TRANSPORT RESEARCH LABORATORY

Motorway tolling — modelling the impact of diversion

Prepared for Tolling and Private Finance Division, Department of the Environment, Transport and the Regions

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CONTENTS

Executive Summary

This report describes work carried out by the Transport Research Laboratory on behalf of the Tolling and Private Finance Division of the Department of Transport (now Department of the Environment, Transport and the Regions).

The introduction of motorway tolls would be expected to cause some traffic to cease use of motorways, and transfer to alternative non-tolled routes. The MCONTRM model was used to estimate the effects in the area served by the M2, M20, A2, A20 and M26 between the M25 and the Channel ports. A range of toll rates was investigated including the 1.5p/mile rate and the toll producing a 10% diversion level (2.5p/mile) at 1994 costings. Network resource costs, based on COBA9, were calculated for all cases.

The effects of tolling are very much as expected:

- some traffic is diverted from using motorways
- the amount diverting increases as tolls increase
- more traffic diverts onto rural routes than onto urban routes
- a toll of 2.5p/mile gives an average 10% diversion of traffic away from motorways
- traffic is more likely to divert if alternative routes are of good quality and not already congested.

An examination of the distribution of trips on motorways once again emphasised that a high (45%) proportion of trips were short - under 10km, and the same proportion were using only one motorway link between junctions. The effect of tolling was to cause drivers previously making longer motorway trips to reduce their motorway use, either by not using the motorway, by reducing the length of motorway used, or by breaking a single longer use of motorway into two or more shorter sections. The effect is virtually identical whether considering actual distance driven on motorways or the number of contiguous inter-junction sections used.

The behaviour of traffic was very similar when traffic demand levels were considerably increased, and the motorways were expanded by the addition of an extra lane. The cases examined suggest that a larger toll would be tolerated when the alternative routes were more congested, leading to more delays.

1 Introduction

TRL are undertaking a research project concerned with motorway tolling for the Tolling and Private Finance Division of DOT (now DETR). Previous TRL reports in this context have studied the likely effects of tolling on accident risk.

One possible consequence of the introduction of motorway tolls is the diversion of some motorway traffic from tolled roads on to the adjacent road network. This will occur as a proportion of drivers choose to reduce their perceived travel costs by avoiding tolled roads. The inevitable change in traffic patterns will lead to increased mileage on alternative routes on the all purpose roads, and possibly to a change in the length of trips on motorways. This report presents the results of using the MCONTRM model to examine the effects which the diverted traffic will inevitably have on traffic parameters in the vicinity of the motorway. In particular the increased flows on the diversion route will lead to a change in the vehicle-kilometres (veh-km) on the motorway and the all-purpose network. It also investigates the extent to which, as drivers include the cost of tolls in their consideration of route choice, the pattern of motorway trip lengths will change.

The area modelled, and the methods used to represent the effects of tolls at various rates are described in section 2, and the incorporation of cost factors from the DOT (DETR) appraisal program COBA is explained in the calculation of a generalised travel cost. The use of COBA should ensure compatibility with other DOT (DETR) work.

Section 3 examines the effects of different toll rates on the transfer of traffic movements, and the effects of a 10% transfer of traffic from the motorway.

The effects of greatly increased traffic levels are described in section 4, and the results of adding an extra lane to each carriageway of the motorway are examined, for different toll rates.

2 Methodology

2.1 Traffic network

When modelling traffic behaviour it can be instructive to design synthetic road networks which can emphasise specific aspects of interest without the results being confused or obscured by the complex interactions experienced in normal road networks. The method is useful when studying general traffic responses, and was used for part of the study of accident risks associated with fixed changes in levels of traffic using motorways. There is a risk inherent in using artificial road networks, in that irregularities in real networks may well have significant effects on traffic movements. Synthetic networks should seldom be used to make predictions about traffic routeing, where local variations in road lengths and conditions can be influential. For the purpose of this study, involving changes in routeing as drivers avoided tolled roads, it was clear that, if possible, a real network should be used. Fortunately, a suitable network with sufficient traffic data was available. The area chosen was the ‘Kent corridor’ formed by the M20, A20, M2 and A2 between the M25 and the Channel ports. An MCONTRM model of this area has been constructed for use in projects on motorway control, and considerable attention has been given to calibrating the demand data. The routes covered are shown in Figure 1. The area is suitable because it has major motorway routes with practical alternatives on trunk roads for motorists who choose to avoid tolled motorways. Urban areas are not modelled in detail, as in most cases they can be by-passed by the traffic being studied. In addition the modelling of local traffic is time consuming, and the inclusion of data relating to such traffic tends to dilute the effects being investigated. The only town which cannot be easily avoided is Maidstone, and the major routes through the town are represented in the network model. The TRL traffic assignment model MCONTRM was chosen for the purpose because it has the ability to model tolling costs and to record the routes and times taken by traffic on all the roads in the network. MCONTRM models the average behaviour of traffic assuming that drivers have a good knowledge of the network and are accustomed to prevailing traffic conditions.

The traffic data has been compiled from extensive O-D surveys. The period modelled extends from 06:00 to 22:00, for an average weekday. This covers both morning and evening peaks, and the daytime off-peak travel. The region is not particularly heavily trafficked, which allows transfer of routes without the problem of congestion on most of the non-tolled routes, except in the most urbanised areas. The traffic was treated as though composed only of passenger cars. It was decided not to include the extra complexities which might result from modelling heavy vehicles, which only form a comparatively small proportion of the traffic, of which a small proportion might change routes.

2.2 Modelling procedure

A baseline run of MCONTRM was performed with no tolling costs applied to provide a ‘normal’ situation as a basis for comparison when tolling was introduced on the motorways.

MCONTRM allows the inclusion of cost factors which can influence the route choice of vehicles. There are two costings in the program: perceived cost and resource cost. The drivers choose their route according to the perceived cost of travelling, and the actual resource costs are then calculated from the traffic assignments which result. Little information exists about how drivers allow their perception of cost to influence their choice of route, but it is clear that journey time is very much the major factor. It is assumed that drivers make their choice of route on a rational economic basis.

The traffic assignments calculated by MCONTRM assume that drivers are familiar with the concept of tolling and include it in their assessment of route choice. It is possible that, when tolls are initially introduced, there may be a reaction against them which will decrease with familiarity. Thus the figures presented here represent the behaviour of toll-acclimatised traffic.

In this series of tests perceived and resource costs have been calculated using identical coefficients, but the values of the tolls have been added to the perceived costs. This is

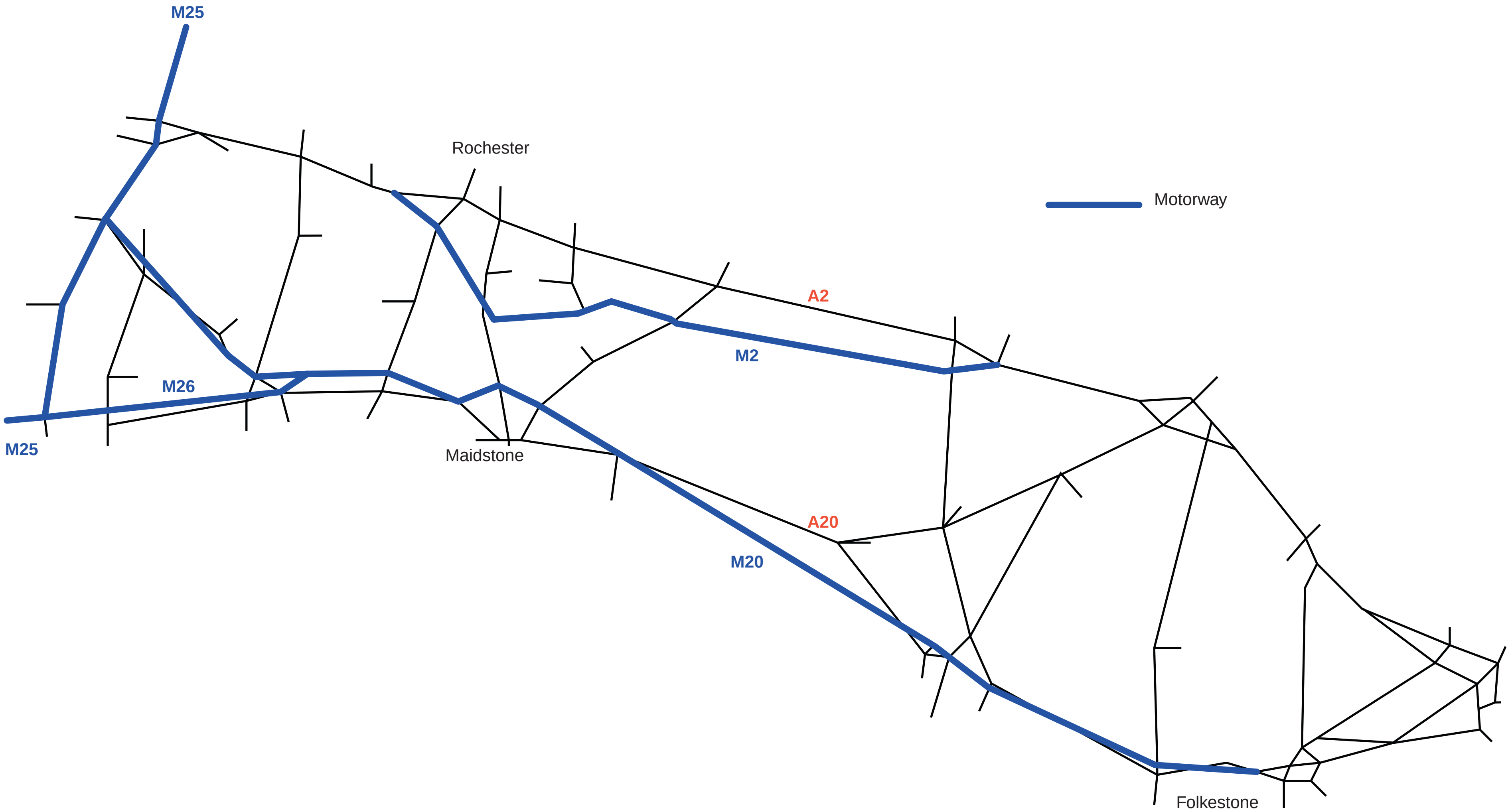

Figure 1 Link diagram of Kent corridor

partly because of lack of evidence of what form any differences should take, but also, since time is so important a factor, and one which is well understood by drivers, it is thought that any inaccurate perceptions of other factors by drivers would have little effect.

The costs are based on COBA9, as interpreted for MCONTRM as described in part 1 of the CONTRAM5 Userguides (Taylor, Leonard et al, 1989), using 1994 values.

Thus the 'resource cost' is the standard COBA resource cost, while the 'perceived cost' includes the cost of the tolls. When tolls are in operation the toll cost is included in the perceived cost, and will affect route choice.

A series of runs of MCONTRM was made with the Kent corridor model, applying different tolling costs. The results are discussed in the next section.

3 Effects of toll rates

Toll rates can be applied in MCONTRM as pence per kilometre. As rates for tolls are usually quoted in pence per mile, some of the toll rates applied may appear to be rather curious amounts - 0.625 p/km corresponding to 1p/mile, for example.

For the purpose of examining the changes in road usage, the links in the model were categorised as being motorway, rural or urban. For each category the amount of travel in vehicle-km was extracted from the data and compared with the values for the untolled situation (in the tables the numbers given are of thousands of veh-km). For simplicity tolls of 1, 1.5 and 2p/km were used, and the fractional values of 0.625p/km and 1.5625p/km, corresponding to 1p/mile and 2.5p/mile respectively were added to supply values relating to exact monetary units.

The changes in road use are plotted as percentages in Figure 2. It is obvious that as motorway traffic decreases, there is a corresponding increase on other roads.

The increase on urban roads is effectively linear, but on rural roads the rate increases as the tolls increase. This is because, in this network at least, the urban roads are closer to capacity, and traffic diverting from the motorway gains a greater benefit by using the rural rather than the urban route. Although this result is specific for this network, it is expected that similar results would be obtained wherever the alternative routes were of sufficient capacity to carry the diverted traffic without undue delays. It is, of course, frequently the case that motorways replace existing trunk routes which are still available for use, though the level of free capacity varies in different localities. In the network model used, the M20 has a good alternative in the A20, the M2 has an alternative in the A2 which is generally less attractive because it is more heavily trafficked, and the section of the M25 modelled has no effective alternative. Thus, some traffic (on the M20) can very freely move to an alternative, whereas other traffic will be more likely to encounter delays or long detours if diverted. It is believed that this mix of suitability of alternative routes is a reasonable representation of much of the motorway network.

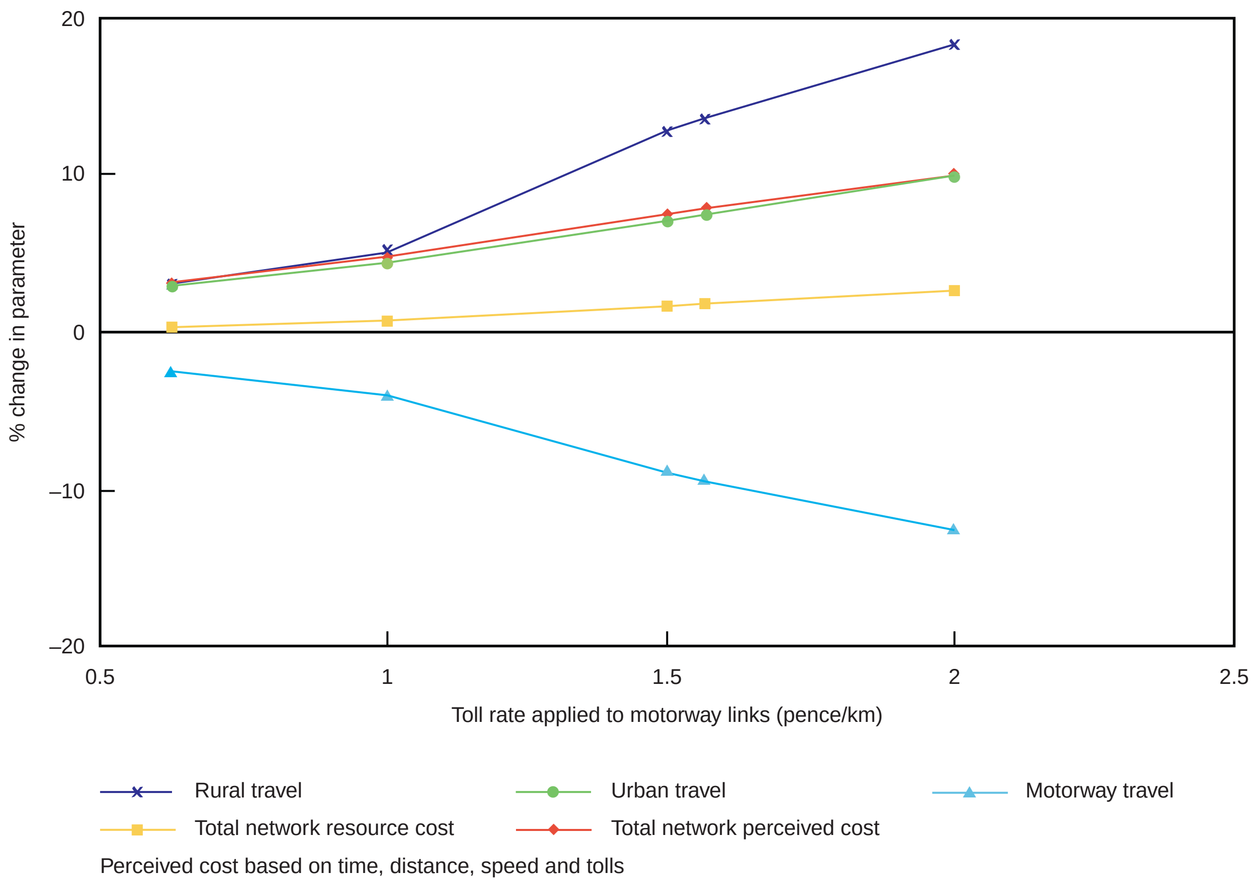

Figure 2 Kent network: change in results against motorway toll rate

It is interesting to note that, with the costings applied, the level of toll which gives a 10% movement away from the motorway is 2.5p/mile, somewhat higher than earlier estimates. This is because of the rise in road user costs, relative to the tolls, from previous estimates, eg in the Green Paper.

On the same graph are plotted the perceived and the resource costs in each case. The rise in resource costs is relatively modest, reaching a maximum of about 2.3%, while perceived costs rise by almost 10%.

The actual values for the quantities compared in the graph are given in Table 1. The vehicle-km figures are given as ‘veh Mm’ - that is, vehicle Mega metres, or thousands of kilometres. The total network journey time (TNJT) is given in vehicle hours, and the total network resource costs (TNRC) and the total network perceived costs (TNPC) are given in pounds (£).

The other factor examined is the distribution of trips which take place on motorways. It might be expected that, although some drivers might avoid paying tolls altogether, for other drivers their best choice would be to avoid tolls except where using non-motorway roads would be too costly (in terms of time, for example). The effect of such choices would be to change the distance travelled on motorways by some drivers, but not to remove them entirely from motorway travel. Special programs were written to enable the distances travelled by vehicles for each section of those journeys which used motorways to be extracted from the data for all vehicles and these have been plotted as histograms comparing the different tolling levels in Figures 3-5. The three figures show the histograms for the whole simulation period, the peak periods, and the off-peak periods respectively. The numerical values which were used to create the histograms are shown in Tables 2-4.

The first and most striking feature of the histograms is the very strong bias towards the short end of the trip length scale. In the peak plus off peak case fully 45% of trips are under 10km, and 75% under 20km, although trips of up to 100 km are possible in the network. This is a demonstration of the dominance of short trips in much of motorway travel, which is at variance with the often-held popular view that motorways are principally carrying long distance trips.

This report mainly focuses on the differences in distribution resulting from the imposition of tolls. One point to notice is the apparent increase in the number of trips on the motorway as tolls increase. This is caused by the fact that journeys which previously had one longer section of motorway driving now have two or more shorter sections on the motorway. This is reflected in the increases in short motorway trips - the columns at the left-hand end of the histogram. There is also some increase in mid-range journeys, those between 40 and 60 km, which is part of the same pattern. It would not be expected that all the transfers would be smoothly distributed, because the lengths of motorway trips is not a continuous function. The total length of a motorway trip can only alter by the length of a motorway section between two junctions, and there are only a limited number of such sections.

Another way to measure the distribution of motorway trips is to count the number of sections of motorway on a trip, where a ‘section’ of motorway is the stretch between adjacent junctions. The results are shown as histograms in Figures 6-8 for the same periods as Figures 3-5. The numerical values are given in Tables 5-7.

The results are very similar to those for trip lengths shown in Figures 3-5; that is, a noticeable increase in short trips and some decline in longer trips. However, there is a peak for trips with 6 continuous sections. This is caused by the traffic on the section of M25 modelled, which only has 6 links included in the network. The stretch of M25 has been modelled with no practical alternative routes, and so, faced with the choice between tolls and lengthy time-wasting detours, drivers are modelled as staying on the M25. Although this behaviour may not be entirely true for this section of M25, because of limitations in the model, it is reasonable for stretches of motorway with poor alternatives.

An indication of the general movement of traffic after the imposition of motorway tolls can be seen in Figures 9 and 10. These show the changes in flows between the present, untolled state and the 2.5p/mile toll producing an average 10% diversion. The two figures show the changes for half hour periods in the am peak and the pm peak respectively. The ‘warm’ colours indicate a gain in traffic, and the ‘cool’ colours show where traffic has been lost. The width of the coloured rectangles is proportional to the amount of traffic, with the colouring indicating broad bands in the traffic changes.

In the am peak case (Figure 9) it is clear that traffic has moved away from the M20, mostly to the parallel A20, except that between Maidstone and the M25 the motorway traffic has diverted northwards and joined the A2. This is partly because the A20 is a good quality road over this stretch, and also because the route avoids the M25. There is also some movement away from the M20, but not as

Table 1 Parameter variation with Toll Rate

	Tolls (p/km)					
Parameter	*0*	*0.625*	*1.0*	*1.5*	*1.5625*	*2.0*
Rural (veh Mm)	5520.4	5677.7	5787.4	6215.2	6257.9	6513.7
Urban (veh Mm)	1289.1	1326.8	1343.9	1378.4	1382.5	1414.0
Mway (veh Mm)	9317.8	9090.1	8943.4	8477.5	8429.4	8130.5
TNJT (veh hr)	209053.7	210362.2	211332.1	214530.8	214821.1	217273.2
TNRC (£)	2223307.2	2230699.2	2236225.0	2257364.0	2259234.4	2275093.8
TNPC (£)	2223307.2	2287538.2	2325665.2	2383857.2	2390962.2	2437712.2

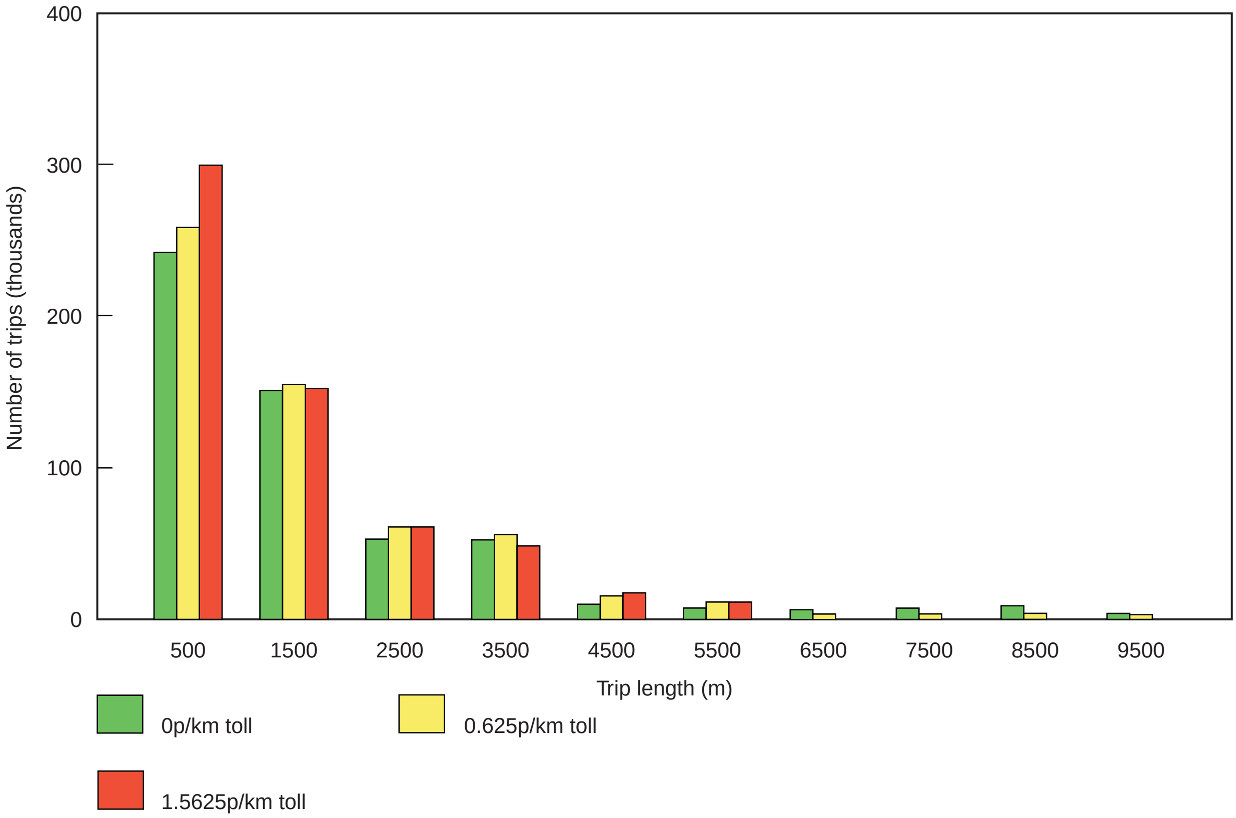

Figure 3 Motorway trip length distribution — Peak and off–peak

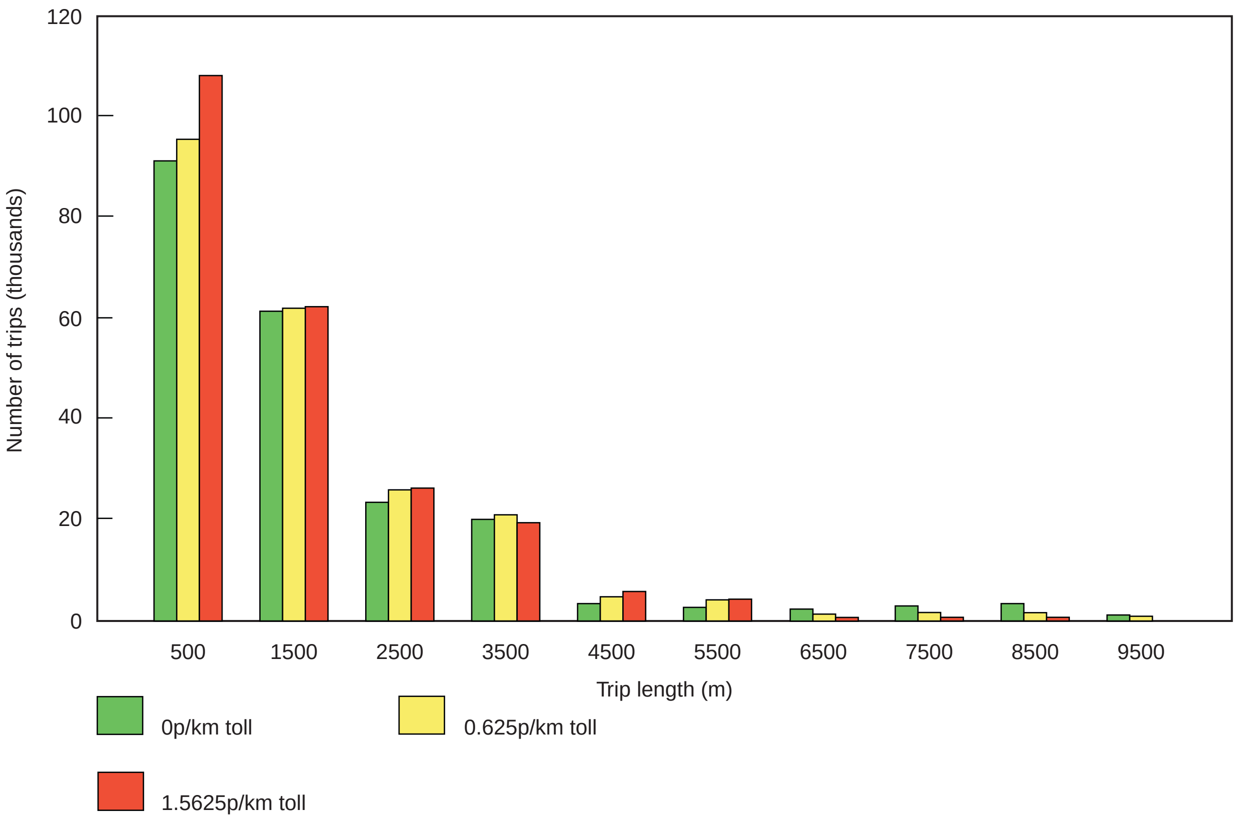

Figure 4 Motorway trip length distribution — Peak

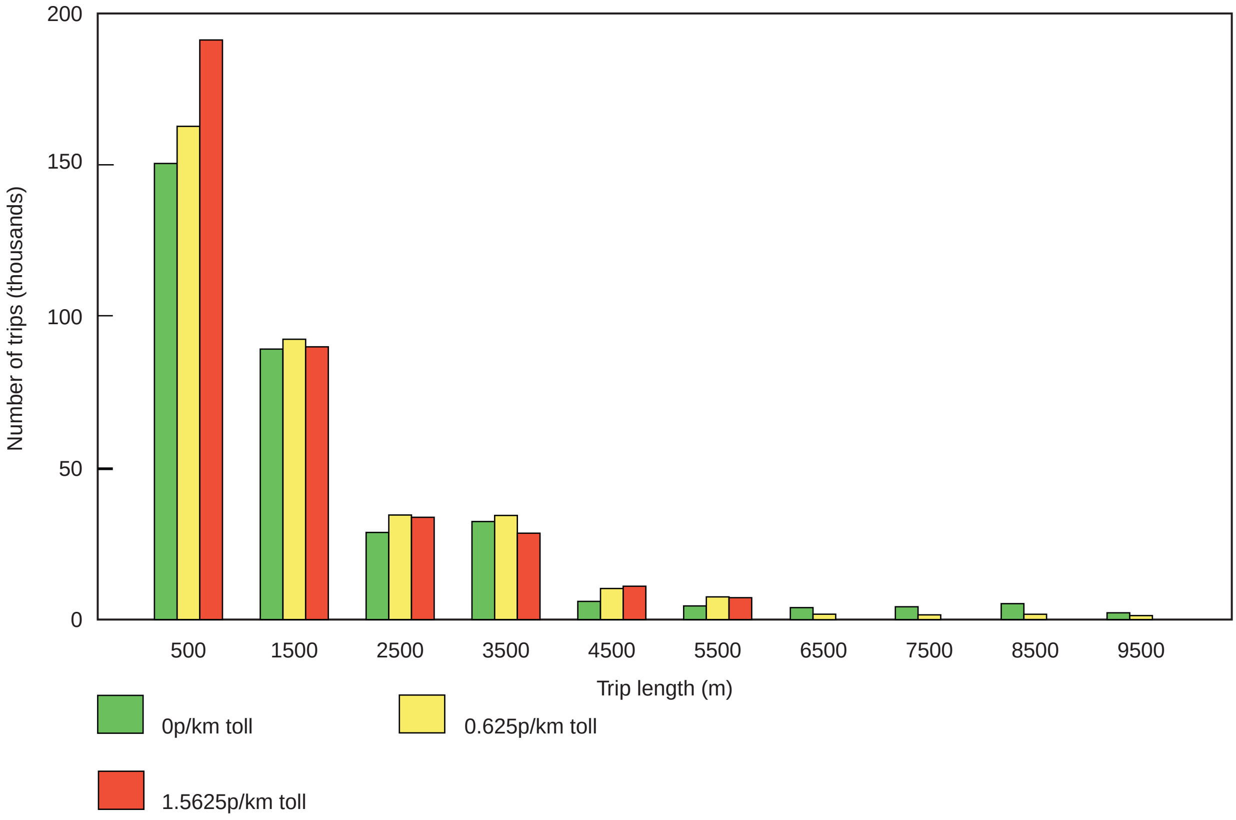

Figure 5 Motorway trip length distribution - Off–peak

Table 2 Distribution of trip lengths - Peak and off-peak

Toll rate (p/km)	*Trip length (km)*										
	0 - 10	*10 - 20*	*20 - 30*	*30 - 40*	*40 - 50*	*50 - 60*	*60 - 70*	*70 - 80*	*80 - 90*	*90 - 100*	*Total*
	Number of trips										
0	240032	149885	52490	51891	9176	6407	5585	6784	7862	3316	533428
0.625	256823	153334	59950	54747	14314	10667	2051	2979	3018	2098	559981
1.5625	297760	151261	60336	47416	16319	10338	480	599	922	368	585799

Table 3 Distribution of trip lengths - Peak

Toll rate (p/km)	*Trip length (km)*										
	0 - 10	*10 - 20*	*20 - 30*	*30 - 40*	*40 - 50*	*50 - 60*	*60 - 70*	*70 - 80*	*80 - 90*	*90 - 100*	*Total*
	Number of trips										
0	90519	61250	23228	19886	3009	2220	1952	2655	3192	1144	209055
0.625	95232	61937	25760	20844	4239	3700	932	1518	1545	800	216507
1.5625	107726	62005	26374	19179	5378	3818	290	445	671	281	226167

Table 4 Distribution of trip lengths - Off-peak

Toll rate (p/km)	*Trip length (km)*										
	0 - 10	*10 - 20*	*20 - 30*	*30 - 40*	*40 - 50*	*50 - 60*	*60 - 70*	*70 - 80*	*80 - 90*	*90 - 100*	*Total*
	Number of trips										
0	149513	88635	29262	32005	6167	4187	3633	4129	4670	2172	324373
0.625	161591	91397	34190	33903	10075	6967	1119	1461	1473	1298	343474
1.5625	190034	89256	33962	28237	10941	6520	190	154	251	87	359632

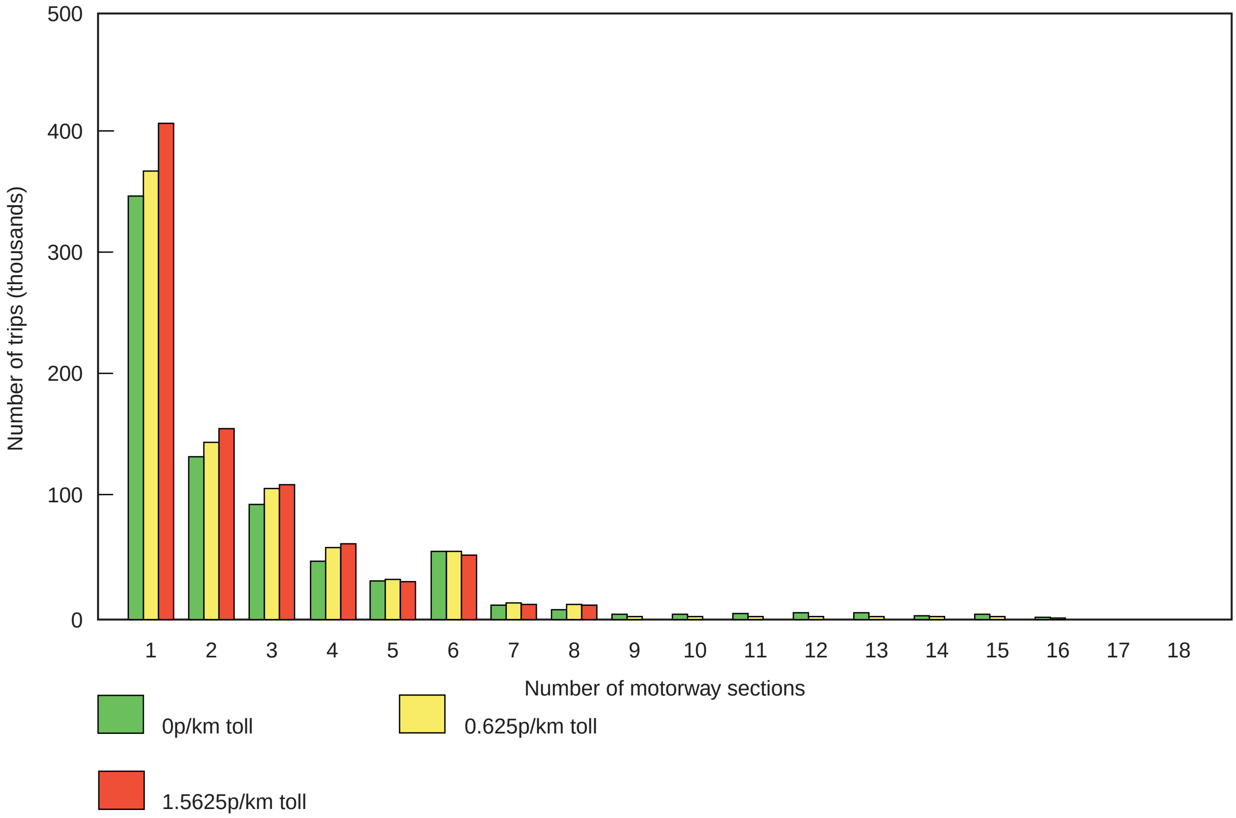

Figure 6 Number of motorway sections in each trip — Peak and off–peak

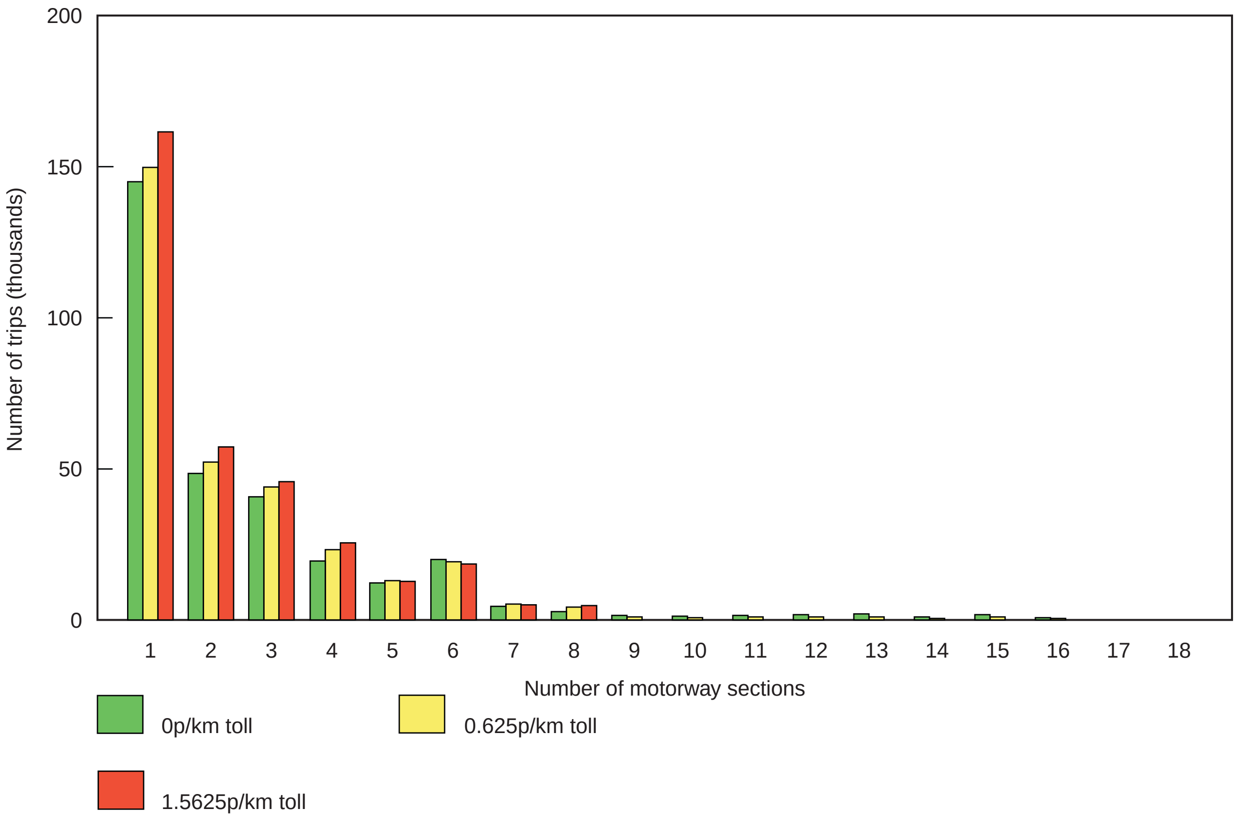

Figure 7 Number of motorway sections in each trip — Peak

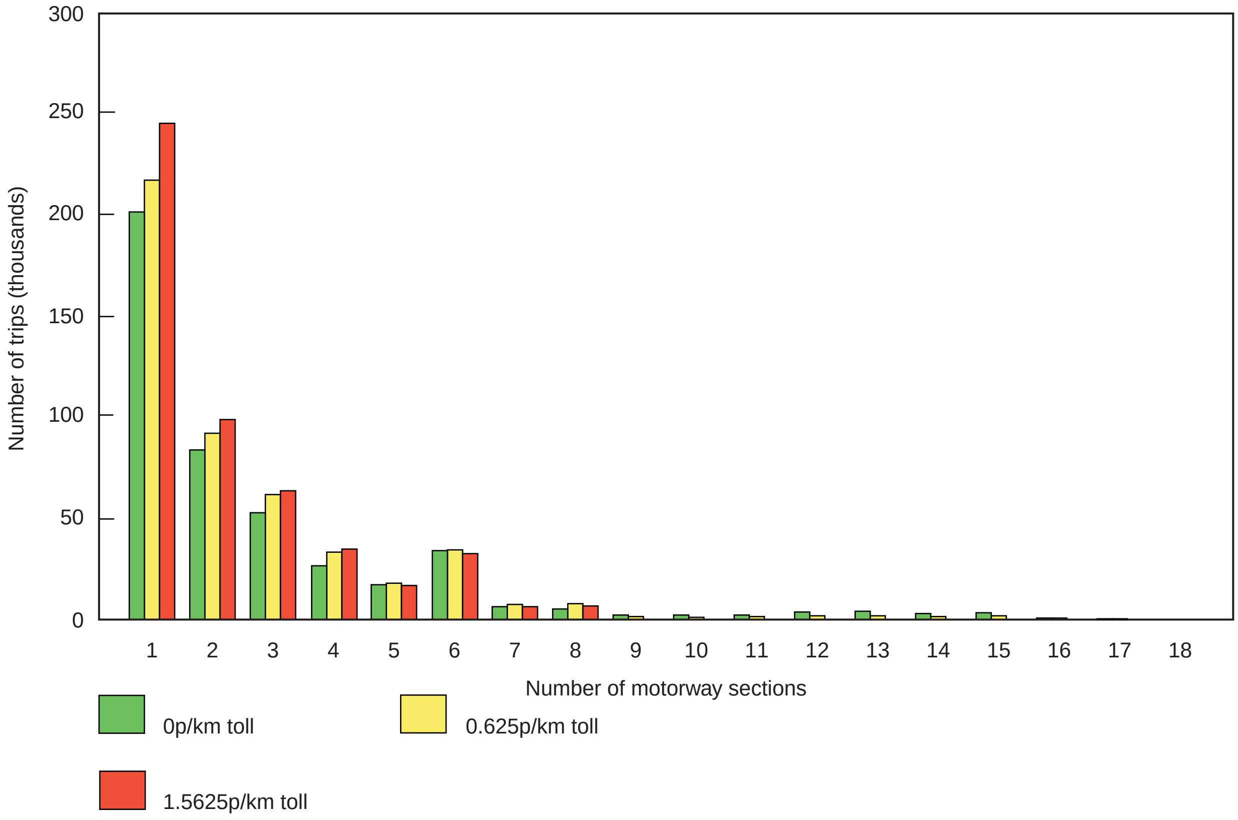

Figure 8 Number of motorway sections in each trip — Off–peak

Table 5 Distribution of trip lengths by motorway section - Peak and off-peak

Toll rate (p/km)	*Number of motorway sections* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0	345392	131139	92239	46037	29843	54131	11149	7538	3818	3652	3705	4886	5327	2630	3826	1348	760	288	56	34	0
0.625	365861	143016	105251	56432	30917	54004	12441	11892	2124	1989	2052	2334	2192	898	2271	899	338	90	33	7	0
1.5625	405786	154918	108271	60009	29880	51079	11668	10857	1159	659	715	519	646	237	384	166	32	23	4	0	0

Table 5a Total numbers of trips - Peak and off-peak

Toll rate (p/km)	*Total number of trips*
0	747798
0.625	795041
1.5625	837012

Table 6 Distribution of trip lengths by motorway section - Peak

Toll rate (p/km)	*Number of motorway sections* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0	144162	48070	40244	19571	12235	19696	4444	2634	1573	1473	1527	1726	2020	997	1632	656	202	96	24	3	0
0.625	149020	51495	43345	23141	12978	19304	4866	4252	957	914	1013	1096	1086	424	1103	400	122	24	23	0	0
1.5625	160778	56788	45428	25228	12695	18214	5225	4540	788	489	475	330	412	195	351	156	12	23	4	0	0

Table 6a Total number of trips - Peak

Toll rate (p/km)	*Total number of trips*
0	*302985*
0.625	*315563*
1.5625	*332131*

Table 7 Distribution of trip lengths by motorway section - Off-peak

Toll rate (p/km)	*Number of motorway sections*																				
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
0	201230	83069	51995	26466	17608	34435	6705	4904	2245	2179	2178	3160	3307	1633	2194	692	558	192	32	31	0
0.625	216841	91521	61906	33291	17939	34700	7575	7640	1167	1075	1039	1238	1106	474	1168	499	216	66	10	7	0
1.5625	245008	98130	62843	34781	17185	32865	6443	6317	371	170	240	189	234	42	33	10	20	0	0	0	0

Table 7a Total numbers of trips - Off-peak

Toll rate (p/km)	*Total number of trips*
0	444813
0.625	479478
1.5625	504881

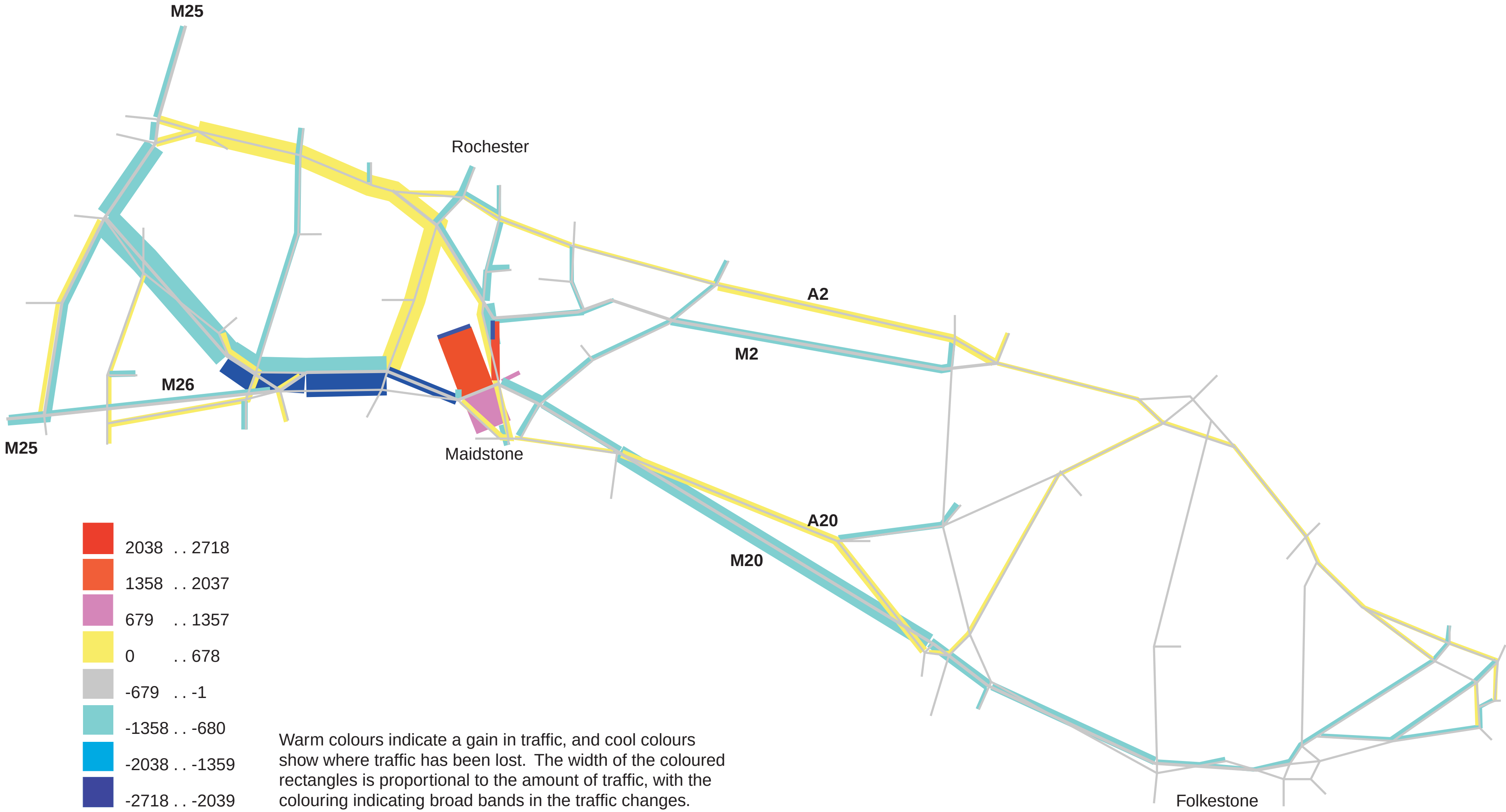

Figure 9 AM Peak: Transference resulting from tolling

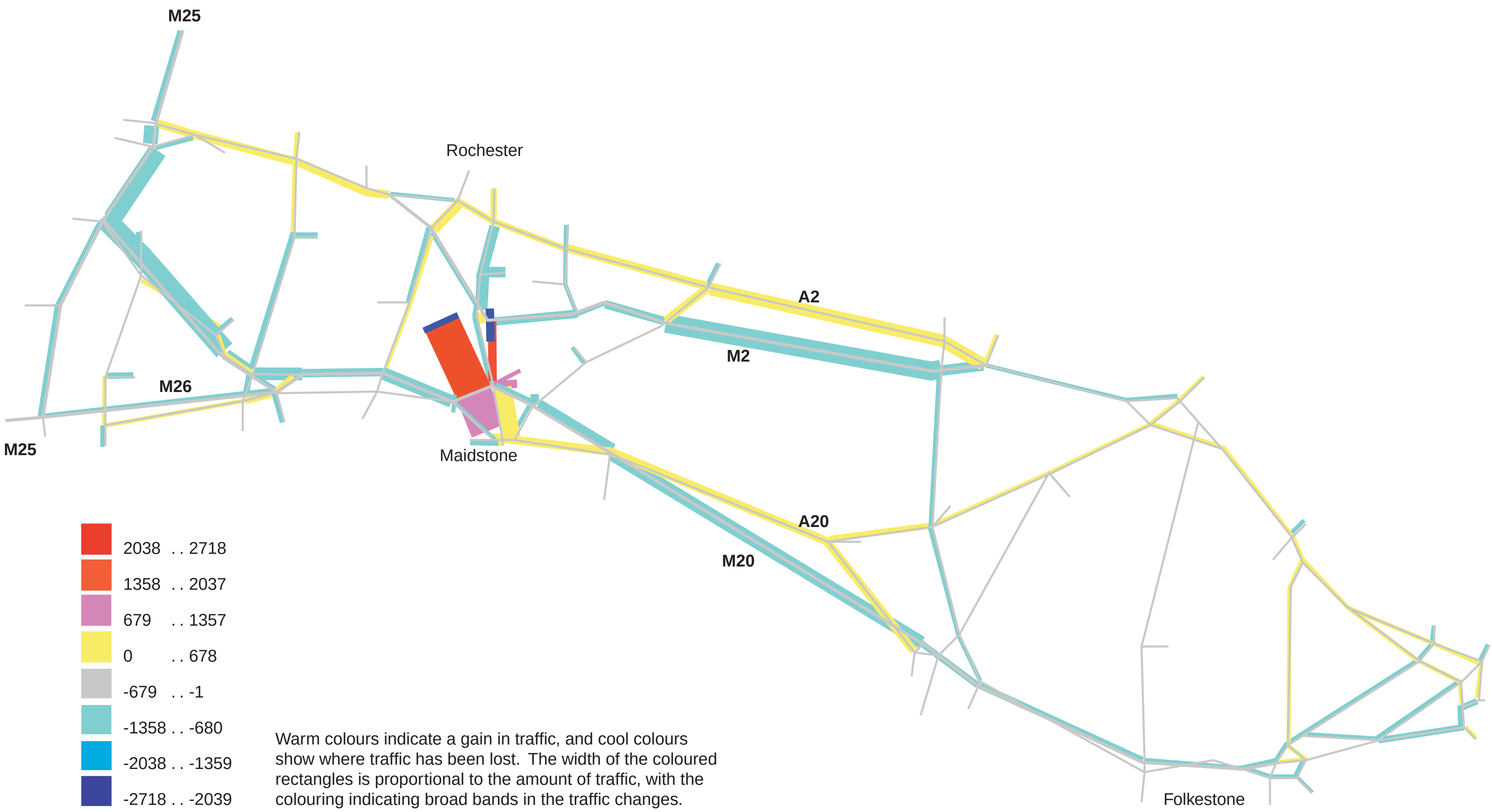

Figure 10 PM Peak: Transference resulting from tolling

much, mostly because the obvious alternative, the A2, is not a very good alternative - either because it is not of such good quality or is more heavily trafficked and liable to congestion. The largest movements in traffic are seen around Maidstone. This is because the motorway and the alternative routes are very closely parallel, and both are high quality dual carriageways. Without a toll, the motorway attracts most traffic because it has a slightly higher speed regime (no bicycles, no milk floats, no junctions), but when the motorway is tolled the differential is reversed and virtually all the traffic transfers to the A road. (The colour rectangles for the 'lost' traffic are obscured by the traffic gains on the A road.) Little traffic is diverted from the M25, because the alternative routes are relatively poor.

In the pm peak case (Figure 10) the movement away from the M20 is less pronounced and a much stronger effect is seen on the M2 transferring traffic to the A2. The difference seems to be partly the result of the fact that the am and pm peaks have different 'shapes' - the am peak is much more sharply peaked than the pm, so that at the height of the peak roads are carrying higher flows. Also the distribution over the network varies, so in choosing an example from the pm peak which shows a stronger movement away from the M2, it is not possible to show the largest movement from the M20. The sections of the M20 and A20 bypassing Maidstone are again showing very large changes, as they do throughout the day.

It is noticeable that while there is at all times some transfer away from the motorways, it is not constant. This is consistent with drivers having a good knowledge of conditions on the non-motorway roads in the area, which is a reasonable assumption for regular users of the network.

4 Motorway widening

The results shown in the previous section relate to traffic at its present level in the Kent corridor. It is instructive to consider the situation, which may occur in the future, of much higher flow levels, necessitating the provision of extra capacity in the form of motorway widening.

It was decided to increase the traffic demand to the state where some motorway links were experiencing congestion, which would presumably be the situation which would arise before widening were undertaken. There are difficulties in increasing traffic in a simulation model. In reality, traffic increases vary greatly with location and purpose of trip, but the model does not identify these differences, so some external method would probably be used to represent variation in traffic increases. However, the first step in setting up a model with higher flows was simply to increase overall demand until congestion occurred. Even with a 200% increase in demand the motorways were hardly congested, but some other roads were experiencing large queues and very long delays. It was clear that differential increases would be needed, as had been anticipated. After a series of trials with different levels of increase applied to various O-D movements, an overall increase of 150% was applied, with much greater increase in the traffic using the M20/A20 section. This modification left some queues still undischarged at the end of the simulation, so the flow levels in the last four time slices were progressively reduced to 80% of the original value. Because traffic is only loaded onto the network at a limited number of locations, these were becoming overloaded and 'gating' the network. This effectively prevented some traffic entering the network until much later than was realistic and giving unacceptably high levels of delay centred on these entry points. The capacities of these points were increased, and a distribution of flows and delays was achieved which seemed reasonable.

The M2, M20 and M26 motorways were all then expanded by effectively having an extra lane added to each carriageway.

The same investigations at different toll rates were made with the network containing the expanded motorways. However, the toll rate of 2.5p/mile gave a smaller diversion than 10% change in motorway usage. No changes had been made to the perceived and resource cost parameters, so the smaller movement away from motorways appears to be due to the relative increase in 'cost' (delay time) experienced on the non-motorway roads. It was found necessary to increase the toll to 4p/km (approximately 6.5p/mile) to reach the 10% diversion away from the motorway. This suggests that as congestion on non-motorway roads increases, tolls may become more acceptable if motorways continue to offer better journey times. The results of the investigation are shown in Figure 11. Apart from the fact that resource and perceived costs are higher, the most noticeable difference in the shape of the curves is the flattening off of the urban travel. This is presumably because the urban routes are more heavily loaded and thus closer to capacity, and are unable to accept much of the traffic transferring away from the motorway, at least without imposing considerable delay. The numerical values for the Figure 11 are given in Table 8.

The effects on motorway trip lengths and motorway section use were also calculated for the expanded, heavily loaded network. The results are shown in Figures 12-17, and Tables 9-14, which correspond to Figures 3-8 and Tables 2-7. The overall picture is very similar, with the same shift towards shorter trips as tolls increase. The total numbers of trips are increased, of course, because of the higher demand, and there is an additional toll rate to be included (at 6.5p/mile).

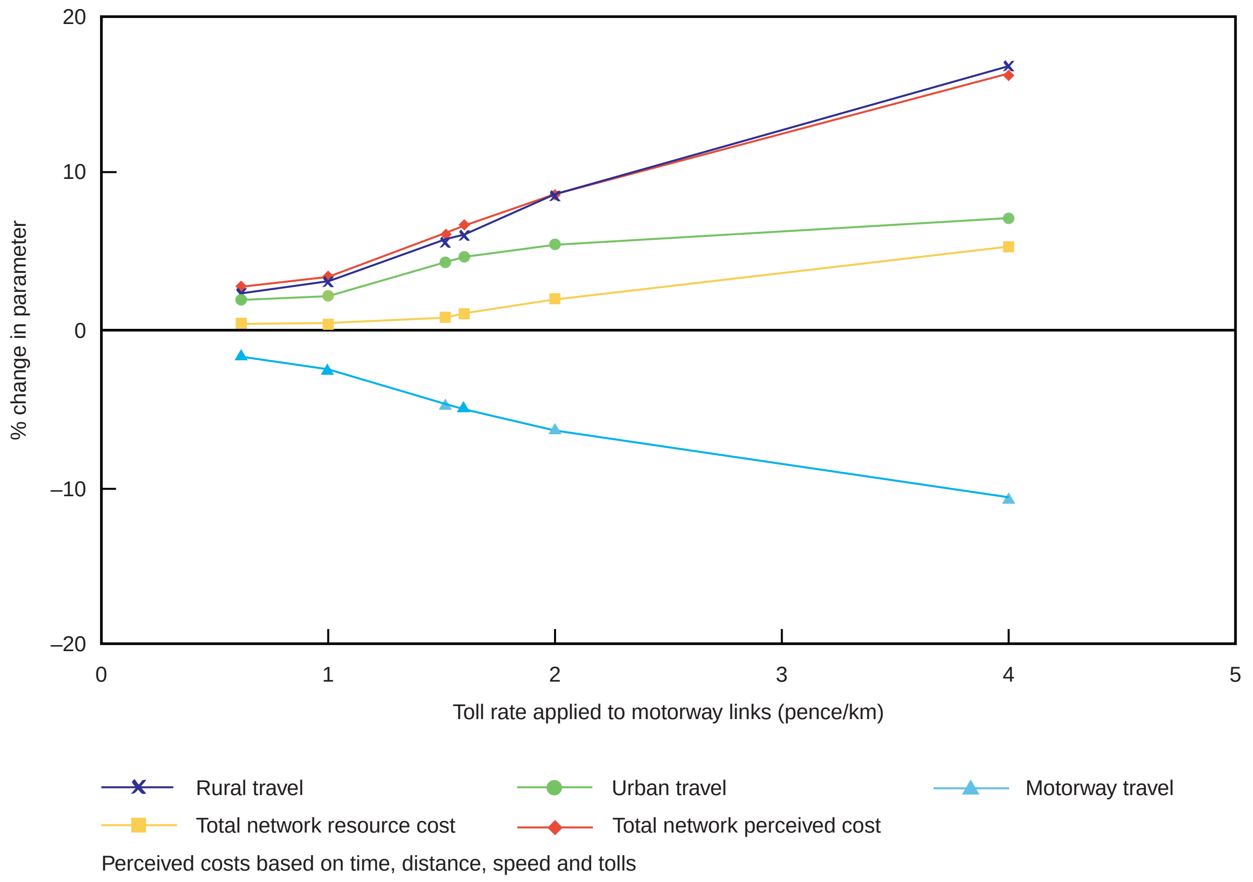

Figure 11 Kent network: change in results against motorway toll rate. Additional lane added to M2, M20 and M26

Table 8 Parameter variation with Toll Rate (with extra lane added to M2, M20 and M26)

	Tolls (p/km)						
Parameter	*0*	*0.625*	*1.0*	*1.5*	*1.5625*	*2.0*	*4.0*
Rural (vehMm)	8068.7	8223.5	8322.0	8522.3	8541.9	8705.5	9420.0
Urban (veh Mm)	2041.3	2076.2	2083.0	2131.9	2140.2	2156.5	2181.0
Mway (veh Mm)	14642.3	14394.4	14268.4	14025.0	14004.6	13809.0	13047.7
TNJT (veh hr)	503646.5	506998.0	506272.6	513821.9	514743.1	517455.2	537051.3
TNRC (£)	4690609.6	4711412.4	4705323.2	4758203.2	4764865.6	4782900.0	4918072.0
TNPC (£)	4690609.6	4801738.0	4848528.4	4969214.0	4984352.8	5059788.0	5440999.6

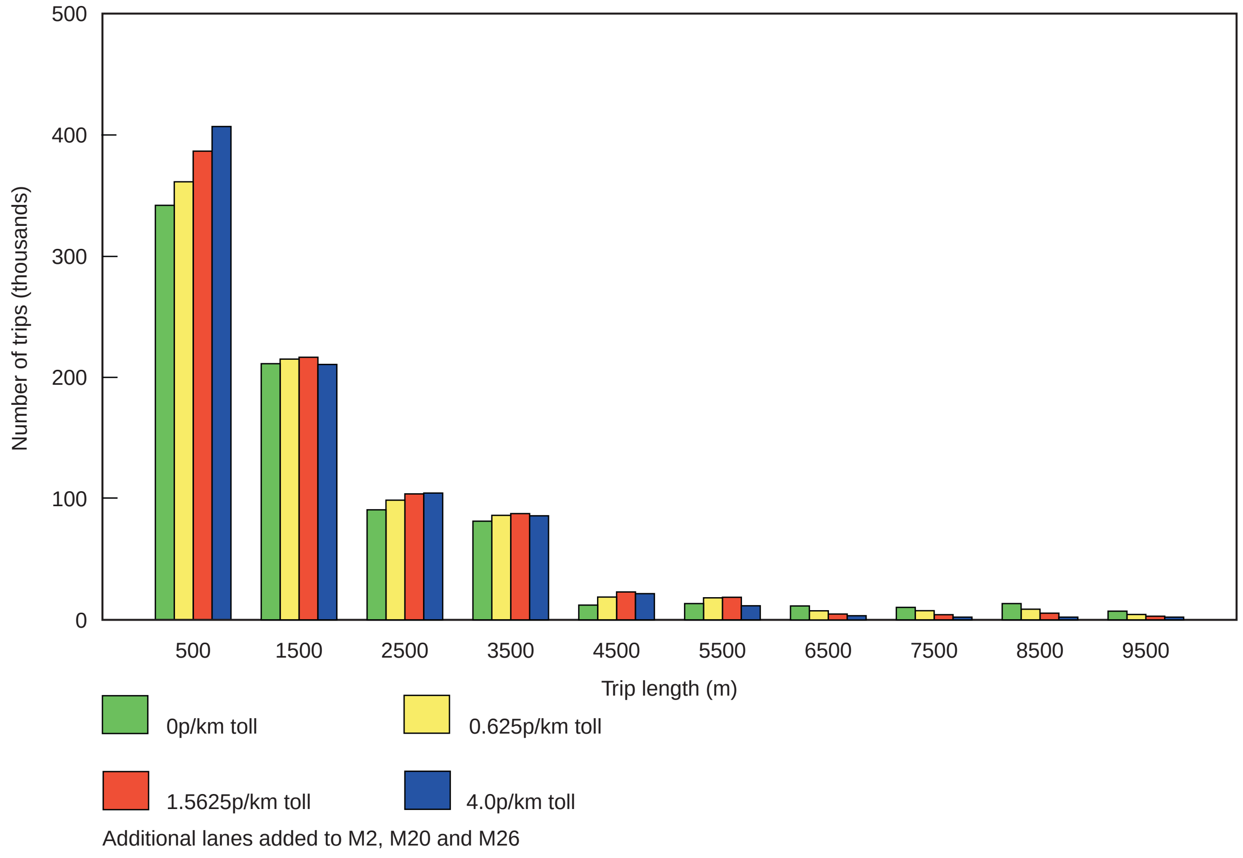

Figure 12 Motorway trip length distribution (with extra lanes) — Peak and off–peak

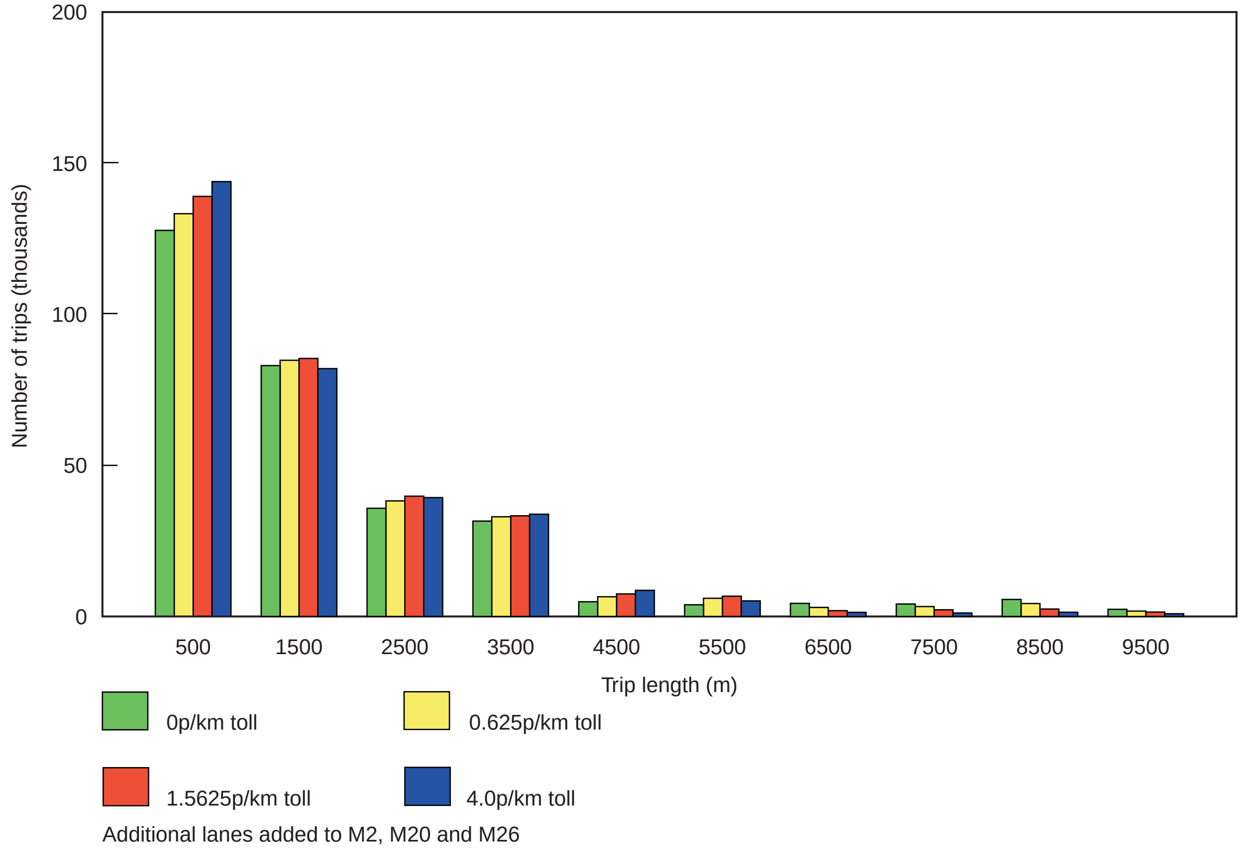

Figure 13 Motorway trip length distribution (with extra lanes) — Peak

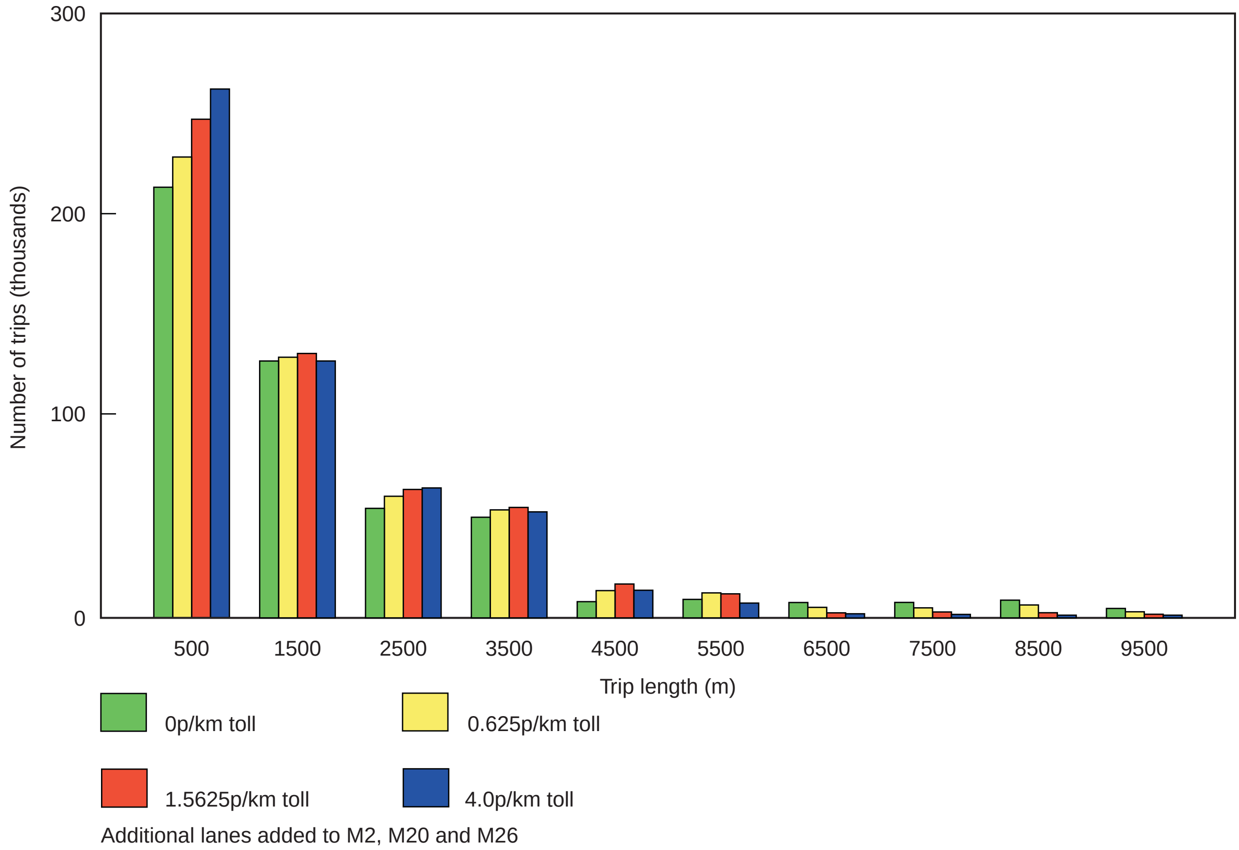

Figure 14 Motorway trip length distribution (with extra lanes) — Off–peak

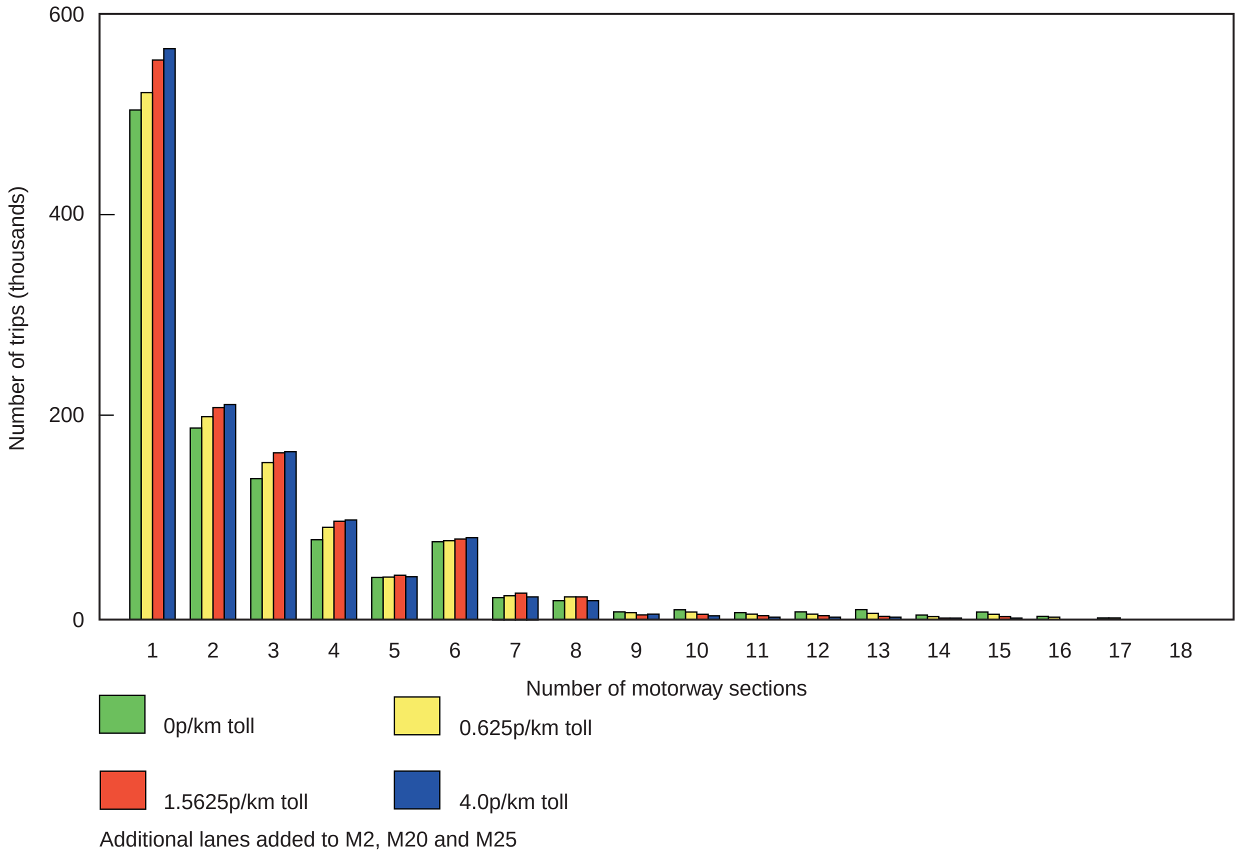

Figure 15 Number of motorway sections in each trip (with extra lanes) — Peak and off–peak

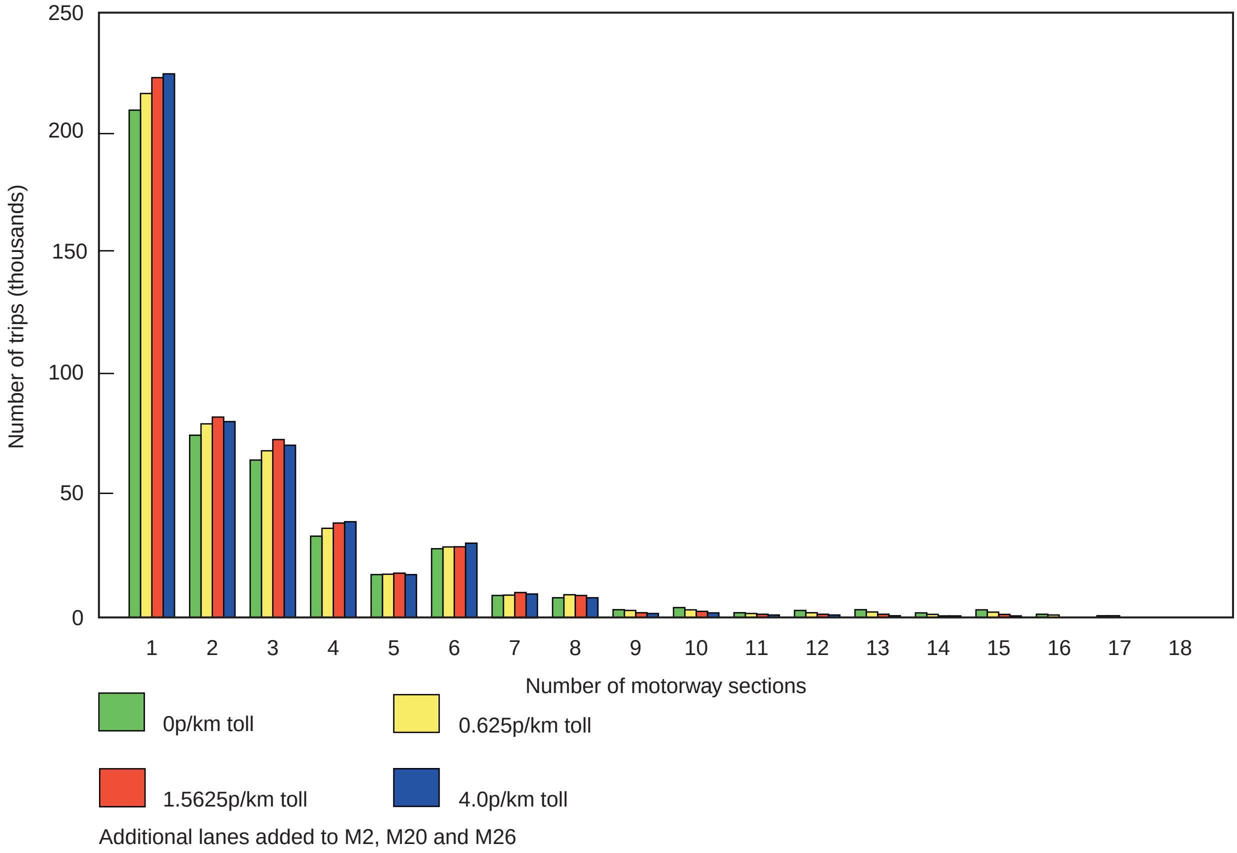

Figure 16 Number of motorway sections in each trip (with extra lanes) — Peak

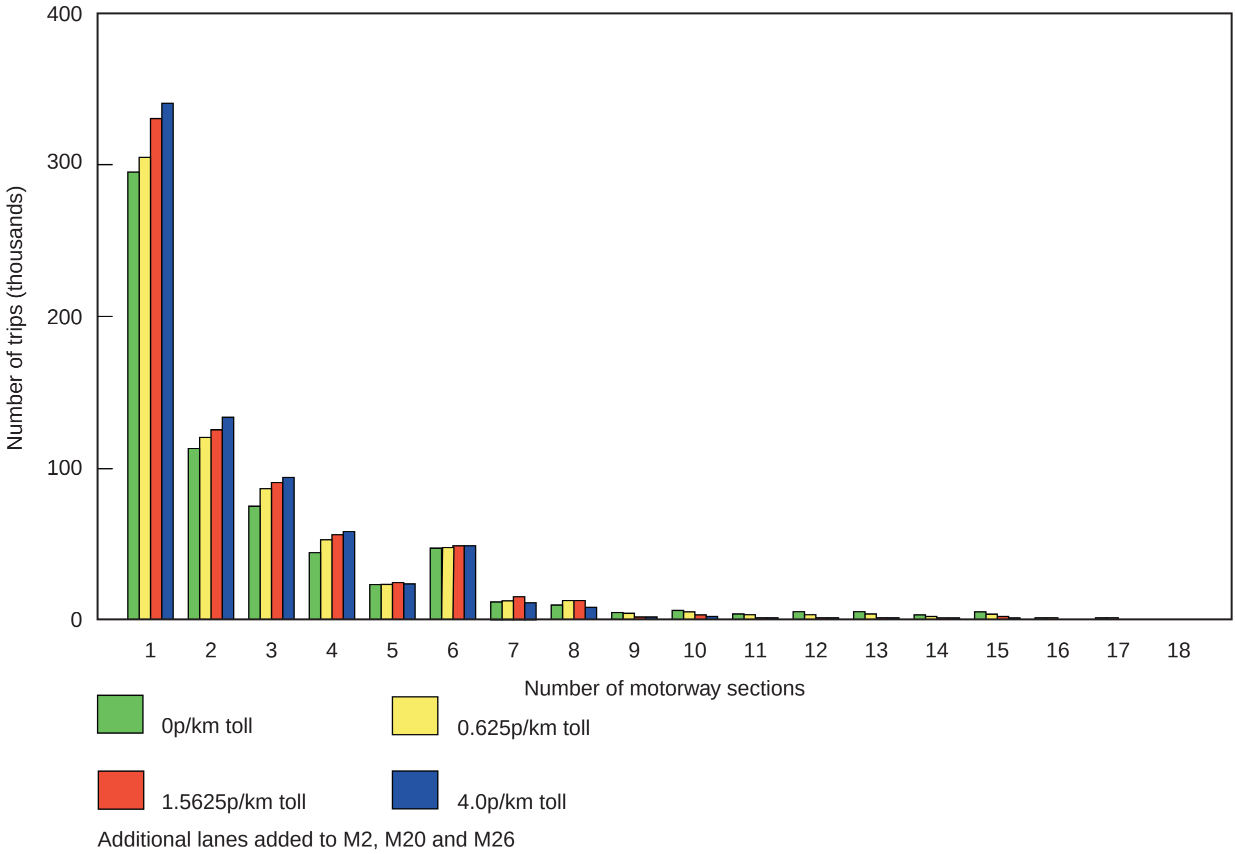

Figure 17 Number of motorway sections in each trip (with extra lanes) — Off–peak

Table 9 Distribution of trip lengths (with additional lane added to M2, M20 and M26) - Peak and off-peak

Toll rate (p/km)	Trip length (km)										
	0 - 10	*10 - 20*	*20 - 30*	*30 - 40*	*40 - 50*	*50 - 60*	*60 - 70*	*70 - 80*	*80 - 90*	*90 - 100*	*Total*
	Number of trips										
0	342811	208992	88986	85200	12710	12517	11497	10330	14720	5739	793502
0.625	361604	213102	97797	86218	19237	17553	7740	7157	8840	3438	822686
1.5625	386609	215933	103005	87117	23562	18233	4429	4092	4369	2365	849714
4.0	407584	210160	103715	85858	21936	11764	2943	2349	2051	1009	849369

Table 10 Distribution of trip lengths (with additional lane added to M2, M20 and M26) - Peak

Toll rate (p/km)	Trip length (km)										
	0 - 10	*10 - 20*	*20 - 30*	*30 - 40*	*40 - 50*	*50 - 60*	*60 - 70*	*70 - 80*	*80 - 90*	*90 - 100*	*Total*
	Number of trips										
0	127777	83465	35581	31273	4623	4254	4269	3645	5521	1733	302141
0.625	132970	84352	37857	32474	6057	6029	2977	3024	3528	1197	310465
1.5625	138451	84845	39506	32735	7104	6564	2158	2078	2118	1062	316621
4.0	143541	81466	39152	33215	8259	5134	1549	1199	1332	524	315371

Table 11 Distribution of trip lengths (with additional lane added to M2, M20 and M26) - Off-peak

Toll rate (p/km)	Trip length (km)										
	0 - 10	*10 - 20*	*20 - 30*	*30 - 40*	*40 - 50*	*50 - 60*	*60 - 70*	*70 - 80*	*80 - 90*	*90 - 100*	*Total*
	Number of trips										
0	215034	125527	53405	53927	8087	8263	7228	6685	9199	4006	491361
0.625	228634	128750	59940	53744	13180	11524	4763	4133	5312	2241	512221
1.5625	248158	131088	63499	54382	16458	11669	2271	2014	2251	1303	533093
4.0	264043	128694	64563	52643	13677	6630	1394	1150	719	485	533998

Table 12 Distribution of trip lengths by motorway section (with additional lane added to M2, M20 and M26) - Peak and off-peak

Toll rate	*Number of motorway sections*																				
(p/km)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
0	493061	186786	145354	77214	38620	73881	20548	15349	6628	9409	5472	6857	8472	3999	6646	3490	1916	254	176	29	0
0.625	519636	198457	153590	88692	40211	76464	21195	20879	5742	6922	4425	4407	4998	2366	5020	2381	776	84	111	2	12
1.5625	552150	206805	163462	94625	41754	77732	24601	20714	3612	4661	3000	2354	2821	1166	3033	1111	398	41	56	12	0
4.0	563309	212014	164278	96351	40981	79006	20481	15883	2988	3238	2106	1639	1535	543	1402	553	169	46	0	11	0

Table 12a Total numbers of trips - Peak and off-peak

Toll rate (p/km)	*Total number of trips*
0	*1104161*
0.625	*1156373*
1.5625	*1204108*
1.5625	*1206543*

Table 13 Distribution of trip lengths by motorway section (with additional lane added to M2, M20 and M26) - Peak

Toll rate	*Number of motorway sections*																				
(p/km)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
0	208794	75525	66220	32421	16826	27814	8842	6255	2527	3728	2141	2594	3235	1571	2588	1531	677	44	12	10	0
0.625	215605	78690	67642	36175	17300	28725	9009	8466	2222	2797	1778	1925	2126	934	2005	1063	273	37	48	0	0
1.5625	222401	81486	72378	38167	17795	28696	10047	8598	1634	2331	1549	1225	1389	553	1406	688	156	9	22	12	0
4.0	223522	79241	70034	38666	17160	30311	9650	7980	1468	1669	1114	955	897	357	767	312	149	23	0	11	0

Table 13a Total numbers of trips - Peak

Toll rate (p/km)	*Total number of trips*
0	463355
0.625	476820
1.5625	490542
4.0	484286

Table 14 Distribution of trip lengths by motorway section (with additional lane added to M2, M20 and M26) - Off-peak

Toll rate (p/km)	*Number of motorway sections* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0	284267	111261	79134	44793	21794	46067	11706	9094	4101	5681	3331	4263	5237	2428	4058	1959	1239	210	164	19	0
0.625	304034	119767	85948	52517	22911	47739	12186	12413	3520	4125	2647	2482	2872	1432	3015	1318	503	47	63	2	12
1.5625	329749	125319	91084	56458	23959	49036	14554	12116	1978	2330	1451	1129	1432	613	1627	423	242	32	34	0	0
4.0	339787	132773	94244	57685	23821	48695	10831	7903	1530	1569	992	684	638	186	635	241	20	23	0	0	0

Table 14a Total numbers of trips - Off-peak

Toll rate (p/km)	*Total number of trips*
0	640806
0.625	679553
1.5625	713566
4.0	722257

5 Conclusions

The average behaviour of traffic using the Kent corridor network has been modelled with motorists accustomed to varying levels of tolls imposed on the motorways.

The effects of tolling are very much as expected:

- some traffic is diverted from using motorways
- the amount diverting increases as tolls increase
- more traffic diverts onto rural routes than onto urban routes
- a toll of 2.5p/mile gives an average 10% diversion of traffic away from motorways
- traffic is more likely to divert if alternative routes are of good quality and not already congested.

An examination of the distribution of trips on motorways once again emphasised that a high (45%) proportion of trips were short - under 10km, and the same proportion were using only one motorway link between junctions. The effect of tolling was to cause drivers previously making longer motorway trips to reduce their motorway use, either by not using the motorway, by reducing the length of motorway used, or by breaking a single longer use of motorway into two or more shorter sections. The effect is virtually identical whether considering actual distance driven on motorways or the number of contiguous inter-junction sections used.

The behaviour of traffic was very similar when traffic demand levels were considerably increased, and the motorways were expanded by the addition of an extra lane. The cases examined suggest that a larger toll would be tolerated when the alternative routes were more congested, leading to more delays.

It must be remembered that these calculations assume that drivers make rational decisions about their costs, and are accustomed to the idea of tolls. The initial effects of tolls might be greater than shown in this report, but could be expected to revert to comparable levels as tolls became commonplace.

6 Reference

Taylor N B, Leonard D R, Maher M J and Tootill W J (1989). *CONTRAM Userguides*. Application Guide AG13. Transport Research Laboratory, Crowthorne.

Abstract

The introduction of motorway tolls would be expected to cause some traffic to cease use of motorways, and transfer to alternative non-tolled routes. The MCONTRM model was used to estimate the effects in the area served by the M2, M20, A2, A20 and M26 between the M25 and the channel ports. A range of toll rates was investigated including the 1.5p/mile rate and the toll producing a 10% diversion level (2.5p/mile) at 1994 costings. Network resource costs, based on COBA9, were calculated for all cases.

The model was also used to show the change in amount of use made of motorways: drivers wishing to reduce costs by avoiding motorway tolls may still use motorways for shorter distances, notably where the alternative routes cause unacceptably long journey delays. The model showed a greater transfer of traffic to rural routes than to urban routes. The great majority of motorway trips were very short, and this feature was shown more strongly as tolls were raised.

Related publications

TRL345 *Measures for assessing on-board units for electronic toll collection — Parts 1 and 2* by J Holder and J Sutherland, 1998 (price £35, code H)

TRL348 *User requirements of on-board units for electronic fee collection* by P T McCabe. 1998 (price £35, code H)

TRL350 *Radiation safety standards for electronic fee collection and enforcement equipment* by A J Lines and A Stevens. 1998 (price £35, code H)

TRL351 *Motorway tolling — modelling some congestion effects of diversion* by P Gower and J Mitchell. 1998 (price £35, code H)

TRL352 *The likely effects of motorway tolling on accident risk — Phase 2* by J Broughton and P Gower. 1998 (price £35, code H)

TRL354 *Toll enforcement using numberplates* by G Gaunt and A Stevens. 1998 (price £35, code H)

TRL355 *The potential for the evasion of electronic motorway toll systems* by G Maycock and C Corbett. 1998 (price £35, code H)

TRL356 *Lateral distribution of motorway traffic* by E J Woodgate and M A Winnett. 1998 (price £25, code E)

TRL357 *The likely effects of motorway tolling on accident risk*s by J Broughton and P Gower. 1998 (price £35, code H)

TRL359 *A preliminary study of in-vehicle interfaces for electronic toll collection* by D Watts, J Rattle and A Stevens. 1998 (price £35, code H)

TRL361 *Review of tolling and communications aspects of the US National Architecture* by J Holder and A Stevens. 1998 (price £35, code H)

This report and all the above, plus a further eight reports by Hyder Consulting, P-E International, MVA and DETR are available on CD — *Research on Road User Charging 1995–1998*. 1998 (price £295)

TRL220 *Review of the potential benefits of road transport telematics* by K E Perrett and A Stevens with contributions by I J Wilkinson and P F Masurel. Editorial support: J M Hopkin. 1996 (Volume 1 Main Report price £60), (Volume 2 Technical Annex price £100)

CT25.2 Road pricing update (95-97) (*Current Topics in Transport: selected abstracts from TRL Library's database*) (price £20)

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