5	6.1	2.7
C600	-15.7	6.8	2.5
C800	-15.7	7.4	2.3
D25	-10.9	3.2	2.4
D37.5	-14.6	5.8	2.4
D50	-17.6	8.0	2.5
D75	-22.0	11.6	2.4
D100	-24.9	14.2	2.2

Segment = CO2 (no car, medium income)

	MODE		
Scheme Code	**Car**	**Bus**	**Train**
A25	-9.8	0.3	2.5
A50	-11.1	4.7	1.8
A100	-16.1	10.3	1.5
B50	-6.2	-0.9	2.3
B100	-9.7	3.2	2.0
B200	-14.1	7.7	1.8
C200	-7.7	1.3	1.8
C500	-11.1	5.5	1.5
C600	-11.1	6.3	1.5
C800	-11.2	7.3	1.3
D25	-8.4	1.6	2.1
D37.5	-11.2	4.7	1.9
D50	-13.6	7.1	1.9
D75	-17.4	11.1	1.7
D100	-19.9	14.2	1.6

Segment = CO3 (no car, high income)

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	-9.2	0.4	2.2
A50	-9.9	5.2	1.3
A100	-14.9	11.4	1.0
B50	-5.7	-0.9	2.0
B100	-9.0	3.8	1.6
B200	-13.5	8.8	1.5
C200	-6.7	1.1	1.5
C500	-10.3	5.6	1.2
C600	-10.5	6.5	1.2
C800	-10.9	7.8	1.1
D25	-7.4	1.3	1.8
D37.5	-9.8	4.4	1.6
D50	-11.9	6.9	1.5
D75	-15.5	11.0	1.3
D100	-18.0	14.2	1.3

Segment = C11 (car, low income)

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	-5.8	-4.2	4.3
A50	-6.2	0.3	4.6
A100	-8.6	6.9	5.4
B50	-4.2	-5.7	4.2
B100	-6.0	-1.1	4.7
B200	-8.1	4.0	5.5
C200	-3.5	-4.8	3.3
C500	-4.4	-1.3	3.4
C600	-4.6	-0.5	3.6
C800	-4.9	0.3	3.7
D25	-5.2	-3.1	4.4
D37.5	-6.6	0.4	4.8
D50	-7.9	3.2	5.3
D75	-10.0	8.4	6.1
D100	-11.7	12.6	6.8

Segment = C12 (car, medium income)

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	-5.9	-5.3	4.0
A50	-6.0	-0.5	4.0
A100	-8.6	6.8	4.8
B50	-4.2	-6.8	3.9
B100	-6.1	-1.8	4.3
B200	-8.5	4.0	5.0
C200	-3.2	-6.3	3.0
C500	-4.3	-2.6	3.1
C600	-4.5	-1.8	3.3
C800	-5.0	-0.8	3.4
D25	-4.8	-4.8	3.9
D37.5	-6.1	-1.4	4.2
D50	-7.3	1.4	4.6
D75	-9.4	6.3	5.2
D100	-11.0	10.3	5.8

Segment = C13 (car, high income)

		MODE	
Scheme Code	**Car**	**Bus**	**Train**
A25	-4.4	-6.1	3.1
A50	-4.2	-1.3	3.0
A100	-6.4	5.8	3.6
B50	-2.8	-7.5	3.0
B100	-4.4	-2.6	3.2
B200	-6.5	3.2	3.9
C200	-2.6	-6.6	2.6
C500	-4.1	-2.5	2.8
C600	-4.5	-1.6	3.0
C800	-5.5	-0.4	3.2
D25	-3.4	-5.7	3.0
D37.5	-4.3	-2.4	3.1
D50	-5.3	0.2	3.3
D75	-7.0	4.9	3.8
D100	-8.4	8.7	4.3

Changes in Patterns of Movement

3.12 Table 6 shows the modal shares for all day trips to central London for each of the tests. Table 7 shows similar information for trip-km, excluding the walk mode for which distance is not recorded.

3.13 The optimum charges have the greatest impact with Structure C, which reduces the car share from 12.2% to 7.0% and with Structure D, which produces a similar reduction. In all cases the largest increase is for bus trips; in all but Structure C rail use is scarcely affected. The pattern is similar for trip-kilometres, with the exception that Structure C has a markedly greater impact than Structure D.

3.14 It is also possible to compare the results for Structure A with those obtained from the aggregate model which are summarised in Annex A (LPAC, 1992). All the results are consistent to within 0.6%.

Table 6: Mode split for trips all day to Central London (%)

	Car	Bus	Train	Walk
No Charging*	12.2	5.3	40.4	42.1
A25	11.2	7.2	39.2	42.4
A50	9.5	8.1	39.0	43.4
A100	7.5	9.1	38.9	44.5
B50	11.4	7.0	39.6	42.0
B100	10.5	7.8	39.5	42.2
B200	9.3	8.6	39.5	42.6
C200	9.7	7.7	39.1	43.5
C500	7.5	8.9	39.6	44.0
C600	7.0	9.2	39.9	44.0
C800	6.4	9.7	40.4	43.6
D25	10.8	7.4	39.2	42.7
D37.5	10.2	7.8	39.0	43.0
D50	9.3	8.3	39.0	43.5
D75	8.1	8.9	38.9	44.2
D100	7.3	9.4	38.8	44.5

* LPAC Strategy without road pricing

Table 7: Mode split for trip km all day to Central London (%)

	Car	Bus	Train
No Charging*	17.4	5.8	76.8
A25	15.8	8.1	76.1
A50	13.5	9.3	77.1
A100	10.6	10.9	78.5
B50	15.5	7.9	76.7
B100	13.7	9.0	77.3
B200	11.5	10.3	78.3
C200	14.0	8.8	77.2
C500	9.8	10.4	79.8
C600	8.7	10.8	80.5
C800	7.0	11.4	81.6
D25	15.2	8.3	76.5
D37.5	14.4	9.0	76.6
D50	13.1	9.6	77.3
D75	11.2	10.6	78.3
D100	10.0	11.3	78.7

* LPAC Strategy without road pricing

Changes in Traffic Flow

3.15 Table 8 shows the percentage change in flows (in vehicle-km) as compared with the LPAC Preferred Strategy for five movement types and three time periods. The movement of types have been defined as follows:-

Central movements within zone 1 (figure 1);
Inner Radial: all radial movements within zones 2-5 (figure 1);
Inner Orbital: all orbital movements within zones 2-5;
Outer Radial: all radial movments within zones 6-13 (figure 1);
Outer Orbital: all orbital movement within zones 6-13.

Table 8: Percentage change in flows by time period

Time Period = 1

	AREA				
Scheme Code	**Central**	**Inner Radial**	**Inner Orbital**	**Outer Radial**	**Outer Orbital**
A25	-19.8	-17.6	-2.1	-5.3	-15.8
A50	-29.7	-27.9	-7.8	-6.6	4.3
A100	-38.7	-41.4	-10.4	-10.5	5.4
B50	-19.4	-19.3	-0.9	-4.8	2.9
B100	-27.7	-30.6	-3.6	-8.2	4.5
B200	-34.3	-42.8	-11.1	-11.8	4.9
C200	-26.0	-11.7	7.1	-0.5	3.7
C500	-36.3	-14.1	8.0	-0.8	4.0
C600	-38.8	-14.3	8.6	-0.8	3.8
C800	-43.0	-16.3	8.9	-1.3	2.3
D25	-20.2	-14.3	1.0	-5.5	2.0
D37.5	-23.4	-17.2	-0.6	-7.6	1.7
D50	-27.2	-21.7	-2.6	-9.2	3.2
D75	-32.0	-27.6	-6.7	-13.0	4.0
D100	-34.4	-31.7	-10.4	-15.3	4.7

Time Period = 2

	AREA				
Scheme Code	**Central**	**Inner Radial**	**Inner Orbital**	**Outer Radial**	**Outer Orbital**
A25	-11.1	-3.8	7.3	-0.8	14.8
A50	-17.2	-3.6	9.6	0.4	6.4
A100	-22.2	-0.5	12.4	2.9	3.8
B50	-7.3	-1.0	5.2	0.5	2.7
B100	-12.2	-0.4	8.1	1.4	3.6
B200	-33.1	0.5	10.2	2.0	3.9
C200	-21.3	-11.3	7.1	-0.5	4.1
C500	-31.4	-16.5	8.3	-2.1	2.5
C600	-33.5	-17.3	8.7	-4.6	3.3
C800	-36.9	-18.4	9.7	-5.0	2.2
D25	-15.8	-13.0	1.4	-4.1	3.5
D37.5	-19.5	-17.3	-0.4	-5.9	4.1
D50	-23.1	-19.7	-2.5	-7.4	3.6
D75	-28.2	-25.0	-6.9	-9.8	6.5
D100	-31.3	-30.1	-10.7	-11.7	6.0

Time Period = 3

Scheme Code	Central	Inner Radial	Inner Orbital	Outer Radial	Outer Orbital
			AREA		
A25	-17.9	-17.7	-3.2	-11.5	-19.5
A50	-29.3	-29.9	-7.3	-15.3	-4.9
A100	-40.5	-46.7	-18.0	-14.8	-18.8
B50	-17.4	-16.8	-2.6	-16.8	-21.1
B100	-26.6	-33.3	-5.0	-15.9	-19.5
B200	-34.9	-43.2	-11.8	-23.8	-6.6
C200	-24.7	-12.7	4.6	-5.5	-6.0
C500	-37.0	-17.9	5.4	-6.2	-6.9
C600	-39.9	-18.2	5.9	-6.3	-9.5
C800	-44.8	-19.0	6.3	-6.8	-4.9
D25	-17.9	-14.1	-0.9	-8.3	-7.5
D37.5	-21.4	-18.0	-2.0	-9.9	-7.8
D50	-25.4	-22.2	-3.5	-11.3	-6.0
D75	-31.2	-28.3	-6.9	-14.0	-10.1
D100	-34.1	-33.0	-10.6	-16.2	-8.7

3.16 These results are broadly as expected, except for test A25, which had not fully converged. In the morning peak, the optimum charge levels reduce flows in central London by around 30%, although the reduction is higher for Structure C. This optimum flow reduction is reasonably consistent with earlier studies. For Structure C, which only has a cordon around central London, inner London radial flows fall by 8%. Effects in outer London are small, but there is a 4% increase in orbital flows, which is surprising, but may be a response to reduced congestion. For Structures A, B and D which extend to inner London, radial flows there fall by 30%, and orbital flows, which are less affected, by around 5% but by 10% for Structure D. Outer radial flows fall by 7% (15% for Structure D) and outer orbital flows again rise by 4%.

3.17 The off peak changes are, as expected, smaller for Structures A and B, which have peak only charges in inner London. Changes in inner and outer radial flows are small, but there is a substantial increase, of around 8%, in inner orbital flows generated by the off peak cordon around central London. The impacts of Structures C and D are very similar to those in the peak.

3.18 Evening peak changes are reasonably similar to those in the morning peak, except for a reduction in outer radial and orbital flows, the reasons for which are not immediately clear.

3.19 It is also possible to compare the results for Structure A with those obtained from the aggregate model, which are summarised in Annex A (LPAC, 1992). All but one of the peak results (A25, time period 2) are consistent to within 1.0%. This result and those for the interpeak are between 1.4% and 2.6% higher than for the aggregate model.

Changes in Traffic Speed

3.20 Table 9 shows the percentage change in speed, as compared with the LPAC Preferred Strategy, for the same five movement types and three time periods.

Table 9: Percentage change in speed by time period

Time Period = T1

			AREA		
Scheme Code	**Central**	**Inner Radial**	**Inner Orbital**	**Outer Radial**	**Outer Orbital**
A25	13.0	28.8	2.6	3.5	12.1
A50	19.5	32.8	6.0	8.0	-2.2
A100	25.5	56.8	13.5	10.7	-3.8
B50	12.7	20.6	2.5	5.6	-1.8
B100	17.5	30.7	4.8	9.1	-2.8
B200	22.6	41.6	10.3	12.4	-4.0
C200	17.0	15.1	-3.0	1.3	-1.0
C500	23.9	17.9	-3.6	1.5	-1.3
C600	25.5	20.9	-4.1	1.6	-1.5
C800	34.5	25.1	-5.2	1.9	-3.0
D25	16.2	14.0	-0.8	2.2	-2.6
D37.5	18.7	18.7	0.5	3.1	-2.2
D50	21.8	22.1	1.8	3.8	-4.1
D75	25.6	26.7	4.8	5.1	-5.2
D100	27.6	31.2	7.5	6.2	-6.1

Time Period = T2

			AREA		
Scheme Code	**Central**	**Inner Radial**	**Inner Orbital**	**Outer Radial**	**Outer Orbital**
A25	8.5	6.2	-2.9	-0.4	-12.2
A50	13.2	6.6	-4.5	1.9	-1.3
A100	17.0	5.4	-6.4	0.0	-2.9
B50	5.0	4.0	-1.5	0.8	-0.6
B100	9.3	4.5	-3.5	0.0	-2.6
B200	12.8	2.4	-4.9	-0.4	-1.9
C200	16.3	12.7	-3.0	1.6	-1.3
C500	24.2	15.8	-3.6	1.6	-1.5
C600	25.7	16.4	-3.9	1.6	-2.3
C800	34.2	18.6	-4.3	2.2	-4.0
D25	24.3	8.1	-0.9	1.7	-4.2
D37.5	18.0	12.0	0.3	2.5	-4.8
D50	21.4	14.1	1.7	3.1	-4.2
D75	26.1	18.3	4.6	4.2	-5.6
D100	29.0	22.0	7.1	5.0	-7.0

Time Period = T3

			AREA		
Scheme Code	**Central**	**Inner Radial**	**Inner Orbital**	**Outer Radial**	**Outer Orbital**
A25	15.5	11.2	-10.6	-14.3	41.6
A50	25.3	21.3	-7.8	-16.2	-22.2
A100	35.1	32.2	5.8	-16.5	-18.8
B50	15.1	10.1	-11.0	-15.3	-21.1
B100	23.0	28.3	-9.3	-15.4	-19.5
B200	30.2	43.2	-4.8	-13.8	-20.2
C200	21.4	5.3	-15.9	-20.2	-20.8
C500	32.0	12.3	-16.4	-20.3	-19.8
C600	34.5	16.8	-16.7	-22.1	-16.6
C800	38.8	17.3	-17.0	-20.3	-22.1
D25	15.5	2.3	-12.1	-15.0	-19.0
D37.5	18.5	5.6	-11.4	-16.3	-18.7
D50	22.2	10.1	-10.4	-17.2	-20.8
D75	27.0	16.3	-8.1	-16.3	-16.0
D100	29.5	19.2	-5.9	-15.7	-17.5

3.21 Once again, the results are broadly as expected, except for test A25, which had not fully converged. The changes in speed are consistent with the changes in flow with the notable exception of outer area speeds in the evening peak. It is noticeable that the speed increases per unit reduction in flow are much lower in central London.

3.22 Overall, the results suggest, for optimal charge levels, speed increases of around 20% for central London and 30% for inner London radials for Structures A and B, 25% and 15% respectively for Structure C and 30% and 25% respectively for Structure D. For Structures C and D the off peak effects are similar; for Structures A and B central area speeds rise by around 10% and inner area speeds by around 5%. For all other movements, apart from the anomalous evening peak speed changes in outer London, the changes are small.

3.23 It is also possible to compare the results for Structure A with those obtained from the aggregate model, which are summarised in Annex A (LPAC, 1992). The greatest discrepancies occur in the morning peak, where the changes are between 1.6% and 4.4% higher than for the aggregate model. For the evening peak, the changes are between 0.4% and 1.7% lower. The inter peak results are all consistent to within 1.0%.

4 Summary of Results for Structures A to C

4.1 Data on trips and trip-kilometres by mode, time period and user category; trips specifically to central London; and flows and speeds by time period and area have been generated for each of the three charging structures tested in WP 400. The software to provide this data also generates data on accessibility and parking, which have not been analysed.

4.2 The data on trips, flows and speeds has been generated for ten tests, representing the optimum for each of three road pricing structures, and charge levels above and below the optimum. In each case the results have been compared with the LPAC Preferred Strategy without road pricing, for conditions in 2001.

4.3 In all but three respects the results are broadly as expected, with greater impacts for higher charge levels and for those charging structures which extend to inner London. The first significant inconsistency is a switch away from buses and to rail in the evening peak. The second is the greater impact on trip-kilometres than on trips. The third concerns the reduction in both flow and speed in the evening peak in outer London. It will be necessary to check the model to investigate the causes of these anomalies, but it has not been possible to do this within the time available.

4.4 These anomalies apart, the results suggest that the distributional effects of road pricing, predicted earlier (Fowkes et al, 1993) are supportable. They also demonstrate that charging structures which extend to inner London are likely to be more effective, by reducing congestion in inner London and (to a limited extent) in outer London, and by avoiding increased orbital traffic in inner London. On this basis it was decided to test a fourth charging structure, Structure D, which extended Structure A to include off peak charging on the two outer cordons, thus potentially increasing the benefits of charging in inner London.

5 Comparison of Economic Performance

5.1 Section 3 has presented the changes in travel and in speeds predicted for the four changing structures. The earlier ESRC - funded study had concentrated on the economic and financial performance of Structures A-C. This section compares these results with those for Structure D.

5.2 Changes in benefits and in costs can arise in a number of ways as indicated in Table 10, which is taken from the earlier report (Fowkes et al, 1993). It is the complex interactions between these which are assessed and summarised in the economic evaluation tables.

Table 10: Main expected effects of road pricing

1.	Payments of charges by drivers	(-)
2.	Receipts of charges by local government	(+)
3.	Time savings by continuing drivers	(+)
4.	Time savings for buses	(+)
5.	Increased waiting times if buses/trains become overcrowded	(-)
6.	Fares paid by ex-drivers	(-)
7.	Fares received from new travellers	(+)
8.	Car operating cost savings by ex-drivers	(+)
9.	Fuel tax losses by UK government	(-)
10.	Operating cost savings for buses due to less congestion	(+)
11.	Operating cost increase for public transport due to extra traffic	(-)
12.	Savings in parking charges by ex-drivers	(+)
13.	Losses in parking charge receipts by local government	(-)

Note: time changes for transferring drivers could be (+) or (-).

5.3 Tables 11-14 show the distribution of benefits and disbenefits by income group for each of the charging structures. Tables 11-13 are drawn from the earlier report (Fowkes et al, 1993) and include some less optimal charge levels for which results were not presented in Section 3. As already noted in the earlier report, all tests result in a net disbenefit for households; that is, the out of pocket costs of road pricing exceed the travel time savings gained. It should be noted that the money paid for road pricing represents a transfer payment to local government, and does not therefore contribute to the overall net benefit.

5.4 Tables 15-18 show the percentage distribution of these household disbenefits among households, and compare them with the distributions of households, people and trips. Tables 15-17 are drawn from the earlier report.

5.5 It is immediately apparent from Table 1 that Structure D achieves benefits far in excess of the other Structures. The optimal charge has not been firmly identified but appears to be at around 100p, and at that level the benefits are £243.9m, some six times the optimum benefit for Structure A. It seems surprising that the benefits from extending charging to the off peak in Inner London should be so great, and that the optimum charge for extension to the off peak should be higher than that for peak period charging.

5.6 Table 14 (Structure D) sheds more light on this, particularly when compared with Table 11 (Structure A). The largest absolute differences are in the freight and local government benefits. At a charge of 50p (the optimum for Structure A) the freight benefits are increased from £19.9m (A) to £62.6m (D), while those for local government rise from £150.7m (A) to £262.9m (D). At 100p the increases are freight: £31.7m (A) to £103.7m(D); local government: £200.2m (A) to £392.7m (D). The 75% and 100% increases in the latter are explained by the increase in the number of trips affected by a charge. The threefold increases in freight benefits are a reflection of the larger level of freight activity off peak in inner London, and the fact that freight is not charged in these tests.

5.7 Table 18 presents a distribution of disbenefits for Structure D very similar to those in Table 15 for Structure A and to the distribution of trip making. The distribution is also little affected by the level of the charge. There is no evidence of the regressive effect of charging demonstrated in Table 17 for Structure C and this appears therefore to be a feature of limitation of the charges to central London, rather than of extension of charges to the off peak.

Table 11: Benefits from adding road pricing to the LPAC Preferred Strategy, using the LPAC charging structure (denoted A). Figures in £m for 2001.

Code	A25	A50	A100
Crossing Charge	25p	50p	100p
Household Types			
CO1	-6.7	-10.7	-15.0
CO2	-4.2	-7.5	-12.4
CO3	-4.7	-9.2	-17.0
C11	-17.7	-28.5	-42.7
C12	-43.8	-72.6	-112.1
C13	-24.1	-43.1	-73.3
Households	-101.3	-171.5	-272.5
Freight	2.4	19.9	31.7
Operators	31.8	44.7	65.6
Local Government	101.8	150.7	200.2
UK Government	-4.1	-5.4	-5.7
Total	30.7	38.4	19.0

Table 12: Benefits from adding road pricing to the LPAC Preferred Strategy, using the 3-cordon charging structure (denoted B). Figures for 2001 in £M p.a.

Code	B25	B50	B100	B1500	B200
Crossing Charge	25p	50p	100p	150p	200p
Household Types					
C01	-3.6	-5.0	-7.6	-9.7	-11.3
C02	-2.0	-2.5	-4.1	-5.7	-6.9
C03	-2.0	-2.2	-4.1	-6.4	-8.1
C11	-10.0	-14.4	-21.4	-25.8	-28.1
C12	-23.6	-34.3	-52.2	-64.1	-70.0
C13	-12.2	-16.8	-27.8	-37.4	-43.2
Households	-53.3	-75.2	-117.1	-149.1	-167.6
Freight	-24.7	-7.6	6.9	15.6	20.2
Operators	23.4	31.3	43.2	53.8	60.4
Local Government	50.4	79.4	100.4	109.7	103.0
UK Government	-1.4	-3.2	-4.0	-4.3	-4.4
TOTAL	-5.5	24.8	29.3	25.6	11.7

Table 13: Benefits from adding road pricing to the LPAC Preferred Strategy, using only the central (ie "innermost") cordon (denoted C). Figures are net benefits in £M for 2001.

Code	C100	C200	C400	C500	C600	C800
Crossing Charge	100p	200p	400p	500p	600p	800p
Household Types						
C01	-6.1	-9.4	-12.1	-12.1	-12.0	-11.4
C02	-3.3	-5.8	-7.7	-7.2	-6.5	-4.7
C03	-3.8	-7.1	-10.4	-9.5	-8.4	-5.1
C11	-9.3	-11.7	-11.9	-11.4	-11.4	-10.3
C12	-20.6	-24.8	-19.9	-16.4	-14.8	-9.6
C13	-12.1	-15.4	-11.2	-7.7	-6.2	-2.8
Households	-55.2	-74.2	-73.1	-64.2	-59.2	-43.8
Freight	1.9	18.1	37.6	40.9	41.8	52.4
Operators	22.3	27.1	34.5	36.5	40.0	43.2
Local Government	38.0	38.5	26.0	12.9	-2.1	-46.8
UK Government	-3.5	-4.3	-5.5	-5.8	-5.9	-7.2
TOTAL	3.6	5.1	19.6	20.4	14.5	-2.1

Table 14: Benefits from adding road pricing to the LPAC Preferred Strategy, using the LPAC charging structure, extended to the off peak period in inner London (denoted D). Figures in £m for 2001.

Code	D25	D37.5	D50	D75	D100
Crossing charge	25p	37.5p	50p	75p	100p
Household types					
CO1	-7.4	-9.7	-11.6	-14.1	-15.5
CO2	-5.1	-7.0	-8.9	-11.8	-14.0
CO3	-6.0	-8.6	-11.3	-15.7	-19.3
C11	-21.2	-28.2	-34.5	-44.6	-52.4
C12	-52.4	-70.4	-87.0	-113.6	-133.9
C13	-29.3	-40.4	-51.5	-69.8	-84.7
Households	-121.4	-164.4	-204.6	-269.8	-319.8
Freight	26.3	45.5	62.6	85.2	103.7
Operators	36.9	45.2	54.2	69.2	83.0
Local Government	163.9	232.2	262.9	324.5	392.7
UK Government	-6.7	-9.0	-10.4	-12.9	-15.7
Total	99.0	149.5	164.7	197.0	243.9

Table 15: Distributional implications of the results of Table 11

Household type	% of Households	% of Persons	% of Trips	% of Net Disbenefits A25	A50	A100
C01	18	10	6	7	6	6
C02	7	6	4	4	4	5
C03	7	6	6	5	5	6
C11	18	16	15	17	17	16
C12	30	35	38	43	42	41
C13	20	27	31	24	25	27

Table 16: Distributional implications of the results of Table 12

Household Type	% of Households	% of Persons	% of Trips	% of Net Disbenefits B25	B50	B100	B150	B200
C01	18	10	6	7	7	7	7	7
C02	7	6	4	4	3	4	4	4
C03	7	6	6	4	3	4	4	5
C11	18	16	15	19	19	18	17	16
C12	30	35	38	44	46	45	43	42
C13	20	27	31	23	22	24	25	26

Table 17: Distributional implications of the results of Table 13

Household Type	% of Households	% of Persons	% of Trips	% of Net Disbenefits C100	C200	C400	C500	C600	C800
C01	18	10	6	11	13	17	19	20	26
C02	7	6	4	6	8	11	11	11	11
C03	7	6	6	7	10	14	15	14	12
C11	18	16	15	17	16	16	18	19	24
C12	30	35	38	37	34	27	26	25	22
C13	20	27	31	22	21	15	12	11	6

Table 18: Distributional implications of the results of Table 14

Household Type	% of Households	% of Persons	% of Trips	% of Net Disbenefits D25	D37.5	D50	D75	D100
C01	18	10	6	6	6	6	5	5
C02	7	6	4	4	4	4	4	4
CO3	7	6	6	5	5	6	6	6
C11	18	16	15	18	17	17	17	16
C12	30	35	38	43	43	42	42	42
C13	20	27	31	24	25	25	26	27

6 Summary of Performance of Structure D

6.1 Table 19 summarises the net benefits for the optimal charge runs for the four charging structures. It demonstrates clearly the very much greater net benefit obtained by Structure D than by any other structure. The principal differences are a substantially greater transfer from households to local government through road pricing charges; an increase in the time benefits to households (which is hidden by the effect of the money transfer); and an increase in the benefits to freight.

Table 19: Comparison of the net benefits of optimal charge runs for the four charging structures. Figures in £M for 2001.

CODE	A50	B100	C500	D100
Household types				
C01	-10.7	-7.6	-12.1	-15.5
C02	-7.5	-4.1	-7.2	-14.0
C03	-9.2	-4.1	-9.5	-19.3
C04	-28.5	-21.4	-11.4	-52.4
C05	-72.6	-52.2	-16.4	-133.9
C06	-43.1	-27.8	-7.7	-84.7
Households	-171.5	-117.1	-64.2	-319.8
Freight	19.9	6.9	40.9	103.7
Operators	44.7	43.2	36.5	83.0
Local Governments	150.7	100.4	12.9	392.7
UK Governments	-5.4	-4.0	-5.8	-15.7
TOTAL	38.4	29.3	20.4	243.9

In addition to achieving substantially higher benefits, Structure D also achieves larger reductions in overall travel and flows, and greater increases in speed. Table 20 compares the effects of structures A and D at charges of 50p and 100p.

Table 20: Comparison of the impact of Structures A and D at charges of 50p and 100p.

Charge	**50p**		**100p**	
Structure	**A**	**D**	**A**	**D**
Total car trips	-2.6%	-3.5%	-4.1%	-5.8%
Peak flows, centre	-29.7%	-27.2%	-38.7%	-34.4%
Peak flows, inner radial	-27.9%	-21.7%	-41.4%	-31.7%
Peak speeds, centre	-17.2%	-23.1%	-22.2%	-31.3%
Peak speeds, inner radial	-3.6%	-19.7%	-0.5%	-30.1%
Off peak flows, centre	+19.5%	+21.8%	+25.5%	+27.6%
Off peak flows, inner radial	+32.8%	+22.1%	-56.8%	+31.2%
Off peak speeds, centre	+13.2%	+21.4%	+17.0%	+29.0%
Off peak speeds, inner radial	+6.6%	+14.1%	+5.4%	+22.0%

6.3 The 40% greater reduction in total car trips achieved by Structure D is reflected in substantially greater improvements in travel conditions in the off peak in both central and inner London. Improvements in peak conditions are not as great, since Structure D does not permit transfer to the off peak, but the improvements are still substantial.

7 Conclusions

7.1 This project has provided the software to enable the impacts of strategies, when tested in the disaggregate version of the START model, to be presented in terms of changes in trips, trip-kilometres, flows and speeds, as well as in accessibility and parking access.

7.2 Further investigation of the results of earlier tests of three road pricing charging structures has revealed three anomalies in the model results which deserve further investigation:

- a reduction in bus use in the evening peak;
- a greater change in trip-kilometres than in trips; and
- a reduction in both flows and speeds in the outer area in the evening peak.

7.3 With these exceptions, the model results appear to be acceptable and are sufficiently robust to support the conclusions from the earlier study of the distributional impact of road pricing (Fowkes et al, 1993).

7.4 This project has included the testing of a fourth charging structure, Structure D, which has extended the LPAC charging structure to the off peak in inner London. The results indicate that this charging structure achieves far higher benefits than the LPAC structure, particularly as a result of the improvement in off peak conditions in both central and inner London, and the resultant benefit to freight operators. Extension of the charges to the off peak has no greater adverse impact on low income households; overall, the impacts on different income groups are largely neutral.

8 References

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APPENDIX

Summary results for Structure A with the aggregate model

The following table summarises the effect of Structure A predicted by the aggregate START model at three charging levels on modal share to Central London, and flows and speeds in Central London, when compared with the LPAC Preferred Strategy without road pricing.

Scheme Code	A0	A25	A50	A100
(a) Mode share for trips to Central London all day (%)				
Car	11.9	10.6	9.3	7.2
Bus	5.5	7.3	8.1	9.2
Rail	40.1	39.1	38.8	38.7
Walk	42.5	43.1	43.8	44.9
(b) Change in flow in Central Area (%)				
AM peak	-	-19.8	-28.7	-38.2
Off peak	-	-9.7	-15.0	-19.6
PM peak	-	-19.9	-28.6	-39.8
(c) Change in speed in Central Area (%)				
AM peak	-	+15.6	+22.1	+29.9
Off peak	-	+8.7	+12.8	+17.9
PM peak	-	+15.1	+23.6	+33.8