TRADE OFF ANALYSIS : ITS USE IN PREPARING MARKETING AUDITS

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ABSTRACT: *Increasingly, transport operators are finding that they are required to operate within a more commercially defined framework. This has required them to gain a greater understanding of the passenger benefits that are likely to ensue from a given change in their operation which can be weighed against the expected costs of investment and marketing etc. Trade-off analysis has proved to be a particularly useful analytical tool in this context.*

In Europe, this type of approach had tended to become known as a Marketing Audit whereby investment considerations are consumer appraised, the output being presented as a series of monetary passenger benefit values.

The paper discusses how the approach is typically applied, the sensitivity of the results to the way in which it is conducted and the kinds of conclusions which have emanated from previous research.

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INTRODUCTION

Increasingly, transport operators are finding that they are required to operate within a more commercially defined framework. This has required them to gain a greater understanding of the passenger benefits that are likely to ensue from a given change in their operation which can be weighed against the expected costs of investment, production and marketing. This paper provides a description of a technique known as trade-off analysis which has proved to be particularly useful in this context.

In Europe, this type of approach has become known as a **Marketing Audit** whereby investment considerations are consumer appraised, the output typically being presented as a series of monetary passenger benefit values.

The paper is split into four sections. In the first, some background to the use and development of this approach is provided. This is followed, in the second section, by a set of application guidelines for such work. The kinds of areas for which it has been made use of are discussed in the third section alongside a detailed practical example of a major study conducted in Europe. Finally, there is a concluding section to the paper in which we identify developments which are taking place in this type of approach.

BACKGROUND TO THE USE OF TRADE-OFF RESEARCH

What is meant by the term trade-off research? Using a fairly general description, it can be said that trade-off research includes any method which uses **statements** about consumer preferences for a set of (transport) options to estimate utility weights. The options are typically **descriptions** of a number of alternative transport products, defined by experimental design rules. By its nature, trade-off research makes significant use of survey techniques for its data collection.

Trade-off techniques, of one form or another, have been around in transport research for some twenty-five years. The early forms, however, were fairly heavily criticised because they were felt to be rather simplistic. Such objections were arguably reasonable since, at that time, use of this type of research was confined to variations on the 'bag of money' approach, ie using questions of the 'what would you be prepared to pay if .... ' type.

During the 1970s more sophisticated approaches (often referred to as conjoint analysis) were developed, predominantly in the United States. Conjoint analysis typically involves the appraisal of a set of alternative options and is a term which has been applied to "any decompositional method that estimates the structure of a consumers' preference (eg part worths, importance weights, ideal points) given his/her overall evaluation of a set of alternatives that are pre-specified in terms of levels of different attributes" (Green and Scrinivasan 1978).

The current popularity of such research in transport is illustrated by the increasing number of applications which have been reported during the past few years (eg Sheldon and Steer 1982, Bovy and Bradley 1984, Andersen, Moeller and Sheldon 1986, Bradley, Kroes and Sheldon 1987).

Trade-off research methods were increasingly introduced into transport research as limitations associated with more traditional revealed preference based approaches (ie based on **observed** behaviour rather than stated preferences) became more clearly recognised. Though such revealed preference models were, and in many contexts still are, convenient and powerful analytical tools, a number of issues have been raised which question their general suitability. These are broad ranging, concerning not only the difficulty and cost of obtaining the required input data but also the appropriateness of revealed preference research for examining certain variables of interest.

It is this latter issue which provided the predominant motivation for developing stated preference based Marketing Audits to help identify for operators the levels of importance which consumers attach to changes in a vast array of travel variables, most of which are not amenable to examination through revealed preference techniques.

The major difficulty is that revealed preference techniques require that explanatory variables can be adequately expressed in terms of "objective" units. As a consequence such models can normally only be used to estimate the importance that people attach to primary travel variables (such as journey time and cost), leaving unquantified a broad range of secondary travel variables such as station facilities, staff appearance/behaviour, rolling stock design, catering facilities, etc.

During the last decade, the use of such research has become increasingly popular as the advantages and scope of this type of technique have become more well-known. In broad terms, such approaches are seen to be easier to control than revealed preference methods (because the researcher defines the conditions which are being evaluated by the respondent), they are more flexible (being able to deal with a wider variety of variables), they are cheaper to apply (each respondent providing multiple observations thus reducing data collection costs) and they can be used to derive a range of statistics including all those available through revealed preference techniques.

APPLICATION GUIDELINES

Trade-off research has become increasingly sophisticated during the past fifteen years but, because it is typically undertaken under experimentally controlled conditions, experienced practitioners have developed a set of rules and conditions which, if they are followed, make the application of this type of research a relatively straight-forward procedure.

In this section, a research recipe is set out which is intended both to provide a helpful framework for intending users and to remove some of the mystique which surrounds certain aspects of the technique. The recipe components include:

- (a) model specification
- (b) experimental design
- (c) stimulus presentation
- (d) response measurement
- (e) model calibration
- (f) testing and validation
- (g) result presentation.

For many of these aspects a number of options exist. The authors' choices in such situations have largely been governed by the general principle that in order to obtain useful results the research needs to be undertaken in as realistic a context as is possible. It is for this reason that the data has typically been collected by way of in-depth face-to-face interviews usually undertaken by experienced interviewers. These are structured to ensure:

- that the background to the consumer's original decision making process is fully understood by the researcher (what situational constraints existed, for instance, such as travelling with children, weather conditions, need to be at a meeting for a specific time, etc......)

- that the respondent is not educated if he/she currently had some product misconceptions, or led by "enticing" stimuli into an overly-positive response to change, and

- that complete product specifications are provided for appraisal in recognition of the fact that when faced with a product or service an individual is likely to perceive it as a whole rather than as the sum of a number of component attributes.

The recipe components are briefly discussed in turn below:

(a) Model Specification

The model specification process involves deciding what type of utility function best describes the way in which individuals combine component attribute utilities into an overall evaluation or preference. Usually, a linear additive compensatory model is assumed.

The attributes can be specified in the model as continuous variables or as discrete variables. In the first case one single utility weight is associated with each attribute (irrespective of its level) while in the second case a separate utility weight is associated with each attribute level (dummy variable).

The basic linear specification can be extended in several ways. Quadratic terms can be added to cater for nonlinearities in continuous attributes and interactions can be specified to take account of interrelationships between the utility of two (or more) attributes.

(b) Experimental Design

The options (alternative product descriptions to be appraised by the respondents) are created using the rules of experimental design. The total number of options which could be defined is a function both of the number of attributes and the number of attribute levels incorporated into the exercise but it is recognised that respondents can only evaluate a fairly limited number of alternatives at a time, typically some 9 to 16. Therefore a design incorporating all possible combinations of all levels of each attribute (a full factorial design) can only be used if there are very few attributes and attribute levels. When a full factorial design generates too many alternatives this problem can be overcome by adopting a fractional factorial design, so that only a selection of all the possible combinations are presented to respondents.

It should be noted that the adoption of a fractional factorial design may limit the estimation possibilities. Typically, certain interaction effects will not be able to be estimated.

If the number of alternatives with a fractional factorial design is still too large, the exercise can be broken down into a set of smaller separate exercises, linked by one common factor (see, for example, Andersen, Moeller and Sheldon 1986). The experimental design can be arranged so that, when necessary, interactions between features are specifically built into the exercise as well as the main effects.

(c) Stimulus Presentation

In many respects, this is the critical stage in the process. It is the authors' view that to ensure that valid preferences are expressed by consumers the experimental conditions need to be as realistic as possible. To facilitate this face-to-face interviews are highly preferable to mail-out surveys and it is felt to be important to determine during the first stages of an interview a number of details about the respondent (when possible in situ during the course of making a journey):

- who they are
- why they are making the journey at that time by that mode, etc.
- what situational constraints exist
- how they planned/booked the journey
- what they know about the service (times, fares, etc.) and, where appropriate, what they know about alternative means of travel.

By way of this the interviewer is able to establish the level of comprehension a consumer has about features of the service he/she would need to take into account when alternative options are presented. The interviewer should also be able to understand how a respondent is likely to react to changes in the service given the backdrop of their attendant circumstances. Gaming procedures have been developed which directly address this issue (see Payne and Steer 1981 and Steer and Willumsen 1981).

Attribute descriptions are typically provided verbally but pictorial aids (photos, drawings, timetables) may be useful to help explain conceptually difficult attributes. The important issue here is to ensure that the respondent is fully aware of what he/she is asked to evaluate, but at the same time he/she should not be "led" by enticing stimuli material.

The options are typically presented to respondents on coloured show cards which are interactively built up by the interviewers working with the respondent. An example of a typical show-card design is provided in Figure A. This contains examples of variables which are pre-defined along with others which would need some direct interviewer involvement during the course of the interview.

(d) Response Measurement

For developing preference models of this type two alternative data collection methods exist: respondents can be asked either to rank the options or to provide a rating for each. The data provided by the ranking approach would appear to be more reliable as respondents find it easier to say what is preferred than to express the magnitude of this preference. However, some practitioners do prefer to collect rating data since this provides information not only about the relative preferences but also about the distance between the options.

(e) Model Calibration

Different statistical techniques are available to estimate the utility weights attached to the component attributes. The choice of which to use is typically determined both by the measurement scale of the response variables as well as by the form of model assumed. ANOVA or regression is typically used for rated data, while MONANOVA has been widely used when ranked data have been collected. More recently exploded LOGIT has been often applied to ranked data. Experience, however, suggests that the different methods produce very similar results on ranked data.

(f) Model Testing and Validation

As with the calibration of any model it is important to assess the value of the estimates obtained by conducting a number of validation tests. These can be based upon prior knowledge (examination of signs and values of parameters), upon internal validity tests (using ex-post predictions for a sample of respondents not included during the calibration of the model and comparing the estimated and actual outcomes) and upon external validation (comparing model predictions with actual behaviour) using, say, before and after surveys. Clearly the external validation tests are most severe and most revealing, but unfortunately rarely ever performed. Prior knowledge and internal validity tests have more often been applied to stated preference research and typically produce positive results.

(g) Result Presentation

The direct result of a stated preference modelling exercise typically comprises a set of utility weights. These can be either specific for each individual respondent (MONANOVA) or means across respondents (ANOVA, regression, LOGIT). A number of measures can be derived from these weights. By including a fare or cost variable in the exercise along with an estimate of the cost of making the journey which the evaluation has been based upon monetary values can be obtained for each of the variables under examination. This allows the operator not only the possibility to (consumer) prioritise changes in a number of travel variables but also to determine how much passengers would be prepared to pay were an additional charge to be levied for a given change in service.

From a marketing viewpoint, another advantage of this type of approach is that it allows the operator to examine consumer response not only in an aggregate sense but also for a broad range of identified market segments (eg students, OAPs, women, travellers with children, etc). Alternatively, the resulting preference data itself can be used to identify market segments which are particularly sensitive to certain aspects of travel. This information can provide a useful guide for determining how to market certain changes in service and to whom.

RESEARCH EXPERIENCE

This form of research is now made use of by a large number of transportation managers concerned with developing their product range, both through improvements to existing products and through product extensions or rationalisation. Some areas where trade-off research has repeatedly been employed include:

- station modernisation feasibility studies
- rolling stock development
- passenger information service design
- terminal facility improvement studies
- development of bus service investment programmes.

For this paper, we have focussed upon one particular study conducted in Denmark for the national rail company (DSB) which it is hoped will serve to identify not only the practical steps involved in this type of project but also to demonstrate the kind of output that can be obtained and the ways in which such data can be used.

The study in question was undertaken during 1985 and involved a very detailed examination of the views of passengers using the railway's InterCity services.

The main objective of the project was to establish and quantify the relative importance that passengers attach to changes in various rail travel features. The information was required as an input for the development of future railway marketing and investment action plans.

By a careful rotation of variables it was possible to examine a large number of product specifications (32 in total), some of which involved changes to existing travel features (eg interchange, journey time, train catering) while others involved the appraisal of new product specifications (eg minibus services to/from station, baggage conveyancing procedures, etc). Many of these had to be very carefully defined for respondents with the interviewers taking due account of the levels of awareness and understanding that passengers already had about the services that DSB offer.

The variables were split into six separate and appropriately categorised exercises. Each exercise contained either eight or nine options depending upon the design requirements. The six exercises were presented by interviewers on a rotation basis with each respondent being asked to appraise the options for three of them. A fare variable was included in all six exercises to allow for a cros-comparison of results. In the main, the variables were defined with two levels each, the few exceptions containing three levels.

The 32 examined variables are set out in Table 1, appropriately grouped.

TABLE 1 : VARIABLES EXAMINED

GENERAL		TRAIN		STATION	
(1)	(2)	(3)	(4)	(5)	(6)
journey time	access/ egress	catering	environment	catering	weather protection
frequency	baggage conveyance	special carriages	toilet facilities	ticket booth design	toilets
punctuality	seat reser-vations	seat density	cleanliness	waiting faci-lities	cleanliness
journey planning information	bikes (on train)	coach design	seat type	infor-mation at station	car parking
interchange	timetable format	crowded-ness	ferry catering	station shops	platform accessi-bility
		train/ ferry link			
fares	fares	fares	fares	fares	fares

Some examples will help illustrate how these variables were presented to respondents and, most importantly, how they were individually geared to each respondent's own awareness and understanding levels.

Looking at Exercise 1, for instance, the first variable shown is the journey time. The starting point for presenting this variable was determined by the respondent her/himself. During the early part of the interview the interviewer asked how long the respondent expected to be travelling by train for that journey. The two levels for this variable were then defined as:

(1) passenger's current perception for journey (bad level)

(2) a 20% improvement (good level).

So, the interviewer played back to the respondent a pair of journey times, relating to the two levels, which were entirely consistent with that person's existing perceptions, however misguided they may have been. If, for instance, the actual journey time for a particular origin/destination was 4 and a half hours but the respondent perceived it to be 5hrs then the two levels would have been defined as:

(1) 5 hrs (ie current perception)
(2) 4 hrs (ie 20% improvement)

Another example can be cited from the same grouping, that of punctuality. Here, the good level was defined as:

- passenger's **expectation** of delay on scheduled time

and the bad level as:

- 10% (time) delay, which passenger is notified of during journey (ie no advance warning).

The research was also used to test out some new product ideas, including the following (with level definitions):

(1)	**journey planning information**	: existing sources
		: a complete journey plan would be sent through the post after passenger phoned through 'specification' to DSB staff (in addition to existing sources)
(2)	**access/egress**	: existing possibilities (bus, taxi etc)
		: a minibus service between home/work etc and nearest station priced between bus and taxi fares (plus existing possibilities)

(3) **seat reservations** : current procedures (you can reserve but don't have to)

: all seats to be reserved (no standing allowed)

(4) **bike conveyance** : no bikes allowed on the train

bikes allowed (at cost of 30kr)

(5) **baggage conveyance** : looked after by passengers or booked in and it goes on another train (current)

: looked after by passenger or booked in and it follows you on same train(s) (like aircraft services)

A total of 623 interviews were completed on the mainline between Copenhagen and Arhus, allowing for a detailed disaggregated market segmentation analysis. To facilitate this process and in recognition of the fact that certain key or interesting groups of travellers would be only minimally represented if a random sampling approach were adopted, some quotas were set in advance for respondent recruitment.

The primary output of such an exercise comprises a set of importance weightings attached to each of the attribute levels. If, however, one of the individual attributes has a monetary value (for instance, the fare level) then the value for each of the other attributes can be defined in monetary units, either for individual passengers or for defined market segments. These can be treated as quasi revenue benefit estimates for the purpose of investment appraisal, since they indicate how much the fares could be increased if such improvements were implemented while leaving consumer "utility" unchanged. Alternatively, by linking the weightings to a known demand elasticity, demand change estimates for each variable can be calculated.

As was expected, the study concluded that the primary variables (ie those most commonly explored through other statistical procedures such as revealed preference models) were of most importance to consumers. But of importance here was that other "secondary" variables could be examined and quantified.

For instance, the new product which received the most acclaim from respondents was the facility to take their bikes with them on the train. This facility was presented to them as having a cost of 30kr attached and passengers (11% of those interviewed) who had wanted to take their bike with them on that particular journey showed a preparedness to pay a further 25kr (ie 55kr altogether on a fare of 138kr) which is not far from the half price fare often charged by railway operators for the conveyance of bikes.

In regard to catering, passengers showed a preference for the provision of basic facilities. The provision of drinks and cold meals on the train had a value of 19kr attached compared with an additional value of only 5kr for the provision of hot meals as well. Similarly, the preference was for cafes at stations (7kr); the value attached to a station restaurant rather than a cafe was only 2kr.

These results can also be presented for various market segments, as required. The major advantage in breaking the market into its component parts is that it allows one to identify which aspects of the service (existing or developed) should be highlighted for different target markets.

Looking at journey purpose, for instance, higher than average monetary values were attached by business passengers to all three primary characteristics featuring at the top of the hierarchical list (time, timetable format and punctuality). On the other hand, convenience was of most concern to optional passengers. The two highest monetary values for this market segment were attached to the train/ferry link offered and the lack of a train/train interchange at Fredericia Station.

With regard to age, the intermediate groups (26-40 and 40-60 years) were more concerned with the primary aspects of rail travel (time, timetable format and punctuality) than either of their older or younger travel companions. Older respondents, however, were particularly concerned not to have to disembark from the train during the journey, either at the ferry or at a DSB station (train/train).

An alternative way of presenting the same data is to translate the weightings into elasticity (demand change) values by linking the importance weightings to a "known" elasticity - in this case, fares was adopted. For a more detailed explanation of the procedures involved see Kroes and Sheldon 1983. The aggregate elasticity value for fares was taken to be -0.7 from which we were able to conclude, for instance, that the introduction of a minibus access/egress service would be expected to lead to a 5% increase in rail demand. Likewise, the introduction of a facility to allow bikes on the train (at a cost of 30kr) could lead to a demand expansion of some 10%.

Each year DSB develops an action plan for the forthcoming five year period. This is a plan for the future development of the different sectors within the railways for each of which specific actions are identified.

The research, because of its broad ranging nature, was able to provide a direct input into the development of these plans. For each specified action, the estimated demand (and, by using an average fare, revenue) impact was calculated.

By setting these revenue estimates against the necessary investment and incurred operating costs DSB were able to evaluate and prioritise the various actions.

Some direct actions resulting from this research include the development of a modernisation programme for thirty six InterCity stations and the facility to allow bikes to travel on the train with accompanying passengers.

CONCLUDING REMARKS

In the previous sections we have discussed the background and the main design aspects of a research technique known as trade-off analysis. The case for its application has been illustrated by a practical example of a major study carried out in Denmark for the State Railways. This is only one out of a large number of studies which have been undertaken by the authors in Europe and Australasia for a variety of transport operators.

A theme which has been observed throughout the paper is the need to adapt the trade-off exercise to each individual respondent's circumstances in order to present the context for the research as realistically as possible. One solution to this which is becoming more and more attractive is the use of portable computers as a means of presenting options to respondents. Bradley 1987 provides a useful overview of the development of computer based conjoint analysis and its state-of-the-art.

The other area which is currently under detailed review is the subject of interaction. Much of the previous work has focussed upon a number of individually specified improvements each of which were accorded a separate value. Increasingly, however, it is recognised that a multi-attribute investment or marketing package might have a value different from that which would be suggested by summing the component attributes (it could be a larger or a smaller value). A number of research studies have included procedures aimed at identifying such interactive impacts which indicate that the absence of an interaction framework is likely to understate the value of the more important (typically primary) variables and overstate those of lower value.

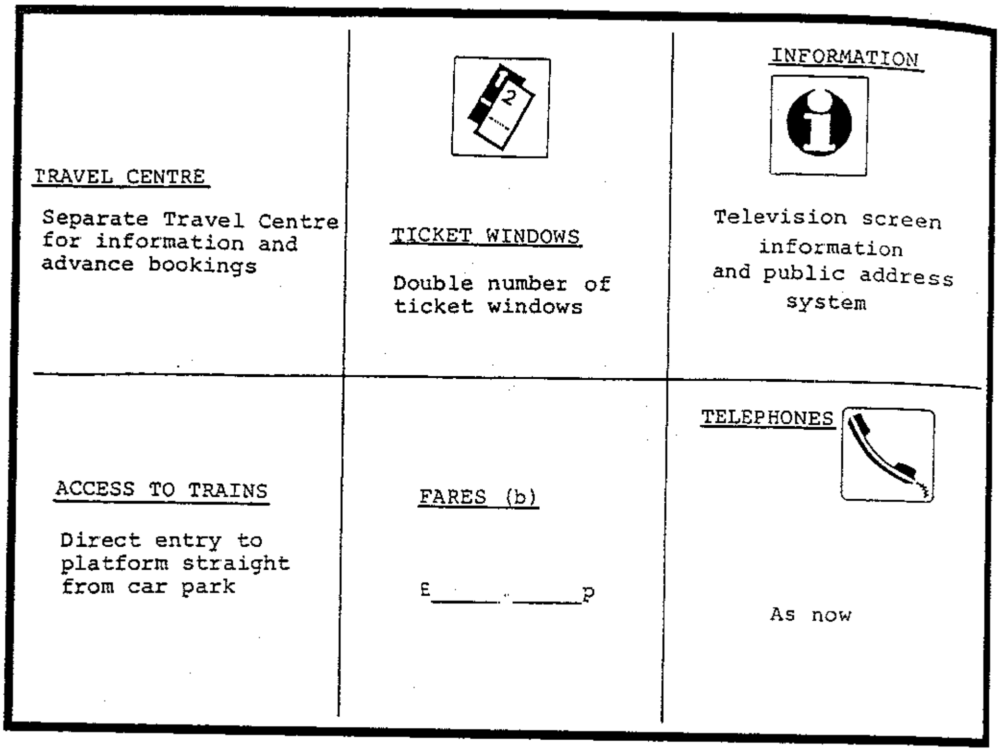
TRAVEL CENTRE
Separate Travel Centre for information and advance bookings
2
TICKET WINDOWS
Double number of ticket windows
INFORMATION
Television screen information and public address system
ACCESS TO TRAINS
Direct entry to platform straight from car park
FARES (b)
£_____._____p
TELEPHONES
As now

Figure A

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