CAPTURING PUBLIC TRANSPORT BENEFITS OF ALLEVIATED ROAD CONGESTION

David Kilsby[1], Paul van den Bos[2]
[1] Principal, Kilsby Australia
[2] Principal, Computing in Transportation

Introduction

This note considers a method for incorporating the benefits to the public transport system in a conventional benefit-cost analysis of a road project. It uses the example of Charles Street in Parramatta as a case study. The calculation is an indicative one only, as assumptions made in the analysis would lead to both under- and over-estimation of the economic performance. Nevertheless the indications are that including the public transport benefits, mainly the savings in replacement depreciation to the operators due to enhanced operational reliability, could increase the economic performance of a project by almost 50%.

Benefits

The savings attributable to the road project are conventionally estimated as a combination of the value of time savings (to individual drivers), savings in infrastructure maintenance costs (to the road supplier) and accident cost savings (to the community). What should the equivalent public transport savings consist of? This partly depends on the nature of the contract conditions under which bus services are provided. But if we assume that the provision of bus services is essentially a government responsibility, then the savings in time to bus users become irrelevant. Given that buses must run to a timetable, it is largely irrelevant whether the buses are full, empty or somewhere in between, or what the value of time should be used for the bus passengers. We believe that the key feature of bus services should be reliability: unreliable operation costs the operator money because he or she has to allow for more recovery time in the scheduled layover and hence perhaps assign more peak vehicles than otherwise to the route. It is mainly these savings related to the Charles Street extension which we believe can be incorporated into the economic analysis and which will increase the BCR. The argument that these savings accrue to the private sector is a quirk of the way public transport is organized in Sydney: it would not apply in inner Sydney, nor to any railway project.

On the cost side, it is debatable to what extent the costs of public transport operation should be included. For simplicity we have omitted them, as most of the costs of operation would lie outside the area affected by the road extension.

Case Study

An interesting test case was brought to our attention by officers at Parramatta City Council. The case for funding a local road extension had been rejected by the State Government road agency, among other things because the cost-benefit ratio was not high enough. Setting aside the other issues, we wondered whether incorporating the effect of improved reliability, and in particular the cost savings implicit in reduced bus layover time, would have a material impact on the cost-benefit ratio.

Parramatta is regarded as the "second CBD" of Sydney, and the central area is very congested. This is exacerbated by an earlier Council policy of placing multi-storey car parking in the central area, and by the future redevelopment of Civic Place (including massive amounts of new car parking) as part of the development associated with the nearby Parramatta Bus/Rail Interchange.

Virtually all buses terminating in Central Parramatta, apart from Transitway buses, follow the same one-way loop through central Parramatta. The majority of buses terminate at the station bus interchange or Darcy Street, and enter the loop from whichever direction they come, proceed around it until they reach their terminus, and on leaving the terminus proceed further round the loop until they leave it in the opposite direction to which they entered it.

Figure 1 – The (clockwise) bus loop in Central Parramatta

Figure 1 shows this bus loop in principle. It consists of Argyle Street/Marsden Street/George Street/Smith Street/Darcy Street/Argyle Street. In fact not all buses follow this loop and establishing the exact routeing of buses would be a refinement of the process (see later).

Charles Street is not part of this loop. It runs between the ferry terminal and Hassall Street, terminating one block short of Parkes Street. It is this extension from Hassall Street to Parkes Street which constitutes the proposed “Charles Street extension”. If implemented, it would make Philip Street and Charles Street an alternative route between the north and east sectors of central Parramatta. While it would not have buses running on it, the relief afforded to the roads on which the buses do run would be such that bus reliability would be greatly enhanced and hence timetable recovery time could be reduced, thereby reducing the peak vehicle requirement and the costs of bus operation in the central area. Figure 2 shows the location of Charles Street and its proposed extension, relative to the bus loop shown in Figure 1.

Figure 2 : The Charles Street Extension

Analysis Tools

The proposal to extend Charles Street was analysed by traditional traffic engineering tools, namely SIDRA intersection analyses to establish user cost savings (ie cost savings to car occupants) and savings in accident costs and maintenance costs. To incorporate the benefits to the public transport system a different sort of tool was needed, one which would model the operation of the small area network including Charles Street and surrounding streets, and which would incorporate some sort of measure of the variation in travel times.

We believed that neither the conventional small area models nor conventional microsimulation models were adequate for this task. The former (e g SATURN) did not produce measures of the variability of travel time while the latter (e g PARAMICS) did not recognize the fact that the paths chosen by motorists to get through the network might vary as congestion varied from minute to minute. We believe that a new analysis tool produced by INRO (the developers of the well-known EMME/2 model), known as DYNAMEQ – dynamic equilibrium – gave us the necessary facilities.

DYNAMEQ is essentially a hybrid model, linking some of the features of network models with some of the features of microsimulation models. It is a very useful complement to the well-known facilities available within EMME/2.

The initial evaluation

The initial evaluation, performed by conventional traffic engineering analysis (using SIDRA) produced a Benefit-Cost Ratio over 20 years of 4.04 and many other performance measures. Details are given later in Table 1. There are issues over funding the Charles Street extension beyond the Benefit-Cost Ratio, and these are beyond the scope of this note.

The revised evaluation

The revision takes account of the fact that the Charles Street extension would make traffic flow on the "bus loop" less variable, even though Charles Street itself was not part of that loop. The concentration of buses in central Parramatta is the exception rather than the norm for western Sydney centres and the results obtained by applying this method in central Parramatta would probably not be produced elsewhere to the same extent.

By building a Dynameq model of the CBD, we can estimate how long it would take to traverse this loop for every two-minute interval of, say, the morning peak two hours. These times would have a distribution with a standard deviation. Presumably the effect of the Charles Street Extension would be to reduce the loop traversal time and the standard deviation. Early indications are that the loop traversal time might reduce by 12 seconds and the standard deviation by about 3 minutes.

The first reduction would affect the Bus Hours Travelled and save the operator money, mainly through a saving in driver payments; the second reduction could save on the number of peak buses required. Because there are so many operators involved, and the number of peak vehicles in each fleet has to be an integer, the savings with the present operating regime are probably greater than would be the case for an integrated operation, which is what we would have to assume in calculating the impact (the alternative would be to treat each operator as a separate entity).

The annual savings for an integrated operation could be calculated by multiplying the time saving by the number of buses per day by the average cost per hour of a bus by a daily-to-annual equivalence factor , and adding this to the change in the number of peak vehicles required to serve Parramatta CBD (if operations were integrated) times the average annual cost per peak vehicle.

The EIS for the Liverpool-Parramatta Transitway included a costing model for bus operations which suggested that bus operating costs should be estimated (in 2000) as

$40.40 per bus hour plus $0.60 per bus km plus at least $31,820 per peak vehicle (the replacement depreciation).

For illustrative purposes only, let us test whether this would make much difference to the BCR. If the Charles Street extension was able to cut 12 seconds from the central loop traversal time in the morning and evening peaks (each assumed to be 2 hours long), and reduce the standard deviation of the traversal time by about 3 minutes, then the additional savings would result from the quicker travel time plus the greater reliability.

For the first, if there were 400 buses a day enjoying 12 seconds faster travel (half in the am and half in the pm peak) and 250 days a year when this applied, the annual savings would amount to maybe 400*0.2*40.40*250/60 or $13,360.

For the second, if we assume that loop traversal times are normally distributed (and hence that 95.45% of buses would have times between T+2s and T-2s, where T is the loop traversal time and s is its standard deviation) and hence that a reduction from s to s* (s*<s) then the annual savings in peak vehicles would amount to maybe 100*(2(s-s*))/60*31,820, or about $318,200 per year, if there were 100 buses entering Central Parramatta in a one hour period of the morning peak (we assume that none of them would enter the CBD twice in that one-hour period) and that the standard deviation was reduced by three minutes – the savings would only apply to the tail of the curve, of course, not the initial portion.

(In practice the distribution of loop traversal times conforms more to a shifted Gamma distribution. In this case, the shifted Gamma distribution starts at the minimum travel time (rather than the origin). There is extremely little variation in the minimum travel time between the "before" and "after" cases. All the variation occurs in the long tail.)

Given these simple assumptions, there would therefore be an additional annual benefit of about $331,560.

The effect of the assumed normal distribution of travel times on the BCR and other measures is shown in Table 1. (This calculation is indicative only as there were some assumptions in the above, discussed below, which would need to be replaced with better estimates. These would change over time, and costs would need to be in 2001$). The saving in the peak vehicle requirement is the major part of the total saving.

Table 1: Illustrative revision of Benefit-Cost performance

	With the PT benefits				Without the PT benefits			
		30 yr	20 yr	10 yr		30 yr	20 yr	10 yr
Discount rate (%)	r=	4	4	4	r=	4	4	4
Present Value of Costs ($2001m)	PVC=	1.87	1.87	1.87	PVC=	1.87	1.87	1.87
Present Value of Benefits ($2001m)	PVB=	15.09	11.13	5.42	PVB=	10.28	7.54	3.65
Net Present Value ($2001m)	NPV=	13.22	9.26	3.55	NPV=	8.41	5.67	1.63
Benefit Cost Ratio	BCR=	8.08	5.96	2.90	BCR=	5.50	4.04	1.95
First Year Rate of Return (%)	FYRR=	46.10	46.10	46.10	FYRR=	30.93	30.93	30.93
Internal Rate of Return (%)	IRR=	28.93	27.86	11.66	IRR=	20.21	17.90	-6.69
NPV/Dollar of Capital Outlay	NPV/CO=	7.08	4.96	1.90	NPV/CO=	4.50	3.03	0.87

It can be seen from Table 1 that the inclusion of the benefits to public transport has raised the 20-year Benefit-Cost Ratio (which of course is just one of the many performance measures) from 4.04 to 5.96.

Issues

Several issues are raised by this approach, most of which could be eliminated by a more painstaking analysis.

For a start, Dynameq estimates the travel time on the bus loop for every two minutes of the morning peak, and from this a picture of the variability is built up. We rather doubt whether any bus could travel the entire circuit within two minutes, meaning that the actual travel time would be the time for part of the circuit in one two-minute period, and the time for the remainder of the circuit in the following two-minute periods. The actual measure required would reflect the variability within each two minute period, not between them. However it is unlikely that the recovery time built into the bus timetables reflects such a degree of sophistication within the morning peak hours, and therefore the variability of the travel time within the peak 2 hours is an acceptable proxy for the variability of the travel time relative to the scheduled times.

Most buses in Parramatta travel in a circuit George Street/Smith Street/Darcy Street/Argyll Street/Marsden Street/George Street, leaving the circuit at the same point that they entered it, although some buses go further and terminate in Market Street. If as a result of the Charles Street extension congestion in the CBD is reduced, it may be possible for buses to travel this loop a little faster and with greater certainty of duration. It is probable that the assumptions made for this calculation have the effect of over-estimating the savings, as not every bus in central Parramatta uses this loop.

The calculation of the savings in peak vehicles assumes that the savings from individual operators can be amalgamated. This is not the case in Parramatta, which is predominantly served by a number of independent private-sector bus operators. The peak vehicle requirement must, by its nature, involve a whole number of buses and therefore a saving of half a peak vehicle to (for instance) Westbus and a saving of half a peak vehicle to (for instance) Baxters would represent a saving of two peak vehicles (one each) and not one which would require an assumption of integrated cross-scheduling. The method in this respect therefore under-estimates the savings.

Conclusions

Inclusion of the benefits to bus operators of improved liability could improve the 20-year benefit-cost ratio of the Charles Street extension by as much as 48% (from 4.04 to 5.96). This is despite the fact that Charles Street is not part of the CBD bus “loop”, but its extension to Hassall Street could improve the operation of the central area network in a way that allows estimation of benefits to public transport operators.

To do this it would be necessary to have a tool that operates at both a macroscopic and a microscopic level, to establish (a) the travel time of buses on roads away from the one being directly treated and (b) the extent of variation of that travel time. The Dynameq tool developed by INRO Systems of Canada (the developers of EMME/2) offered the requisite hybrid capability.

This method demonstrates that the treatment of public transport benefits calls for a different approach than if only road users were being considered, but it has the potential to make a much stronger case for road projects if they are likely to be of value to bus systems operations rather than via direct time savings to bus passengers.