THE LEEDS ADAPTIVE STATED PREFERENCE METHODOLOGY

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Abstract

The objective of this paper is to present for the first time a full description of the current version of the Leeds Adaptive Stated Preference (LASP) methodology. This is illustrated with an example relating to a developing country, India. Although there were funds only for a modestly sized survey, LASP proved capable of providing valuable guidance to freight operators there. This paper first explains the working of the Leeds Adaptive Stated Preference software and then presents brief details of the survey and the data analysis.

1. INTRODUCTION

This paper demonstrates how Adaptive Stated Preference techniques can be used to model freight demand. The particular Adaptive Stated Preference technique adopted is LASP, Leeds Adaptive Stated Preference, and the major objective of this paper is for the first time to present a full description of its methodology. Due to commercial considerations, previously only partial descriptions have been presented (Fowkes and Tweddle, 1988; Fowkes, Nash and Tweddle, 1991), and then only for an early version. The popularity of the method is clear from Danielis and Rotaris (1999), whose list of 16 SP freight studies contains 7 based on LASP.

For illustration purposes, an application of LASP is given, using data from a relatively small sample of freight shippers in India. The Container Corporation of India (CONCOR) required, within a modest budget, to evaluate the viability of introducing regular domestic container train services between main centres. As part of that, the demand side implications were investigated using a LASP experiment to estimate the monetary valuations that shippers place on the various attributes of freight transport by different modes. The particular circumstances encountered led to more being asked of LASP than ever before, six monetary valuations being required.

In section 2 we describe the methodology used and present some details about the working of the LASP software. Section 3 describes the survey design and execution, section 4 presents the analysis of LASP survey data and section 5 presents our conclusions.

2. METHODOLOGY

2.1 Adaptive SP designs

Stated Preference experiments consist of a set of ratings, rankings or choices between alternatives described by attributes set to particular levels. It is usual, because it provides useful data, to choose attribute levels such that alternatives do not ‘dominate’ each other, i.e. are not better in all respects. Instead, interesting trade-offs are built into the experiment, where respondents are given more of one good (or less of a ‘bad’) in return for less of another good (or more of another ‘bad’). Responses then permit something to be said about respondents’ preferences. With just two attributes, for each response we can say on which side of a line a respondent lies. With more attributes we have a plane in multi-dimensional space. A good SP experiment will seek to hem-in the respondent in this multi-dimensional space, such that their preferences (or utility) weightings can be determined with an acceptably small level of error.

Initially Stated Preference experiments in transport were conducted using pen and paper face-to-face interviews or by self-completion questionnaires, with both methods sometimes involving cards showing one or more alternatives. The responses were later entered into a computer. The growth of computing power, especially in portable machines, made it possible to enter responses at the time of the interview, reducing the possibilities for mistakes, and to show the alternatives to the respondent on the computer screen. Background questions could be asked ahead of the SP experiment, the responses entered directly into the computer and so available to ‘customise’ the SP experiment to the respondent.

The term ‘customisation’ has come to denote, within the SP fraternity, the practice of setting the attribute levels ‘around’ the current levels experienced by the respondent. With self-completion questionnaires that was only possible by using descriptions such as ‘As now’, or ‘As now plus 10 minutes’. It was not always clear that the respondents offered a choice between ‘As now plus 10 minutes’ and ‘As now less 5 minutes’ always appreciated that a 15 minute time saving was on offer. With a computer, respondents can be asked for their current travel time, and the SP experiment can take this into account. In the previous example, a respondent with a travel time of 40 minutes would be given alternatives with travel times of 50 minutes and 35 minutes to choose between. Furthermore the design could offer bigger time savings to respondents currently travelling for a long time. Infeasibly small travel times can be checked for and the experiment amended. Customisation is therefore a big help in SP design.

Adaptive Stated Preference (ASP) takes the process one step further, and amends attribute levels offered in later stages of the experiment in the light of responses to earlier stages. For example, a respondent who would not pay £5 for a new transport facility, would not be asked if they would pay £10, until it becomes clear that the earlier response was a mistake.

One great advantage of ASP, when studying freight, is that the experiment will be able to cope with a wide range of ‘true’ valuations. By ‘true’ valuations we mean the unknown population valuation that the experiment is trying to recover. Some commodities will be highly perishable and so have a very high value of scheduled journey time and a great aversion to delays. The firm transporting these commodities might transport other sorts of commodities, so that we could not be sure in advance which commodity they would choose for the interview. Furthermore, some commodities will have different attribute valuations at different times. For example, a car radio being supplied as a part of a Just-in-Time supply chain will have higher journey time and reliability valuations than a car radio moving to a retail sales point. The ability of an ASP to adjust its questions quickly, in the light of earlier responses, is clearly very valuable.

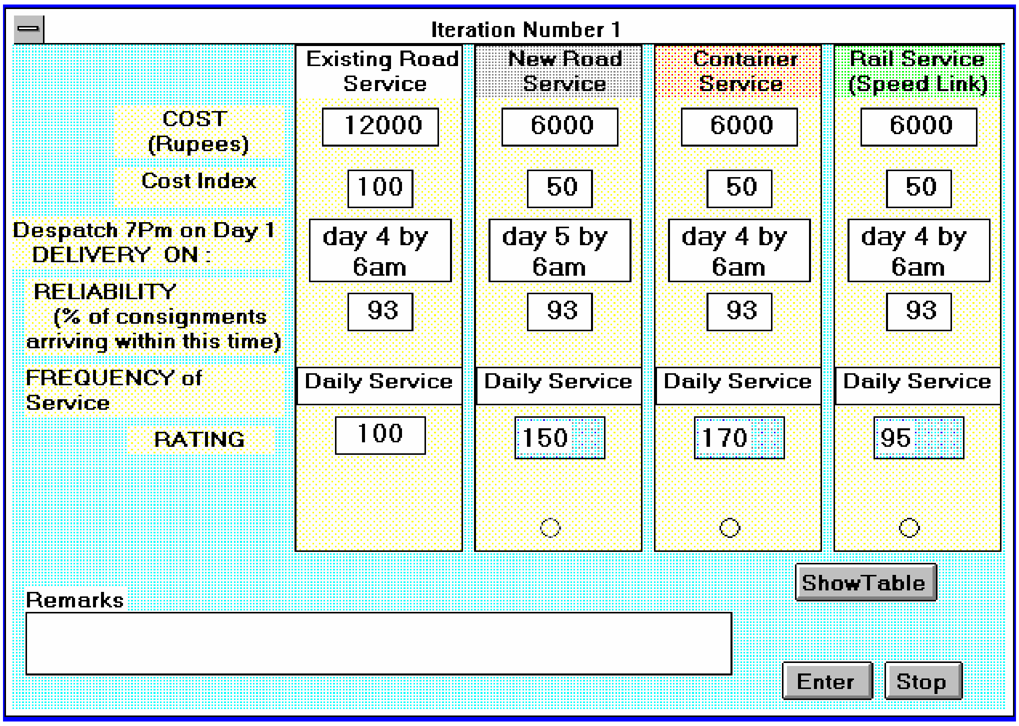
However, many ASP experiments had poor results. Work by Bradley and Daly (1993) showed that bias could easily be introduced into SP data when using adaptive techniques. They found that this bias arose when the levels of the independent variables become correlated with the unmeasured components of individual preferences across the sample.

They put forward various suggestions, including fitting models separately for each respondent. Leeds Adaptive Stated Preference (LASP), does fit a separate model for each respondent. It was introduced by Fowkes and Tweddle (1988) in exactly the context of the determination of attribute valuation of freight shippers facing a new intermodal alternative. The detailed working of LASP has not been presented in the literature before. It is described in the following sections. Section 2.5 describes the pre-survey simulation testing required to check that assumed parameter values can be recovered with no detectable bias from any source.

2.2 Leeds Adaptive Stated Preference (LASP) Software

LASP is adaptive SP data collection software designed to be used on a laptop computer. It is designed for use in freight studies (Fowkes & Tweddle, 1988), though it can also be adapted for other purposes. It has been successfully used for freight studies within Great Britain (Fowkes, Nash & Tweddle, 1991) and for Cross Channel studies (Tweddle, Fowkes & Nash, 1995, 1996; Fowkes & Tweddle, 1997). The software has also been sold for use in the Netherlands and Switzerland (see Bolis and Maggi, this volume).

Figure 1: LASP screen format



LASP uses a four column format, with the initial attribute levels being based on the data about the currently used mode. The attribute levels for subsequent iterations are modified on the basis of the ratings given in the immediately preceding iterations. The respondent is first asked to think of a typical flow and give details. The first column usually resembles the current position regarding the typical flow, and remains unchanged throughout the exercise. Figure 1 illustrates our discussion here with an actual screen from our illustrative survey. Columns 2 (New Road Service), column 3 (Intermodal Container Service) & column 4 (Through Rail Service) represent hypothetical alternatives to the service shown in column 1. Initially, an attempt is made to get the respondent to prefer these alternatives to that in column 1.

For each alternative, attribute levels are given. The base alternative (column 1) is given a rating of 100 and the respondent is then asked to give ratings for each of the three alternatives as compared to the base option. On the basis of the ratings given, the algorithm further modifies the attribute levels for the next iteration (screen).

In the LASP method, each column has a series of 'Tasks' to perform: such as obtaining data for estimating the Alternative Specific Constants (ASCs), the Value of time (VOT), the Value of Reliability (VOR) etc. The algorithm is designed to induce respondents to alter their ratings of the alternatives (columns) and thereby home in on their valuations that make them indifferent between a pair of columns (where usually one of these columns is the first column). The aim is to achieve this in the minimum number of steps. A 'task' is considered to have converged when the ratings for two alternatives are within a certain 'tolerance band'. Once a particular task has converged, the column begins its next task.

For example, in Figure 1 the first task for column 2 is to obtain data for estimating the value of scheduled journey time. The mode for column 2 has been kept the same as for column 1. All attributes except 'time' and 'cost' are kept the same in column 1 and 2 for this 'task'. The cost is varied iteration by iteration until acceptable convergence is reached. If this cannot be reached at any reasonable cost level, the time difference is reduced. Otherwise, once sufficient convergence is achieved, this column will go on to the next 'task'. Similarly columns 3 and 4 work to value the Alternative Specific Constants (ASCs) for the two alternative modes as their first task. Accordingly, initially all non-cost attributes in column 3 and 4 are held identical to those in column 1 and the cost is varied to achieve convergence.

Each respondent is usually presented with at most 9 screens which give us 27 pairs of binary choice data per respondent (i.e. comparing 1 v 2, 1 v 3, 1 v 4 each 9 times). It is, however, possible to terminate the interview earlier in case the respondent appears to be getting fatigued. Alternately, it is possible to have more than 9 sets of tasks, if sufficient useful data has not been obtained and the respondent is willing to continue. In other applications of LASP each screen was converted to 6 binary choices (i.e. 1 v 2, 1 v 3, 1 v 4, 2 v 3, 2 v 4, 3 v 4), and the computer generated standard errors scaled up by the square root of two to compensate. This roundabout procedure sometimes gives more robust results, but not in the Indian case.

2.3 Data Analysis - Individual Level Models

The data collected was analysed by creating a utility function which expressed the utility of a mode as a function of the option attributes. So if option 'i' is characterised by a set of n attributes X_{ij}, the utility, V_i is given by:-

$$V_i = \sum_{j=i}^{n} \beta_j X_{ij} \qquad (1)$$

where the β_j are the relative importances, or weights, of the attributes. The modelling procedure then adopted was the widely used binary logit model which models the probability of choosing option 1, denoted P_1, over a choice set of 2 different options, as a function of indirect utilities (V_i) of the different options:

$$P_1 = \frac{\exp(V_1)}{\sum_{i=1}^{2}\exp(V_i)} \qquad (2)$$

Since in each iteration the respondent was asked to provide 3 ratings, there are three degrees of freedom per iteration. With typically 9 iterations, we will have 27 degrees of freedom available for calibration. When comparing two columns, which we shall here label A and B, the ratings (RATEA, RATEB) were converted into probabilities as follows:-

$$\begin{aligned} &\text{If RATEA} > \text{RATEB then } P(A) = 1 - 0.5*\text{RATEB/RATEA} \qquad (3) \\ &\text{If RATEB} > \text{RATEA then } P(A) = 0.5*\text{RATEA/RATEB} \end{aligned}$$

If we now define a variable DX_j as the difference in attribute X_{ij} between option 1 and 2, that is:

$$DX_j = X_{Aj} - X_{Bj} \qquad \forall\ j \qquad (4)$$

then the model can be re-expressed as

$$\text{LogitA} = \ln\frac{P(A)}{1 - P(A)} = \sum_{j=1}^{n}\beta_j DX_j \qquad (5)$$

which is suitable for estimation by weighted least-squares regression, where the weights (see equation 6 below) are designed to give increased weight to ratings close to 100.

$$\text{Wt\_A} = \begin{cases} \text{RateA/100} & (\text{if RateA} < 100) \\ \text{100/RateA} & (\text{otherwise}) \end{cases}$$

$$\text{Wt\_B} = \begin{cases} \text{RateB/100} & (\text{if RateB} < 100) \\ \text{100/RateB} & (\text{otherwise}) \end{cases}$$

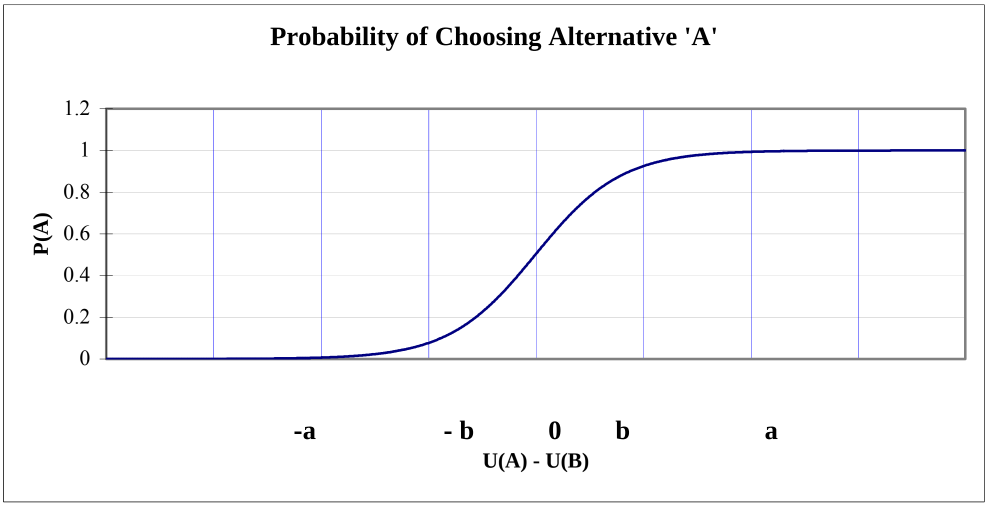
$$\text{Wt} = (\text{Wt\_A} * \text{Wt\_B})^{\gamma} \qquad (6)$$

where γ is determined from the simulation work. In the Indian case $\gamma = 2$ was chosen.

This procedure is based on the possibility that respondents respond most precisely when choosing a rating near 100. They will know whether the rating should be 95 as opposed to 105 (the difference between these ratings implying a changed ranking relative to column 1 with its fixed rating of 100) much better than they would know whether the ratings should be 20 as opposed to 25 (when both are, presumably, completely unacceptable).

To illustrate this point, consider again the two alternatives 'A' and 'B'. In the Logit curve of Figure 2, let the Y axis represent P(A) and the X axis represent the difference of the utilities of the two alternatives {U(A)-U(B)}. Intuitively it can be seen that values of U(A)-U(B) lying between '-b' and 'b' are the values where a change of decision can take place. For values of U(A)-U(B) less than '-b' the choice is almost certainly 'B' and for values of U(A)-U(B) greater than 'b' the choice is almost clearly 'A'. As such, very little information is likely to be obtained from observations with utility differences lying outside the range (-b, b). If we consider the ratings to be indicative of the utilities of the alternative modes, the range (-b, b) would correspond to ratings close to each other.

Figure 2 : Logit Function for P(A)



Simulations carried out using this and other weighting functions, in the Indian case, indicated that the use of this function (equation 6) improves the recoverability of the underlying values significantly as compared to analysis without any weights or with any of the other weighting functions tested. An alternative weighting scheme, not used in the Indian case, is:

$W=P(A)(1-P(A))/n$

which is derived from statistical theory as a means of avoiding heteroskedasticity.

2.4 Data Analysis - Aggregate Sector Level Models

Monetary valuations are given by ratios of the parameter estimates to the cost parameter estimate. The 't' values of the ratios of the coefficients were calculated as :- $-$

$$\mathrm{var}\left(\frac{\hat\beta_A}{\hat\beta_B}\right)=\frac{1}{\hat\beta_B^2}\left[\mathrm{var}\,(\hat\beta_A)-\frac{2\hat\beta_A}{\hat\beta_B}\mathrm{cov}\,(\hat\beta_A,\hat\beta_B)+\frac{\hat\beta_A^2}{\hat\beta_B^2}\mathrm{var}\,(\hat\beta_B)\right] \tag{7}$$

From here, our procedure is to group respondents together (possibly the whole sample together) and take weighted averages of their individual valuations. The weighting used is the inverse of the variances of the estimate, i.e. the valuation which has the greatest variance (i.e. the poorest estimate) gets least weight.

Let us denote the combined estimate as 'r' and the individual firms estimates as 'r_k'. Similarly, let the variance of the combined estimate be 'v', and the variance of the individual estimates be 'v_k', then:

$$r=\frac{\sum\frac{r_k}{v_k}}{\sum\frac{1}{v_k}} \quad \text{and} \quad v=\frac{1}{\sum\frac{1}{v_k}} \tag{8}$$

2.5 Simulation Testing of Experimental Design

From the earliest development of LASP, it has always been held as vitally important that proposed designs (i.e. the rules for altering the attribute levels at each iteration) should be thoroughly tested by simulation. Respondents working with rating scales of varying 'widths' (relative to the rating of 100 for column 1) are considered. Utility functions (i.e. generalised cost functions), often non-linear, are used to generate responses to each iteration, up to the number of iterations proposed for the experiment. The resulting data is then analysed, as detailed above, to check that the assumed parameter values can be retrieved with acceptable precision. This procedure sometimes uncovers biases of the type referred to by Bradley and Daly (1993), in which case modifications must be made to the LASP algorithm rules employed. This has never proved to be very difficult to do, and acceptable accuracy of parameter recovery has been achieved. If, in extensive simulation exercises, parameter values can be retrieved with acceptable accuracy, there is every reason to believe that the same will be true in the actual survey.

In the present case, the simulation testing was done in two main phases. In the first phase the simulation was carried out after each modification (to such things as the number of attributes, task order and attribute ranges) to ensure that the basic algorithm design was capable of recovering the underlying valuations. In the second phase, we modelled simulated data to compare the results using our method of weighted averages for aggregation of individual firm models with different models using data pooled over firms. The details of the simulation testing are given in section 3.3.

3. SURVEY DESIGN

3.1 The Pilot Survey

In the absence of any previous SP survey results from India (and very few in similar contexts in the developing countries), it became necessary to check for any problems that might be faced in applying SP methods to Indian conditions with special reference to the use of Adaptive SP designs. A pilot survey was carried out in India in September 1997. In all, six interviews were conducted using LASP. The respondents included one manufacturer, three Freight Forwarders/transport operators, a transport consultant and a intermodal service provider. At the end of each LASP interview, the respondents were asked to comment about the exercise they had been through and any problems they faced during the course of the exercise.

3.2 Final Survey Design

On the basis of the results of the pilot survey, it was decided to go ahead with the use of LASP with the following format:-

1) Alternatives offered :-

   a) currently used road service

   b) a new road service

   c) intermodal container service

   d) rail service (express service with wagon-load sized consignments moving in trainloads all the way from origin to destination)

2) Attributes to be used :-

a) Cost (for door to door movement)
b) Door to Door Transit time (with increments of one third of a working day i.e.: morning delivery, afternoon delivery, evening delivery)
c) Reliability of service (defined as the percentage of consignments arriving within scheduled time)
d) Frequency of Service (at three levels viz. daily, tri-weekly & weekly)

3) Presentation method: Windows based system running on a laptop computer.

4) Presenting the alternatives in form of four 'cards' on the screen (see Fig 1), so that it is possible to shuffle the cards and change the sequence in which the alternatives are shown.

3.3 Simulation Testing of New design

Simulations were carried out to ensure that the problems associated with Adaptive SP methods (Bradley & Daly, 1993) did not exist in this case. The recoverability of the assumed attribute valuations was tested over a very wide range of values using simulated data, since very little information was available about the sort of attribute valuations that were likely to be obtained. The range of attribute values tested was:-

- VOT : 3% per day to 90% per day (the higher value representing an exporter who might be willing to pay almost double the charges to save a day in order to catch a particular ship).
- VOR : 0.2% to 10% per percentage point change in reliability.
- ASC (Intermodal Container Service) : -20% to 30%. The negative value was used to represent people actually preferring Container service, all else being equal.
- ASC (Rail) : 0% to 40%. In this case, there was thought to be almost no possibility of anyone preferring the rail service due to the extra handling involved.
- F1 (discount required for tri-weekly service as compared to a daily service): 5% to 20%
- F2 (discount required for weekly service as compared to a daily service): 10% to 40 %

Twenty one combinations of these values were taken, as listed in Table 1.

Table 1 Attribute level combinations used in the simulation testing

No	ASC (IM)	ASC(Rail)	F1	F2	VOT	VOR
1	10	10	10	20	1	0.2
2	10	10	10	20	5	1
3	10	10	10	20	10	5
4	10	10	10	20	30	10
5	-20	40	10	20	1	0.5
6	-20	40	10	20	1	5
7	-20	40	10	20	10	1
8	30	40	10	20	10	10
9	30	40	10	20	30	10
10	30	40	10	20	30	5
11	0	20	5	10	5	2
12	0	20	5	10	5	5
13	0	20	5	10	5	10
14	20	40	10	20	30	10
15	20	40	10	20	10	5
16	20	40	10	20	30	5
17	10	20	10	20	1	0.2
18	10	20	10	20	1	5
19	-20	30	20	40	10	5
20	20	20	10	10	10	5
21	0	30	20	40	30	10

In the final analysis of survey data some of the values were found to lie outside these ranges (most notably F1 & F2) and the simulations were then repeated using the actual values to confirm that the algorithm was capable of recovering those values correctly.

In addition to this, the effect of difference in the rating behaviour between respondents (some respondents may give very widely varying ratings while others may give ratings in a narrow range) was also simulated using an additional attribute (‘K’) where a low ‘K’ value represented a narrow rating respondent and a high ‘K’ value represented a wide rating respondent with an average rating respondent being represented by ‘K’ = 100.

The simulated values were generated within the LASP software using Table 1 values as input and ratings generated within LASP with a lognormal error term. This data was then analysed using the methodology described in sections 2.3 & 2.4. Further analysis was also carried out with and without weights as well as with higher powers of the weighting function. The results showed that out of all the firms simulated, the final algorithm was able to complete all tasks in all but a couple of cases where the wide variation in rating behaviour led to non-convergence of the algorithm. The highest errors (between input value and recovered value) occurred for very 'narrow' rating respondents, e.g. those always rating close to 100. However, even in these cases, the weighting function led to errors reducing to under 20%. Other than these, the weight squared function was found to give error levels under 10% for most cases except when the value of VOR was numerically very much higher than the VOT. However, this was not expected to lead to any problems as we did not expect such a pattern in real life.

The second phase of simulations was carried out to compare the recoverability of underlying values using weighted averages of individual firm models as compared to that obtained from models using pooled data including a Random Component model. In this case also the rating data was generated using the simulation routine in LASP with multiplicative lognormal error terms. Different log normal distributions were used to try to obtain one which led to a similar range of adjusted R squared values of regression as found in the final survey data. 800 firms were simulated (giving 21600 observations). In addition to this, we also compared results with and without variation in rating behaviour ('K' values explained earlier). We defined an error index as the sum of the absolute values of the % errors for all the attributes (higher number showing poorer recoverability). An indicative set of simulation results is shown below:-

Table 2 : Error Indices using different methods

Method	Uniform rating behaviour	Variation in rating behaviour
OLS	187	76
WLS	136	106
RCM	37	38
WA	25	20

OLS: Ordinary Least Squares
WLS: Weighted Least Squares
RCM: Random Component Model
WA: Weighted Average of Models calibrated on individual respondents

The results indicated that the weighted average method gave lower errors in the recovery of underlying values than any of the models using pooled data, and the results remained similar for different error distributions as well as different rating behaviour.

3.4 The Survey

The Delhi - Bombay (North to West) corridor was selected for the survey as this is one of the most important freight corridors in India. On this corridor the roads carry over 40 million tonnes of freight per annum with an average length of haul of almost 1000 Km (RITES 1996). In addition, this is also the most important route for export/import traffic, much of which is already containerised. This route accounts for almost 40% of the total volume of traffic handled by the Container Corporation of India (CONCOR), the sole intermodal service provider in India. The distance from Delhi to Bombay is almost 1500 Km by road with the entire route having recently been upgraded to a 4 lane highway with double carriageway.

The main survey was conducted in April - May 1998. The respondents were asked for data on flows travelling on this route for distances greater than 1000 Km, i.e. not necessarily from Delhi to Bombay. In many cases, the traffic originated/terminated beyond these two cities. In a handful of cases no flows could be identified on this route and alternative routes were taken.

A total of 41 firms were contacted from which 32 successful interviews were obtained. Of the nine cases where successful interviews were not possible, two were companies which did not have any full lorry-load movement and all the material was sent in part-loads and so they were not suitable for this exercise. In the case of another, the present mode used was containers whereas the software till that stage had only been designed to accept road as the present mode (this was however modified for subsequent interviews). In another case, pertaining to the Electronics industry, the respondent refused to trade and said that in view of the high value of the consignment he was not willing to consider rail or rail based container services at any discount. In the remaining five cases, the respondents were either not able to spare the time required or pleaded inability to part with data pertaining to their company's freight movements.

A larger sample would, of course, be desirable, but sampling costs are considerable. Interviews with relevant decision makers have to be agreed, set up, often postponed, and will rarely be close enough together to permit two or more to be conducted per day. Because LASP produces models for individual respondents, it is not necessary to publish just one central estimate. By producing all results individually (or in a small group) the main variabilities in the findings can be displayed. In this way a much greater depth of understanding can be obtained than might be expected from so small a sample size.

4. DATA ANALYSIS

4.1 Individual Level Models

The data was first modelled at the individual level using the methodology detailed in section 2.3. The regression model used was (following equation (5)):-

$$\text{LogitA} = \beta_1(C_A - C_i) + \beta_2(T_A - T_i) + \beta_3(R_A - R_i) + \beta_4(\text{Dum1}) \quad (9)$$

$$+ \beta_5(\text{Dum2}) + \beta_6(\text{DumF1}) + \beta_7(\text{DumF2})$$

Here the subscript 'A' refers to the base alternative and 'i' refers to one of the other three alternatives 'B, C, D'. The dependent variable is 'LogitA', see equation (5), and β_1 to β_3 represent the coefficients of 'cost', 'time' and 'reliability' respectively, β_4 to β_5 represent the two ASCs and β_6 and β_7 represent the two frequency discounts. The costs have been taken as percentages of the freight rate by the currently used mode, in order to obtain all valuations in percentages of the current cost. The resulting coefficients β_2 to β_7 were divided by the corresponding coefficient for 'Cost difference' (β_1) to obtain the attribute valuations as percentages of the freight rate.

4.2 Models Aggregated by Sector

The individual level models were then aggregated by sector (see Table 3) using weighted means of the individual attribute valuations with weights set as inverse of the variance of the individual (see section 2.4). All the aggregate results have correct signs even though we had some wrong signs in the individual firm models in the case of the frequency discounts and the VOR estimates. In the case of the Food Products manufacturers we have some low 't' values which appear to be caused by the fact that we have data only for two firms in this segment.

Table 3: Percentage Valuations by Sector
('t' values shown in brackets)

Sector		ASCs					Frequency Discounts		VOT	VOR
		RC/IM	IMC	Rail	Parcel	RC	F1	F2		
Exporters	Estimate	10.5	10.1	-25.4		4.6	-30.2	-59.7	11.5	-3.6
	't'	*(1.4)*	*(4.9)*	*(-5.4)*		*(1.4)*	*(-11.7)*	*(-17.2)*	*(6.1)*	*(-6.4)*
F. Forwarders	Estimate		-7.6	-24.9			-23.7	-56.2	13.5	-1.6
Transporters	't'		*(-3.9)*	*(-12.5)*			*(-8.8)*	*(-21.3)*	*(6.4)*	*(-2.7)*
Chemicals	Estimate		1.3	-30.9		-3.9	-12.8	-26.9	12.7	-2.0
	't'		*(0.5)*	*(-10.8)*		*(-0.7)*	*(-3.8)*	*(-8.1)*	*(5.3)*	*(-3.0)*
Electrical/	Estimate		-7.3	-15.5		-4.6	-8.6	-38.6	8.3	-0.4
Electronics	't'		*(-4.5)*	*(-7.5)*		*(-1.8)*	*(-3.3)*	*(-16.8)*	*(4.0)*	*(-0.7)*
Auto Parts	Estimate		7.6	-37.9	-31.3	-4.2	-4.0	-21.5	12.5	-2.8
	't'		*(2.8)*	*(-2.1)*	*(-5.0)*	*(-1.3)*	*(-1.1)*	*(-5.9)*	*(3.9)*	*(-3.2)*
Food	Estimate		15.9	-16.4			-3.1	-6.2	4.8	-1.7
	't'		*(4.23)*	*(-4.1)*			*(-0.6)*	*(-1.1)*	*(1.0)*	*(-1.7)*

VOT: Value of a Time Reduction of one day
VOR: Value of a Reliability Reduction of one percent less on-time arrivals
F1: Discount required for tri-weekly service as compared to a daily service
F2: Discount required for weekly service as compared to a daily service
RC/IM: ASC for Intermodal services with respect to containerised road services
IMC: ASC for Intermodal services with respect to conventional road services (ie open 2 axle lorries)
Rail: ASC for rail with respect to conventional road services
Parcel: ASC for rail parcel services with respect to conventional road services
RC: ASC for containerised road services with respect to conventional road services

The figures in Table 3 are to be interpreted as percentage reductions in the freight rate (i.e. cost) that would compensate for a unit worsenment in that attribute (and, equivalently, the percentage increase in the freight rate that operators could charge for a unit improvement in an attribute). Starting at the right of the table, we see that for exporters a 10% increase in on-time arrivals would be worth 36% added to the freight rate. For Auto Parts manufacturers, slowing down deliveries by one day could be compensated by reducing the freight rate by 12.5%. Frequency of service is unimportant to the food sector, moving from daily to weekly only requiring 6.2% compensation because the flows considered were bulk flows to warehouses with some flexibility in timing. For exporters, frequency is clearly very important. No sector likes rail, but the Auto Parts sector is particularly dissatisfied with rail. The opinions of respondents about the intermodal alternative were mixed. It is easy to see why exporters would be willing to pay 10% extra for this alternative since many exports will need to be containerised at some stage. The food and auto parts sectors appear to have favoured the intermodal alternative due to the expected reduction in damage in transit.

5. CONCLUSIONS

This paper has for the first time presented a full description of the current version of the LASP methodology, which uses Adaptive Stated Preference to enable sufficient information to be obtained from each respondent to permit the calibration of a model for each respondent. We believe there are occasions where such a methodology will be of value. One such occasion is in freight mode choice, where the number of decision makers is necessarily relatively small. As with all Stated Preference alternatives, it is possible to consider novel alternatives not yet in existence. The paper has illustrated the LASP methodology with an experiment regarding mode choice in India, where one of the options was a new intermodal service. It is the first time that any such work has been done there. The sample size of 32 firms would appear to be smaller than sizes used conventionally for transport demand modelling. However this is one of the main problems with freight studies as it is not possible to get the sort of sample sizes that are possible in passenger studies. This is also one of the strengths of LASP. Most previous LASP studies have shown good results with sample sizes between 30 to 40 firms (see Danielis and Rotaris, 1999) as opposed to sizes of 100+ firms reported in other freight studies. In the present case, also, the results were valuable to Indian Railways, and so this example has served to show what can be achieved with limited resources.

REFERENCES

Bradley, M. and Daly, A.(1993), New analysis issues in Stated Preference research. *PTRC 21st Summer Annual Meeting 1993, Proceedings of Seminar-D*, 75-89, PTRC, London.

Danielis, R and Rotaris, L (1999), Analysing freight transport demand using Stated Preference data: A survey, *Transporti Europei, V13,* 30-38.

Fowkes, A.S., Nash, C.A. and Tweddle, G. (1991), Investigating the market for intermodal freight technologies, *Transport Research-part A,* **25A** (4), 161-172.

Fowkes, A.S. and Tweddle, G. (1988), A computer aided Stated Preference experiment for freight mode choice, *PTRC 16th Summer Annual Meeting 1988, Proceedings of Seminar D,* 295-305, PTRC, London.

Fowkes, A.S. and Tweddle, G. (1997), Validation of Stated Preference forecasting: A case study involving Anglo-Continental Freight, *European Transport Forum - 25th Annual Meeting, Proceedings of Seminar F*, PTRC, London.

RITES (1996), *Study on the Decline in Railway's Share in Total Land Traffic*, Rail India Techno-Economic Services, December 1996, New Delhi.

Tweddle, G., Fowkes, A.S. and Nash, C.A. (1995), *Impact of the Channel Tunnel: A survey of Anglo-European unitised freight. Results of the Phase I interviews*, Institute for Transport Studies, University of Leeds ,Working Paper 443, October 1995.

Tweddle, G., Fowkes, A.S. and Nash, C.A. (1996), *Impact of the Channel Tunnel: A survey of Anglo-European unitised freight. Results of the Phase II interviews,* Institute for Transport Studies, University of Leeds, Working Paper 474, June 1996.

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