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Traffic peak spreading in congested urban environments

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Abstract
The paper will describe the results of research recently completed, funded by Transfund New Zealand, into the phenomenon of traffic peak spreading in congested urban environments. The work looked specifically at two facets:

- the extent to which traffic peak spreading has been observed and the underlying behavioural aspects
- how (if) traffic peak spreading is modeled in different countries and the consequences for scheme evaluation.

In terms of the former, data has been collected from a number of key sites, in the urban areas of Wellington and Auckland. This includes some data from an earlier study which is being 'revisited' and its forecasts re-examined. Although comprehensive time series data has proved elusive in some cases, there is sufficient evidence in New Zealand and overseas to demonstrate the occurrence of peak spreading conclusively.

Information on the modelling of traffic peak spreading has been collected from a number of countries, although it would appear that in many cases it is left to the modeller's discretion. Elasticity approaches appear to be most tractable, although in the UK a number of highly sophisticated, scheduling type approaches have been developed and piloted. Not unexpectedly, these can be very "data hungry" and go hand-in-hand with other modelling techniques such as time slicing. It is particularly noteworthy that time-of-day choice is now seen as being second in its importance in the choice process after route choice.

Reports of the impact of traffic peak spreading on scheme evaluation have to date proved to be few in number, although this is not the case with the wiser issue of "induced traffic" which generally includes peak spreading.

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Introduction

This paper presents the findings of a research study undertaken as part of the Transfund New Zealand 2001/02 Research Programme. The subject is the temporal spreading of traffic peaks in urban areas, or, as it is generally known, peak spreading.

The objectives of the study were:

- to review available evidence of, and research into, peak spreading from NZ cities and elsewhere
- to examine the effect of peak spreading on modelling and evaluation.

The paper covers two major topics. The first describes the phenomenon of peak spreading, why it happens, why it is important and where it has been observed in the world. The second topic assesses how peak spreading, given its importance, has been incorporated into scheme appraisals by Governments in different countries and states and how it has been represented in a modelling context.

Characteristics and Evidence of Peak Spreading

The Importance of Peak Spreading

The pattern of demand during the peak period is of crucial importance within the field of transportation planning when estimating necessary levels of road capacity, and the associated costs to provide and maintain this capacity. Capacity needs to cater for the maximum level of demand estimated at a future date, and if forecasts are not sufficiently accurate then this can lead to an inefficient allocation of resources (provision of over or under capacity).

Broadly speaking conventional planning indicates that capacity should be provided to meet levels of maximum demand, i.e. those that occur in the peak hour or "rush hour". It is thus economically inefficient but inevitable that an asset (in this case road capacity) will remain under-utilised for the bulk of the day; however, a number of techniques, such as tidal flow schemes and parking restrictions, do allow capacity differences between peak and off-peak. So the smaller the differential between average and peak flows the better. Therefore, when the bulk of the peak flow is concentrated into a very short period of time (heavy peaking) capacity is often breached and congestion results. When the traffic volume is of a lower maximum flow but spread more across time, road capacity is being used in a more optimal fashion.

The phenomenon of peak spreading describes a dynamic process whereby the pattern of demand changes over time from one where there is heavy peaking, to one where the demand spreads out over a longer period. Typically this results in the peak period lengthening, either side of the highest peak flow. Because of the constraints of road capacity, peak spreading is one way of accommodating increasing traffic volumes.

Some would see peak spreading as a good thing, a natural market correction that allows supply to equate more closely with demand and remove the need to continually provide extra road capacity or install systems to maximize the existing capacity. Others, however, see peak spreading as a proxy for delay with all its associated negative qualities; they would argue that economic disbenefits result through trip makers not being able to leave or arrive at their chosen times.

Whatever the arguments, peak spreading is clearly of importance to those involved in planning transportation systems. Recognising that the phenomenon simply exists is no longer really an issue; its incidence is well researched and documented. What planners are seeking to gain a stronger understanding of, are the factors that lead to peak spreading taking place, how these can be modelled and influenced with any degree of certainty and how they are best incorporated into appraisal frameworks. This will allow:

- Traffic forecasts not to over estimate levels of congestion and so potentially magnify the benefits of new road schemes to existing users, which in turn will allow,
- Appropriate levels of road capacity to be provided which may not cater to an unlimited maximum level of peak demand, but provides capacity to an affordable limit, knowing that when this is breached the resultant congestion will push traffic into the shoulders. Note that this accepts that a certain level of disbenefit occurring due to all needs not being met but considers it to be of a lower level of magnitude than the additional costs incurred by catering for an unlimited level of traffic.

Reasons behind Peak Spreading

Based on a review of the literature on the subject which has been undertaken as part of the study (reported on later in the paper), there are two identified mechanisms as to why the peak period lengthens over time, both of them a direct consequence of excessive congestion.

Passive spreading, as the title indicates, does not involve the trip maker choosing to travel in a different time segment to their one of choice. Excessive levels of demand cause congestion, which in turn cause delay and lead to the re-timing of trips.

In terms of the appraisal of proposed new schemes, the representation of passive spreading within a modelling framework requires that congestion causing the lengthening of journey times is represented within a "time slicing" approach, with delayed trips being placed into the matrix for a later time slot, ready to be assigned to the network.

Active spreading occurs when the individual trip maker makes a conscious decision to travel at a different time, either earlier or later than the most congested period, so as to miss the worst of the rush hour. In this case, travellers trade off congestion and their preferred time of travel, moving out of the highest peak to reduce the duration of their journeys, while still potentially incurring an element of disutility by having to leave home earlier or arrive at work later compared to their preferred time.

The vast majority of trips in the rush hour period relate to travel for either educational (school runs) or employment reasons. On a micro level the more regimented an employer's adherence to a common start time, the less likely employees of that company/entity will peak spread actively rather than passively.

Conversely employers who subscribe to the concept of alternative work schedules (AWS, an acronym first coined by Hagerstrand, 1967) (such as flexible working hours, staggered work shifts, working from home and compressed work weeks) allow employees the option of actively choosing to travel so as to miss the peak period.

Techniques for distinguishing "passive" from "active" peak spreading are described by Hounsell (1991) and largely revolve around an examination of the traffic flow in pre-peak intervals or before a link reached capacity. The modelling of active peak spreading raises particular methodological issues which are explored further later.

Evidence of Peak Spreading

Incidences of peak spreading taking place are well documented, with some references documenting the phenomenon from more than ten years ago. In other words there is no longer the need to prove that "peak spreading" is a reality. Policy makers are now more concerned with incorporating peak spreading into the appraisal and modelling framework, and assessing how new transport initiatives being mooted, such as congestion charging or internet based real time information systems, are likely to influence temporal patterns of demand.

In the *United Kingdom* the Department of Transport, Local Government and the Regions (DTLR), the research councils, the Universities and Local Government have all studied the subject extensively. Many of the findings were distilled in Porter, Field and Van Vuren (1995). Peak spreading came to be recognised as a phenomenon in the 1980s and early 1990s once congestion levels throughout the country had reached levels that forced motorists to change their behaviour. A survey of peak spreading in London was published as early as 1989 (Johnson et al, 1989). and much of the research to demonstrate the presence of peak spreading took place around this period. More recently research has focussed on understanding the factors that influence people to change their journey times and how to incorporate peak spreading within an appraisal and modelling framework.

SACTRA (1994), on the basis of work carried out by the DTLR stated that:

"....there is evidence to suggest that peak spreading is an important behavioural reaction to changes in road capacity, second only to changes of route."

The DTLR carries out traffic counts on a regular basis across all links on the trunk road network (equivalent to State Highways in NZ), and automated counts at select key sites across the country. Porter et al (1995) cites an unpublished study carried out by Gray (1993) on this data that demonstrates a clear relationship between the volume of traffic and the proportion of traffic in the peak period. This proportion is 10% for low flow roads but falls to 8.5% for higher flows. More detailed analysis of the automated data demonstrated that peak spreading was widespread and significant at over half the sites monitored (95% confidence level).

Peak spreading effects have also been monitored on an independent basis in a number of UK cities including London, Oxford, Newcastle, Birmingham and Manchester. In all cases as traffic volumes have increased both the longevity of the peak period and the volumes within the actual peak hour have grown.

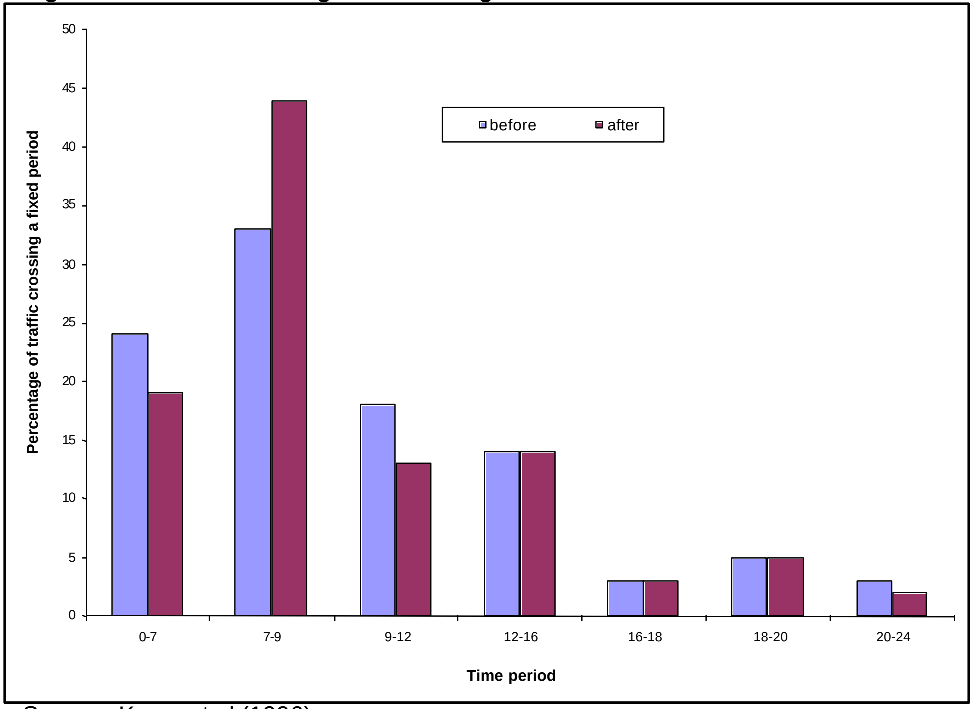
In *Holland*, evidence of peak spreading was shown by Tacken and Mulder (1990) who developed a forecasting model that fitted observed data on the basis of Dutch National Travel Survey data, between 1979 and 1988.

Elsewhere in Holland, Kroes et al (1996) showed that the peak duration can contract when a bottleneck is removed. The research demonstrated that when capacity was increased on the Amsterdam ring road the most significant short-term effect was not extra trips or a diversion from other routes (Figure 1). The major effect was the reversion back to departing during the peak hour by those who had got into the habit of leaving slightly earlier or later. This “reverse” phenomenon is important in assessing scheme benefits, as discussed below.

Recent studies demonstrate that peak spreading is very much a reality in the *USA*. Individual examples are cited include San Francisco (Purvis, 1994), New Jersey (Allen, 1991), in Connecticut by Allaire and Ivan. Work carried out by Louden el al (1988) is cited by Porter et al (1995) and describes a project which investigated the ratio of peak hour to peak flows at 32 freeway sites in the USA, and found evidence of peak spreading at 29 of these sites.

Information provided by New South Wales Department of Transport, Transport Data Centre (2001) shows the number of *Sydney* residents travelling on a weekday in 1991 and 1999. This indicates an increase in volumes, but the peaks start earlier, and finish later, especially in the evening. Correspondence with the New South Wales Department of Transport indicates that this spread could be due to a lack of capacity or changes in working habits; they are unsure what is driving the spread. In addition to the above, the Sydney Harbour Tunnel Environmental Impact Statement as documented in Beder (1991) contained evidence presented by prominent academics in Australia that peak spreading was occurring at certain points in the metropolitan area.

Figure 1 – Observed changes in crossing time of the North Sea canal southbound.



Source: Kroes et al (1996)

Independent work by Bullock (pers comm., undated) showed the build-up of peak traffic, in the form of peak spreading, crossing Sydney Harbour Bridge in the AM peak. It further demonstrates that contraction of the peak took place when additional capacity was provided by the Harbour Tunnel.

Measuring Peak Spreading

The study by Opus (1997) of peak spreading in Wellington identified the Peak Spreading Efficiency Ratio (PSER) as a means of measuring the extent of peak spreading and how it changes through time at a particular location. For a given period of time (eg. 7am to 9am), the PSER is defined as the ratio:

total traffic in period: maximum possible flow in period.

The denominator is calculated as the maximum flow recorded at the location (eg by traffic counters or SCATS) within a shorter interval (eg. 15 mins) multiplied by the number of such intervals.

Thus, in a typical urban congested situation:

- for short periods (eg. 8am to 9am) we would expect the PSER to be close to 100% (ie. there is no spare capacity)
- as the period of measurement becomes longer, for a given year, the PSER gets smaller;
- when the rate of change of the PSER is zero, no further peak spreading is possible within that period.

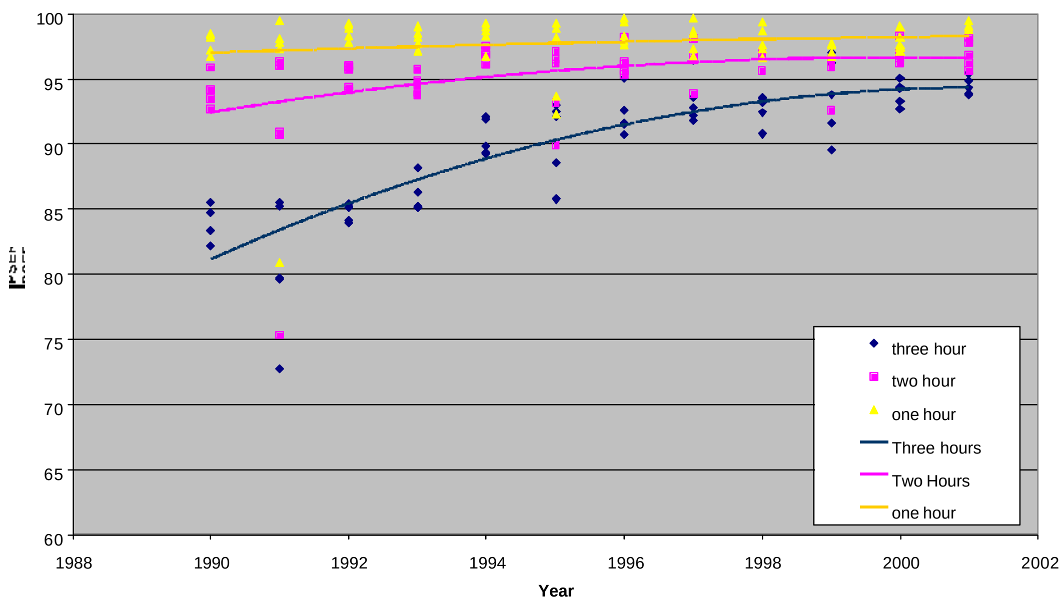
These points are illustrated below in relation to Auckland and Wellington.

It should also be pointed out that the PSER is similar to measures which have been used to model and forecast the extent of peak spreading; this subject is addressed later in the paper.

Peak Spreading in Auckland

Figure 2 relates to southbound traffic volumes across Auckland Harbour Bridge (AHB) for an average weekday. The effects of peak spreading can be seen clearly in the figure, which shows the PSER since 1990 for one, two and three hour periods. Smoothing has been used to reduce the effects of noise and present the outcome more clearly.

Figure 2: AHB one , two & three Hour PSER values (smoothed)



Given that a PSER >95% effectively indicates that there is no spare capacity, a number of conclusions can be drawn:

- for the one-hour period 7.30 – 8.30am, traffic has been at capacity levels since before 1990
- for the two-hour period 7am to 9am, capacity was reached in the mid 1990s and there is certainly no spare capacity now
- the PSER for the three-hour period 6.30 to 9.30 am has increased from 80 – 85% in 1990 to around 95% now.

While the rate of growth of the 3-hour PSER is slowing, it is clear that within a few years there will be effectively no spare capacity on AHB southbound between 6.30 and 9.30 am.

The figure demonstrates graphically that peak spreading is occurring, supporting anecdotal evidence. It would appear that measures to increase supply or reduce demand are the only alternative to the peak spreading even further.

Wellington

Wellington differs from Auckland in that the less dispersed central business district attracts a large proportion of commuter trips . A sizeable percentage of these are by public transport. Congestion is by no means as acute as Auckland, but is noticeable in peak periods, particularly around the convergence of State Highways 1 and 2 on the northern approach to the city centre.

Booz Allen Hamilton (1999) studied the effects of improvements to the Newlands Interchange on SH1 north of Wellington, which were fully opened in June 1998. A fully grade-separated interchange replaced a signalised "T" junction, so a significant increase in capacity was achieved; evidence collected during the study indicated that a reduction of 5-10 minutes in peak journey times has been achieved between the CBD and locations to the north of the interchange.

The objective of the study was to survey peak period travellers on SH1 into Wellington and ascertain their response to the improvement. This included:

- changes in travel time
- variability of travel time
- timing of trips
- Re-routing.

It was found that 29% of the respondents surveyed took advantage of the reduced congestion to leave home later and arrive at work at the same time as before. In other words as a result of capacity improvements the peak contracted, i.e. there was a reversion to the mean.

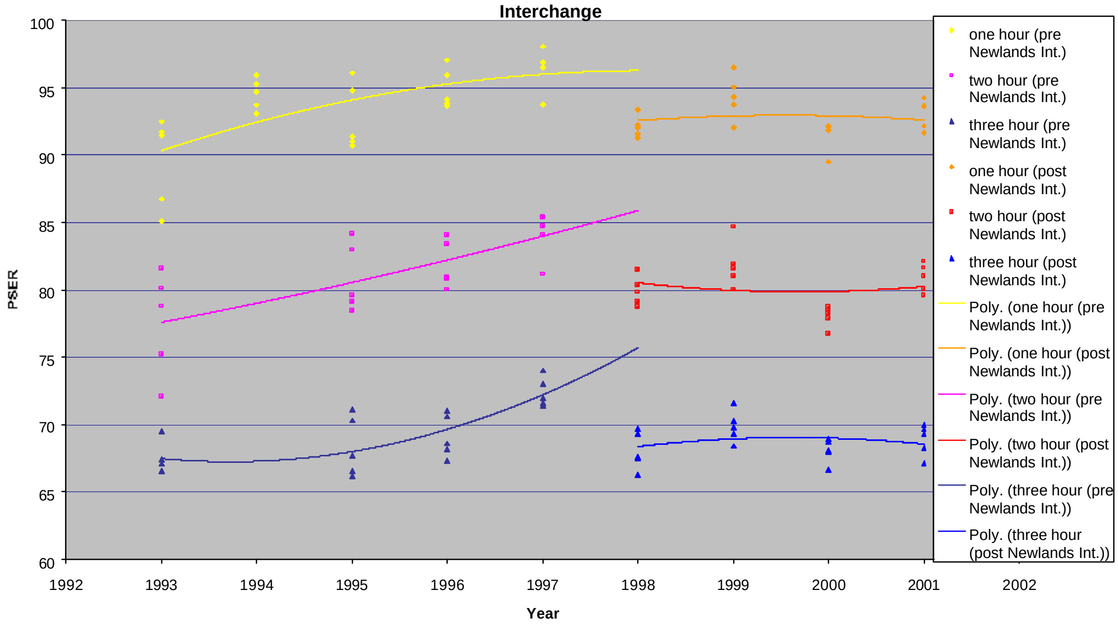
To further examine the effects of the Interchange, the PSER at a site on SH1 just south of Newlands has been computed for the years 1993 to 2001 (inclusive), again over 1, 2 and 3-hour periods. In the light of the findings of the Booz Allen study, it was to be expected that the opening of the interchange would have an effect on peak spreading.

The data was therefore split into two sets of years: up to and including 1997, and 1998-2001. Smoothing for the two sets was done separately, although this considerably reduced the number of data points in each set, so the margin of error will be greater.

The outcome is presented in Figure 3. The following conclusions can be drawn:

- the Newlands interchange caused a “lag” of perhaps 3-4 years in the growth of peak spreading, whichever period (1, 2 or 3 hour) is used for the PSER
- after approaching unity in 1997, the 1-hour PSER is now close to 1 again
- the 2-hour PSER has remained in the range 80-85% since 1995, with a generally upward trend but a drop due to Newlands
- similarly, the 3-hour PSER is in the range 65-75%.

Figure 3: Ngauranga Gorge one, two & three hour PSERs showing the effect of the opening of Newlands Interchange



Comparison with the Auckland data in Figure 2 indicates the (intuitively obvious) fact that congestion, measured in this way, is much greater in Auckland than Wellington. In the latter the 1-hour PSER is currently around 95-100% whereas this was reached in Auckland before 1990. The 2-hour PSER, which in Auckland has been close to 1 since 1996, is only now around 85% in the capital. The 3-hour PSER presents a similar picture.

Impact on Evaluation

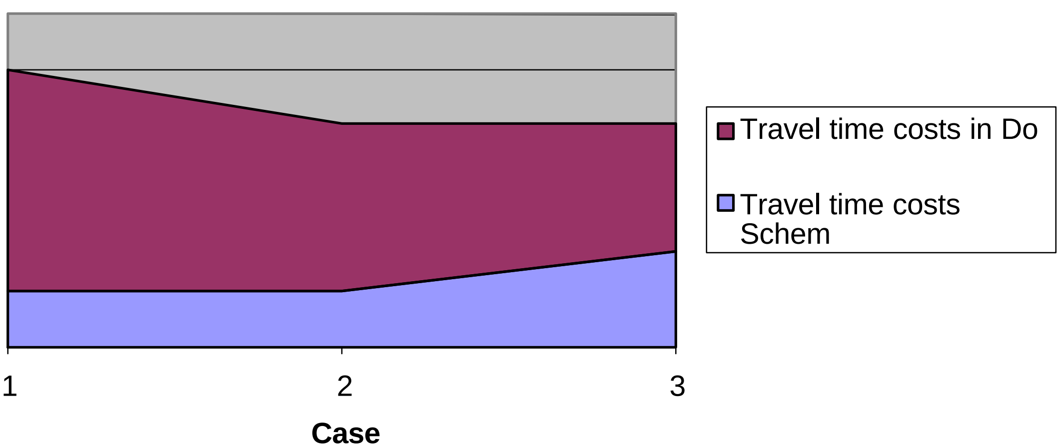
As has been shown above, peak spreading is well documented and of concern to the transport planner and policy makers. A number of countries, probably led by the UK, are taking steps to allow for it in scheme evaluation. If its effects are ignored this will distort the cost/benefit profile of new schemes. There are two ways in which this can happen:

- failure to allow for peak spreading in the "Do Minimum" will exaggerate the forecast level of congestion
- similarly, not taking account of the converse effect of peak contraction in the option case will understate the level of congestion.

In either case the gap between the Do Minimum and the option will be narrower if peak spreading/contraction is included; hence the true benefits will be less.

This is illustrated in Fig 4.

Figure 4: Effect of peak spreading and contraction on scheme benefits



Travel time benefits are the difference between the Do Minimum and the scheme in the forecast year. Case 1 illustrates the "conventional" approach, with no peak spreading or contraction. In Case 2, peak spreading has been allowed for in the Do Minimum, thus reducing the forecast travel time costs and hence the benefits. Case 3 then takes further account of the impact of peak contraction with the scheme. It is clear that the benefits in Case 3 are less than in Case 1, although the extent of this will vary with the specific scheme.

The Four Stage Model

It has been conventional since transport planning was first practised in the late 1950s to represent trip-making as a four stage process. The stages are:

- Trip generation: the number of trips attracted and generated in each zone, depending on factors such as number of households and level of employment
- Trip distribution: establishing the origin-destination pattern of trips, depending on the "attractiveness" of zones and the impedance between them
- Modal split: the choice between private and public modes and possibly also sub-modes such as bus or train
- Assignment: the choice of route, given a particular pattern of trip movements.

Of these, assignment is almost always used as it indicates the level of traffic which can be expected on the different parts of the network. Depending on local factors, such as data availability, and study budget, other stages are often omitted. Where they are included, there is usually an element of iteration or (in more recent studies) performing stages simultaneously. Time of day choice, which is what drives peak spreading and contraction, is conspicuous by its absence.

Notwithstanding the 'traditional' approach, recent evidence of peak spreading and its impact is leading to a much increased emphasis on this 'forgotten' part of the decision process as discussed elsewhere in this report. This is summed up well by the UK DTLR (1997) (emphasis added by the authors):

"Departure time choice is an important, and in practice too often ignored, element in the demand model process. Empirical evidence indicates that, ***after re-routeing*** *(assignment)****, trip re-timing is the most likely response to changes in network costs".***

While this omission is now being addressed, the development of modelling approaches is still in its infancy relative to the other stages and their application is almost non-existent. The issue is made more complicated by the fact that it is now considered most robust to model time of day choice as part of the route choice or assignment stage.

Behavioural Aspects

Bates (1996), in his appraisal of time period choice modelling, summarises the research that has been carried out into what actually causes peak spreading to take place, i.e. how people respond to congestion.

The work highlights the basis of understanding peak spreading – how trip makers compromise their preferred arrival times in order to save travel time. Generally speaking, the majority are indifferent to early arrival but late arrival causes more concern. The degree to which a user can modify their behaviour is a function of the number of available constraints. Uncertainty is shown to be a key driver – in conditions of certainty it seems that very little shifting from preferred arrival times would take place. The work of Small (1992) shows how in highly constrained, uncertain conditions, people will begin to start arriving much earlier at the workplace so as to avoid lateness. Put simply, if there is a high likelihood of being fired for lateness and we are unsure as to the traffic delay to be encountered, then we will leave home much earlier for psychological comfort, thus increasing the probability that we will arrive early.

With regard to the current methods by which travel demand is modelled, the findings may be a cause for concern. Using Preferred Arrival Times (PATs) as the starting point as to how trip timing is estimated is a radically different approach from those currently used in conventional transport modelling methods, and the data collection needs are also different shifting from a basis of unconstrained to constrained travel. The modelling would need to take place at a very disaggregate level and the data required to calibrate the model would be difficult and time consuming to obtain.

Modelling and Evaluation in Different Countries

Whilst computational issues are being resolved, in the interim period the United Kingdom Government has taken the view that it is better to represent peak spreading in a simple fashion than to assume a fixed profile that in effect ignores it.

The UK Government publication "Design Manual for Roads and Bridges" (DTLR, 1997) offers an overview of potential methods for modelling peak spreading . They include:

- Creating uniform relationships between the proportion of peak period traffic that occurs in the peak hour and an index of peak period traffic growth (similar to the PSER described above)
- Calculating the relationships between the ratio of flows in the two half-hour periods adjacent to the peak to the flow in the peak hour itself – peakiness factor – and the average traffic speed
- Count-based methods to estimate the relationship between peak flow and peak period flow using the volume to capacity ratio as an explanatory variable
- Proportionate models using stated preference techniques to determine the proportion of drivers who would set off earlier to avoid specified levels of congestion and,
- Incremental logit models of departure time choice which rely on changes in travel costs to govern the spread of demand over the peak period.

The manual does not advocate a particular method and each technique has drawbacks and advantages. The resulting forecasts can also differ between techniques. According to Van Vuren et al (1995) count based models are easier to apply, with incremental logit models the most "elegant". However it is acknowledged that each technique has its drawbacks.

The latest thinking on the subject from the UK has only emerged within the last few months and is the outcome of a wide-ranging study commissioned by the Government. The resulting model is called HADES: Heterogeneous Arrival and Departure Times based on Equilibrium Scheduling Theory (DTLR, 2002).

Many previous models have approached the departure time process as a discrete one; for example the choice may be between travelling in two different time periods (7 – 8 or 8 – 9, peak or off-peak). However, with certain simplifying assumptions it can be shown that it is possible to approach the problem as a continuous time process.

With the HADES approach travellers choose their departure time so as to minimise a generalised cost which has two components:

- travel time, as in ‘conventional’ assignment models
- schedule delay, the difference between a traveller’s Preferred Arrival Time (PAT) and their actual arrival time.

Further advantages of HADES are:

- network costs can be derived computationally (eg. from assignment)
- it allows for a PAT indifference band (eg. the traveller is prepared to arrive between 8.50 and 9.00 am)
- different user classes (eg. with different sensitivity to delay) can be accommodated.

A number of early applications have been reported, using models of two middle-sized UK towns and a number of software platforms. As would be expected, they are data hungry but this can be overcome to some extent with ‘PATSI’, (Polak et al, 2000) which allows Preferred Arrival Times to be inferred from readily available traffic data.

The US Department of Transportation (2001) and the DOT's Travel Model Improvement Programme (2001) describe how time of day assignment can be incorporated into the traditional 4 stage model - generation, distribution, mode choice and route assignment. More innovative approaches are also detailed that mirror the UK approaches:

- Link-based peak spreading – diverting trips to the shoulders (used in Arizona, below)
- Trip-based peak spreading – spreads the number of trips in an OD

All of these methods, and others, have been used with some degree of success in various appraisal projects. As early as 1988 the Arizona State Department of Transport (1988) developed a model to estimate peak spreading using historical data from forty nine freeway and arterial facilities in Arizona, California and

Texas. A functional relationship was developed between the volume to capacity ratio and the peak hour factor (the ratio of volume of traffic volumes in the peak hour to the three highest hours).

More recently in the USA, Cambridge Systematics (1999), who undertook much of the above work in Arizona reduced the peak hour trip table to reflect network capacity constraints. Selective reduction, rather than global reduction was used in order to keep corridor volumes realistic. This method was used in work carried out for Boston's central artery/ tunnel project for the Massachusetts highway department. In Phoenix, the same company used a peaking factor function for each link to estimate revised travel times during the assignment procedure – this apparently resulted in "significantly more realistic estimates of future traffic volumes and speed on congested highways" (DOT, 2001).

Purvis (1999) documents a model developed for the San Francisco Bay area by the Metropolitan Transportation Committee. In this, two modelling approaches to spread the peak were attempted: the use of traditional peaking factors to convert daily non-work trips into peak period vehicle trips and the use of a multinomial departure time choice model that has the peak, the shoulder and other hours of the day in a three alternative model.

For the Dulles Corridor Transportation Study, Parsons Brinckerhoff (ACT, 1997) used an interchange based logit model that used congestion as the independent variable, with the data being stratified by purpose. Allen (1991) used a poisson model to analyse peaking at the link level in New Jersey.

More recent work (Van der Zijpp et al, 2001) proposes an approach similar to HADES, in which departure time choice is modeled simultaneously with route choice. The paper avers that departure time choice can be viewed as route choice in a suitably defined hypernetwork, with the "conventional" trip matrix further broken down by preferred departure time. A method for estimating the demand matrix so as to reflect PATs is proposed. The mathematical problem arising from this is formulated and solved in the paper, but is not clear whether the approach has been applied practically.

DOT (2001) concludes with a description of some emerging modelling approaches:

A model of time of day choice that predicts the period of travel as a function of variables such as free flow and congested travel times, transit level of service, trip purpose, and area type variables. This can be a logit model that could be applied after mode choice.

A model of whether peak period trips occur in the peak hour or not. This can also be implemented as a logit model as part of a "variable demand" multiple vehicle class assignment. Use of a variable demand assignment guarantees that the results of the peak hour models are in accord with the congestion resulting from the assignment. Off peak vehicle trips would still be assigned using a traditional static demand assignment.

A model based on a combination of traditional TOD factors and a binary time-of-day choice model. The choice model will be based on congestion represented by peak/off-peak travel times, delays, etc. The underlying hypothesis is that *relatively higher congestion during peak time results in a higher likelihood of off-peak choice.*

The approaches to highway scheme evaluation from a number of countries have been examined to determine whether there is any requirement for peak spreading to be taken into account. Only in the UK and New Zealand was this found to be the case, and it is not clear for either the extent to which these requirements are met in practice.

Summary and Conclusions

This research into the spreading of traffic peaks has found considerable evidence of the phenomenon, both in New Zealand and elsewhere. There is also a sizeable body of research on the subject, largely concentrated in the UK and USA.

Peak spreading has been clearly identified in a number of UK cities in studies which go back more than 10 years. Its existence cannot therefore be questioned. In the NZ cities of Auckland and Wellington, at one key point in the roading network of each city it has been possible to identify clearly how the morning peak is spreading. On SH1 north of Wellington, the peak currently lasts about one hour and in the peak 3 hours about 2/3 of the available capacity is used. On Auckland Harbour Bridge, traffic levels are approaching capacity over the full 3 hours from 6.30 to 9.30 am. Both pictures contrast with those of 10 years ago. In Wellington it appears that the Newlands Interchange construction lead to some peak contraction and this finding has been borne out at the level of individual travellers.

Several other examples have been observed of the converse effect, peak contraction: when capacity is increased, trips are re-timed to take advantage, leading to a shorter peak. This has been previously documented in the cases of the Amsterdam Ring Road and Sydney Harbour Tunnel.

The traditional four-stage model explicitly excludes any element of time-of-day choice. Interestingly, however, the current thinking is that the time of travel is the second most important decision after route choice. Extensive work is under way in the UK to address this, with the main emphasis on models which combine the two choice mechanisms; ie. the generalised cost of a trip comprises both the usual elements relating to travel time and the scheduling delay. Trialling of the approach looks promising but is not yet complete. The potential impact on scheme benefits has not been assessed. A similar approach has been reported on in the USA but appears to be less well developed.

Peak spreading has also been modelled using elasticity approaches, although these often relate to the general issue of “induced traffic”, which (depending on the context) may not explicitly include peak spreading. Another approach is to look at how the peakiness over a longer period (typically 3 hours) has been seen to change in the past and projecting this into the future.

Taking account of peak spreading will affect the economics of a scheme, in two ways. Firstly, peak spreading in the future Do Minimum may reduce the level of congestion below what is forecast. Secondly, peak contraction with the scheme in place may mean that the full predicted benefits are not realised. Both these will act to reduce the actual benefits below those forecast. Despite this, only in New Zealand and the UK has reference been found to the need for peak spreading in the documents which set out the approach to project evaluation.

Acknowledgements

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