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# APPLICATION OF MODELS BASED ON STATED AND REVEALED PREFERENCE DATA FOR FORECASTING PASSENGER TRAFFIC BETWEEN EAST AND WEST DENMARK

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## Abstract

The entry of new travel alternatives into an existing market poses special problems for demand forecasting, specifically as there are no observed choice data for these alternatives. In the 1990's methods were developed which used both stated preferences (SP) and revealed preference (RP) data simultaneously to estimate the model parameters. Further problems, however, have been identified with the application of these models. This paper describes a three-step estimation procedure that has been developed to take account of these problems and illustrates how the approach has been applied in the development of a forecast model to predict the number of passengers on new road and rail fixed links, which are being constructed across the Storebælt strait in Denmark.

## INTRODUCTION

Denmark consists of the peninsula of *Jylland* and a large number of islands. The two largest islands are *Fyn*, already linked to Jylland by road and rail bridges, and *Sjælland*, which contains the national capital *København*. The *Storebælt* (Great Belt) strait between Fyn and Sjælland divides the country into two parts, roughly equal in population.

Road and rail traffic between the eastern and western parts of the country is served by ferry lines connecting Sjælland with Fyn and Jylland. These lines are mostly car ferries, with a single ferry serving the main railway connection. A typical conventional ferry crossing of the Great Belt takes about one hour, while the ferries to Jylland take about two hours; catamarans offer faster services on some routes. Frequencies range from half-hourly to every four hours. In 1991 the total average daily traffic carried by the ferries was 10,000 cars and vans, 1,700 heavy goods vehicles and almost 40,000 passengers. There were also 5,500 daily crossings between East and West Denmark by domestic air passengers.

In 1987, an Act of the Danish Parliament provided for the construction of a fixed link across the Great Belt carrying both motorway and double-track railway links. A limited company was established (*Storebæltforbindelsen as*, The Great Belt Link Company), owned by the State, which started construction work in 1989. The rail link was opened in June 1997, just prior to the completion of the work described in this paper, while the opening of the road link is scheduled for June 1998. The total cost of construction work will be about DKK 28 billion.

The link consists of a low bridge carrying both road and rail traffic across the western part of the strait (as far as the small island of *Sprogø*) and a road bridge and rail tunnel across the eastern part. Here, where the main shipping lanes pass, the railway runs in two bored tunnels, while the motorway passes over a 70 m. high suspension bridge with a main span of 1624 m..

Previous studies of traffic across the fixed link have been made (Wätjen *et al.*, 1990, Andersen *et al.*, 1994). These studies indicated that substantial shifts of traffic from the ferry and air services to the fixed link could be expected. However, these studies were based entirely on 'Revealed Preference' information gathered in surveys from current travellers across the strait; they could not take into account the impact of the fixed link itself. That is, they considered only the improvements in travel times, not the freedom given by being able to drive across at any time, being able to make a non-stop train journey, or of any negative impacts of concern about using a tunnel or high bridge.

In 1996 Storebæltforbindelsen AS (The Great Belt Company) commissioned the CCH Consortium to construct a new model of traffic between East and West Denmark, which was to include the use of SP data. The resulting model comprised sub-models for predicting the volumes of passenger and freight traffic and a sub-model for their joint use of capacity. It was implemented as a user-friendly computer system and transferred to the Great Belt Company. This paper describes the most important parts of the passenger component of that model and the methods that were used to construct them.

## Combined SP and RP analysis

The entry of new travel alternatives into an existing market poses special problems for demand forecasting, specifically as there are no observed choice data for these alternatives. In the 1990's methods were developed which used both SP and Revealed Preference (RP) data simultaneously to estimate the model parameters, exploiting the strengths of each type of data (Ben-Akiva and Morikawa, 1990, Bradley and Daly, 1991). These methods have improved significantly the reliability of models based on SP data. Further problems, however, have been identified with the application of the models, particularly with regard to the representativeness of the data samples and the consistency of the stated preference data and forecast context.

A three-step estimation procedure has therefore been developed to take deal with these problems (Daly and Rohr, 1998). In the first step of this procedure, both RP and SP data are used simultaneously to estimate trade-off parameters, applying a scaling factor to the SP parameters to account for the different error variance between the RP and SP data. In the second step, the RP data only are used to estimate alternative-specific constants for the existing alternatives, constraining the values of the other trade-off parameters to be equal to those estimated jointly in the first step. In the final step, the SP data only are used to re-estimate the alternative-specific constants of the new alternatives, now relative to the RP values estimated in the previous step.

## Model Structure

The passenger models described in this paper were set up to operate entirely in parallel with freight models. Predictions from the two model systems were then brought together in a capacity model that confronted the predicted demand with the available capacity. As is conventional in transport planning, an iterative procedure may be required to find an equilibrium between supply and demand; provision is therefore made to make this iteration when necessary.

Within the passenger model, sub-models predicted:

- the choice of time of travel (day of week and time of day);
- the choice of mode and route of travel, incorporated in a single choice structure;
- the effect of improved accessibility on the total volume of traffic (generation);
- the 'exogenous' growth in the market, independent of accessibility changes.

For reasons of space the time-of-travel, generation and growth models are not described in the current paper.

# MODE-ROUTE CHOICE MODEL ESTIMATION PROCEDURE

The base model estimation uses the joint estimation approach described by Bradley and Daly (1991), i.e. that both RP and SP data are used together to model observed choices in the case of the RP data and the choices that the respondents indicate they ***would have made*** given the circumstances presented in the SP surveys. All data are used simultaneously to estimate trade-off coefficients for parameters which are common to the alternatives in each of the data sets, e.g. time and cost; data-specific parameters, like comfort (SP only), are also included in the models.

The base model estimation is carried out using disaggregate unweighted data records; this procedure effectively assumes equal information content in each observation. This approach is believed to make the most statistically efficient use of the data. In the base estimation a scaling factor is applied to the SP choice utilities to account for the different error variance in the RP and SP data, so that all coefficients are estimated relative to the RP scale. This scaling can be applied in a straightforward manner using a hierarchical logit estimation program. In this study, separate alternative-specific constants were implemented for the alternatives within each data source. This is the preferable approach, although we have found in some studies that it was not possible to identify separate constants and therefore this requirement has had to be relaxed.

## Model Data

The RP choice information was obtained from the Danish national travel survey, *Trafikundersøgelse*, which contains data for the adult population of Denmark. Data were used from 1994, 1995 and 1996.

For the estimation of a mode/route choice model, descriptions in terms of level of service are also required for all possible mode and route choice alternatives that are available to each respondent. Level-of-service data which contained travel times, costs, frequency, interchanges, etc. for each origin-destination pair and mode were therefore developed. Special care was taken to reflect accurately travel costs for groups travelling with children and for younger travellers (in terms of reduced rail fares).

SP ***choice*** data were collected in two surveys: one in 1994 (originally applied in a study carried out in 1995) and the other in 1996. Both surveys used computer-based interviews that were conducted on board ferries crossing the screen line. A total of 1500 respondents travelling by car, bus, train or simply walking onto the ferry were interviewed in the 1994 surveys. Each of these respondents participated in two SP experiments: (1) a between-mode and route choice experiment where respondents made choices between their observed mode and another existing mode and (2) a between-mode and route choice experiment where respondents made choices between their observed mode and a new mode, i.e. either a fixed-link or new fast-ferry alternative. The additional surveys conducted in 1996 (500 surveys of car, bus and train travellers) concentrated on the following two objectives:

1. to investigate how respondents choose their day and time of travel and how these choices vary with different tariff structures and capacity issues;
2. to enhance the existing trade-off information with regard to fast ferries, including the treatment of comfort.

In this survey each respondent participated in three stated preference experiment, giving 4-8 responses per experiment:

**Experiment 1**: time choice experiment, where each respondent was presented with choices between their different days of travel (including their observed day), different departure times (including their observed departure time) and different fares;
**Experiment 2**: fast-ferry choice experiment, where each respondent was presented with choices between his observed mode/route alternative and a fast ferry alternative at the same crossing (if the respondent was already making his journey by a regular ferry then he was presented with choices between the fast ferry service and a cheaper regular ferry service); the variables considered in the experiment included ferry crossing time, fare, frequency and comfort;
**Experiment 3**: fixed-link choice experiment, where each respondent was presented with choices between his observed mode/route alternative and a fixed-link alternative.

A total of 15,013 SP observations were used in the mode/route choice model estimation, from both experiments of the 1994 survey and experiments 2 and 3 of the 1996 survey.

## Model Structure

The model structure used for the base estimation of the model reflects the separate choices made in the RP and SP data sources. The RP structure predicted the choice of mode and route (for car and train only) between East and West Denmark, while the SP models predicted the particular – binary – choice of alternatives that was presented to respondents in the different SP surveys. The decision-making unit in the models is assumed to be parties of travellers, which experience has shown to be an appropriate decision unit for long distance travel. However, the tariffs for each model alternative reflect per-person costs.

The mode and route choice models are of a structured logit form, i.e. that which allows a 'tree' structure to be specified. The tree structure has two functions: firstly, it allows for differences in the survey context between RP and SP data sources and between the various different SP contexts; secondly, it allows for differences in cross-elasticities between the model alternatives, for example, to take into account that travellers are more likely to switch between car-ferry alternatives than to switch, say, from car-ferry to air travel.

The model structure is shown in Figure 1 (see end of paper). A structural parameter is present across the different car and train route alternatives to reflect the higher cross-elasticity of route choice relative to mode choice. The parameter was found to be significantly less than 1 and the inclusion of the tree parameter therefore significantly improved the model fit. This same parameter is also present in the bus, air and walk-on branches of the tree to ensure consistency in the scale of the utility functions. Four scaling coefficients (one for each SP data set) were also defined in order to scale the different SP data types relative to the RP data. The 1996 Experiment 1 data was not used in the base year model estimation.

Table 1 shows the SP scale parameters for the different SP experiments in the two surveys (t-statistics are shown in brackets), for the different model segments (see section on segmentation below). The results indicate that the SP-to-RP scaling is necessary - all scaling parameters are well determined and a large number of the values are significantly different from 1. All parameters, except for the business values for SP Experiment 3, indicate that the SP responses have less unexplained variance than the RP data (scale factor is greater than 1).

**Table 1: Model Scale Parameters (and approximate t ratios)**

| Scale Parameter | Business | Leisure - single travellers | Leisure - groups of 2+ |
|---|---|---|---|
| 94 Experiment 1 | +1.08 (+7.9) | +1.37 (+5.2) | +1.88 (+8.0) |
| 94 Experiment 2 | +1.05 (+10.5) | +1.47 (+5.6) | +1.36 (+8.8) |
| 96 Experiment 2 | +1.14 (+4.8) | +4.68 (+4.6) | +3.37 (+5.7) |
| 96 Experiment 3 | +0.50 (+7.2) | +2.07 (+6.2) | +1.11 (+6.8) |

In the joint estimation procedure, each alternative is available only for observations from the relevant data source, e.g. RP alternatives are available only for RP observations. Further availability restrictions were also applied in the RP component of the model, such as restrictions on availability of ferry alternatives because of changes in service availability over the three years of data included in the model estimation. Public transport alternatives were available if services were present. Also, car alternatives were only considered to be available if someone in the travelling group had a driving licence and the household owned a car. Only the licence requirement was deemed necessary for business travellers.

## Model Variables

Table 2 summarises the supply variables that were considered in the base models. Separate cost coefficients were estimated for different income categories to reflect lower marginal values of cost for higher income groups.

**Table 2: Model Utility Components**

| | Car | Train | Bus | Walk-On | Air |
|---|---|---|---|---|---|
| **Travel Times** | | | | | |
| Car Time | √ | | | | |
| Train Time (including access/egress, sailing time) | | √ | | | |
| Bus Time (including access/egress, sailing time) | | | √ | | |
| Walk-on Time (including access/ egress, check-in, sailing time) | | | | √ | |
| Air Time (including access/egress, check-in, air time) | | | | | √ |
| Ferry Time | √ | | | | |
| **Costs** | | | | | |
| Total Per Person Cost | √ | √ | √ | √ | √ |
| **Frequency** | √ | √ | √ | √ | √ |
| **Headway** | √ | √ | √ | √ | √ |
| **Interchanges** | | | | | |
| To/From Ferry | | √ | | | |
| Main mode Interchanges | | √ | | | |

Both frequency and half-headway coefficients were tested in the models as frequency tends to explain better the choices between high frequency alternatives whereas half-headway tends to explain better the choices between alternatives which operate at a lower frequency[i].

## Inertia

Inertia terms were included in the model to test whether there was evidence of respondents being reluctant to switch modes or routes. Separate terms were estimated for the 1994 and 1996 SP experiments on the basis that: (1) inertia to switching to the fixed link would be different between 1994 and 1996 as a result of increased knowledge about the fixed link and (2) inertia may be different as a result of differences in the specification of the SP experiment, e.g. in the specification of the alternatives. Both the 1994 and 1996 terms were large and significant (detailed figures are presented in Table 5).

In the long run, it can be expected that the experience of travel in the base (estimation) situation will not affect travellers' choices and therefore that the inertia effect will decline. It is hypothesised that the impact of inertia on a new mode will be greatest immediately after the new alternative is introduced and will decay over a finite period to zero. Judgements are required to determined what is the appropriate decay level for the scope of the forecasts.

## Segmentation and Other Socio-Economic Variables

Once initial versions of base models had been estimated, the effects of other socio-economic and trip-specific variables were examined by applying the base model across a number of different dimensions in the sample, including trip purpose, income, group size, etc.. Model results indicated that segmentation by trip purpose, i.e. business and leisure, significantly improved the model fit.

Further segmentation of the leisure model by group size, i.e. one model for travellers travelling alone and another for travellers in groups of two or more, also improved the model fit significantly.

Other important socio-economic and trip type variables were added to the purpose of specific models, including constants for the increased attractiveness of car for large groups, constants for the reduced probability of choosing car if the respondent did not have a licence or a car, but was travelling in a group, a constant to reduce the attractiveness of car for female business travellers (as observed in the RP choices), and a constant to take account of the additional attractiveness of air for West Denmark residents compared to East Denmark residents (which we presume to be a result of the concentration of trip destinations (but not origins) in the central Copenhagen area which is easily accessible from the airport). A number of constants which only applied to SP alternatives were also included in the models, including a constant to measure increased attractiveness of car for respondents with large amounts of luggage and a constant to measure the increased attractiveness of car for respondents who are travelling to several destinations on their journey (significant in the business model only).

## ESTIMATION RESULTS

The parameters estimated for the variables described above were all highly significant.

The values of time increase by income category, as a consequence of the lower marginal utilities of cost for higher income groups. The trend for in-vehicle train time for the business model is shown in Figure 2; the values range from 1.90 DKK per minute for the lowest income category to 4.70 DKK per minute for the highest income travellers. In general the business values of time may be considered somewhat high, but it should be borne in mind that the models reflect values for long distance travel, generally found to be higher than for urban and regional travel.

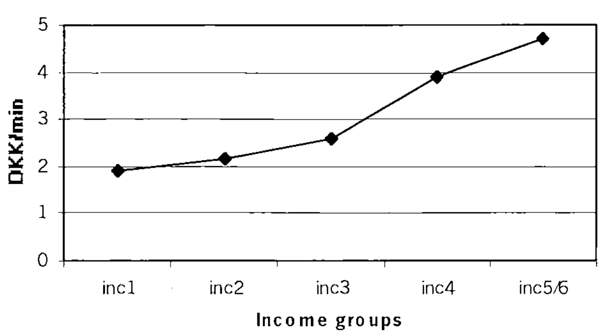


**Figure 2: Values of Train Time by Income Category: Business (DKK/min)**

Figure 3 shows the values of time for the two leisure models: leisure-single travellers (L1) and leisure-groups of travellers (L2+). The values for groups of travellers are lower, per person, than are the values for single travellers; the presence of children may have an influence in the average values here. Also, it is noted that the values for persons travelling in groups increases at a much lower rate than do the values for single leisure or business travellers. The business values of time are between 2 and 3 times higher than the leisure values.

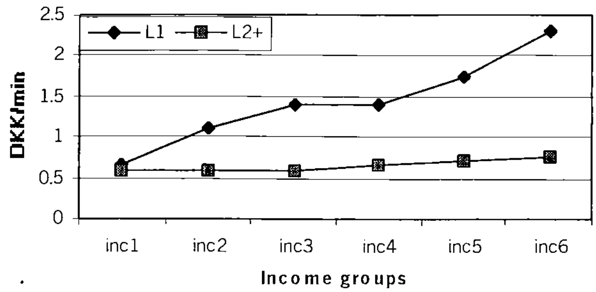


**Figure 3: Values of Train Time by Income Category: Leisure (DKK/min)**

An average income coefficient (derived from weighting the cost coefficients by the observed income distribution for each segment) was used to determine the average value of time for each time component. Figure 4 shows the results for the business model.

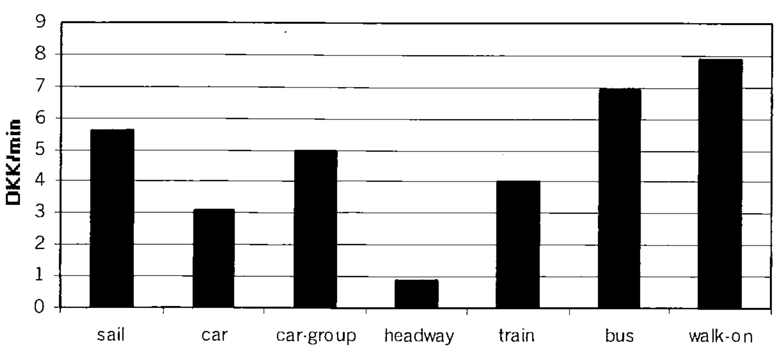


**Figure 4: Average Value of Time for Model Time Components: Business Model (DKK/minute)**

The business results show that the average value of time for groups of business travellers travelling in a car is significantly higher than for single travellers. This may reflect a reduction in car comfort for groups of travellers or that being a passenger is less welcome than being a car driver (something else which is supported by work carried out in England for long distance business trips). The difference may also reflect the reduced ability to work during the journey for a group of business car travellers relative to, say, train travellers. For the business model, both frequency and headway were found to be significant (the frequency results are not presented in the figure) and therefore the headway coefficient does not completely explain the frequency effect, which is why it is lower than the other time components.

The average values of time for the time components from the leisure models are shown in Figure 5. The value of sailing time is consistent between the two leisure models. The same is true for the value of driving time in the L1 model and the value of driving time for groups of two in the L2+ model. The value of driving time for groups of three or more travellers (G3+, identified as a separate parameter in the L2+ model) is significantly higher relative to the value of driving time for groups of two (G2). This may reflect lower comfort levels for larger groups. Finally, the values of train and bus time are substantially higher for the single travellers than for the travellers in a group.

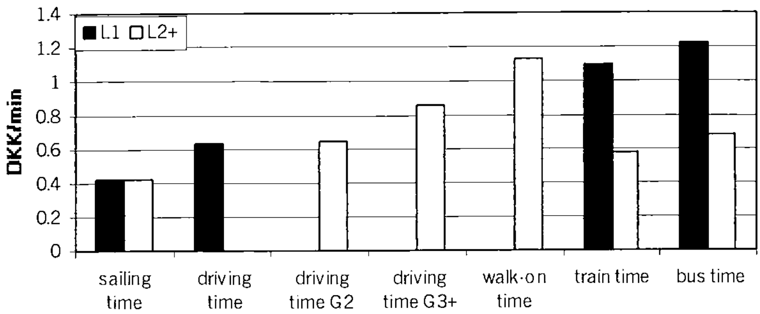


**Figure 5: Average Value of Time for Model Time Components: Leisure Models (DKK/minute)**

A separate air time coefficient could not be identified in either the business or the leisure models, probably because of a lack of variation in air time in the observed (RP only) data. Therefore, the air time coefficient was constrained to be equal to 0.61 times the rail time (a ratio determined from a model using all data together, i.e. business and leisure). In the L1 model, the original estimate of walk-on time was unreasonably high, possibly because the number of observations for this alternative is considerably lower than for other alternatives, therefore in the final L1 model the walk-on time components are constrained to be valued equally to bus time.

Frequency, but not headway, was identified as a significant explanatory variable in the leisure models. The frequency coefficients were significant at the 90% confidence level. The weighted values of frequency for L1 and L2+ models are 13.12 DKK and 5.60 DKK per hourly departure, respectively.

## SECONDARY ESTIMATION

### Adjustments to Observed Mode Constants ('A Runs')

The unweighted RP data used in the base estimation may well not contain representative shares of traffic for each of the alternatives. There are many reasons that the sampling would not be uniform across the alternatives, including simple sampling variation. These variations were present in the Storebælt case, with the additional complication that, since the RP data was collected over a three-year period, there had been considerable variation in the alternatives themselves, including the opening and closing of ferry lines.

The alternative-specific constants estimated in the base models are therefore not likely to be correct, i.e. they may not reproduce the observed alternative shares. The constants therefore need to be adjusted so that the shares in the base year are replicated. An automated procedure can be used in many cases to make these adjustments, but this procedure could not easily be applied in the present case because data was not available on the actual shares for each alternative for each of the three market segments modelled separately. An iterative procedure was therefore used instead to calculate the appropriate constants to obtain the correct shares across all segments in total. It is worth noting that, although this iterative procedure appears heuristic, it does produce approximate maximum likelihood estimates of the alternative-specific constants.

A second reason why an iterative approach was necessary in this study was that the observed numbers of cars and car passengers were not consistent with observed occupancy figures and therefore it was decided that the model would accurately reflect the total number of **cars**, and their distribution across the various ferry crossings, whereas the train, bus, walk-on and air constants were calibrated so that the predicted number of **passengers** reflected observed values for these modes. As a result of taking this approach, and because of inconsistencies in the base data used, it was possible to achieve only approximate matches (within 2-3%) of the observed alternative shares; normally the match would have been closer. Exact matches are not achieved by maximum likelihood estimation of a tree logit model.

The differences between the A-run and base year constants ranged from -6.6 to +3.9 utility units, depending on the alternative. Little can be concluded from the numbers, their values depend on the sampling technique employed to obtain the RP data, but the values in Table 3 give some indication of the size of corrections which can be expected with this procedure.

## Adjustments to New Mode Constants ('B Runs')

The issue here is that of consistency between the SP choice context, which provides the basis for the new alternative-specific constants, and the RP context to be used for forecasting. In order to 'transfer' the SP results to the RP forecast environment a number of adjustments are required; these are discussed in turn below.

Although separate alternative-specific constants are identified for the RP and SP models in this study, there are still, however, inconsistencies in the definitions of the constants. In the RP models, the alternative-specific constants have been estimated on the basis that all alternatives are available for an individual (in the absence of further information such as car availability). However, the SP constants are estimated on the basis of binary choices; where respondents have made choices between their observed alternative and the new alternative. Each of the alternative-specific constants for the 'observed' alternatives in the SP utilities are therefore estimated only by respondents who are using that alternative for their current journey (and therefore reflect the choice based sampling used in the SP surveys) and the new alternative-specific constants are measured relative to these.

Thus, while it is desirable to estimate the trade-off coefficients using a model structure with separate sets of constants for the different data types as is done in the base estimation, when it is required to use the resulting constants in a forecasting context it is essential to ensure that **all** travellers' behaviour is consistent with the 'observed' alternative-specific constants, i.e. those derived from the A Runs. Therefore in this secondary estimation phase (the B Runs), it is necessary to constrain the values of the alternative-specific constants for observed alternatives in the SP utilities to be equal to the RP values as obtained from the A Runs described above. The resulting new alternative constants will therefore be consistent with the observed mode values for forecasting.

The tree structure used for the B-runs is consistent with that which is to be used in the forecasts. This structure is shown in Figure 6 (end of paper), where the observed alternatives are shown in solid boxes and the new alternatives by dashed boxes. All alternatives are scaled by the route tree parameter which was estimated in the base estimation procedure. As well as the new constants, information on where the new alternatives should be located within the tree structure for forecasting can be ascertained from the B-runs (and base estimation) where between-mode and within-mode scale parameters can be estimated if information on between-mode and within-mode trading is present in the SP experiments. For this model structure the fixed-link alternatives were located at the same level as the mode-ferry alternatives, for a given mode as shown in Figure 6.

The B-run procedure was used to re-estimate the alternative specific constants for three new fixed-link alternatives: car fixed-link, bus fixed-link, and train fixed-link. Both the 1994 and 1996 SP data were used. A weighting was applied in a second series of B runs to correct for bias in alternative shares resulting from the SP sampling procedure; these weighted runs were judged to give better results than the unweighted results. The new mode constants from the 1996 data and the B-run values (again for 1996 only) are shown in Table 3 below.

**Table 3: New Constants: B-run Results**

| Constant | Base Estimation (1996 Data) | B-runs Unweighted | B-runs Weighted |
|---|---|---|---|
| **Business** | | | |
| Car Fixed-Link | +2.48 (+2.0) | -1.28 (-6.4) | -1.28 (-6.2) |
| Train Fixed-Link | +0.08 (+0.0) | +1.44 (+3.0) | +3.13 (+6.2) |
| Bus Fixed-Link | -2.82 (-1.5) | +0.19 (+0.3) | +1.96 (+3.3) |
| **Leisure - Single Travellers** | | | |
| Car Fixed-Link | +0.78 (+0.9) | +0.82 (+0.9) | +0.82 (+0.9) |
| Train Fixed-Link | +0.50 (+0.4) | -5.96 (-9.3) | -2.04 (-2.9) |
| Bus Fixed-Link | -0.04 (-0.0) | -1.76 (-2.3) | +2.59 (+3.3) |
| **Leisure - Groups (2+)** | | | |
| Car Fixed-Link | +1.71 (+2.2) | -0.40 (-1.0) | -0.40 (-1.0) |
| Train Fixed-Link | -7.24 (-3.1) | -1.64 (-1.6) | +2.23 (+1.6) |
| Bus Fixed-Link | -11.95 (-4.3) | -2.25 (-1.6) | +1.54 (+0.9) |

Tests were made estimating separate alternative-specific constants for new alternatives for each year and for aggregating the constants. The constants obtained from aggregating the data from both years were eventually adopted in the forecasting models.

## SUMMARY AND CONCLUSIONS

The passenger models described in this paper form part of a complete system for forecasting passenger and freight traffic, and their relationship to ferry capacity, between East and West Denmark. Because of the need to take account of a number of new aspects of the travel market between East and West Denmark, the modelling has been based to a large extent on Stated Preference data. A survey was designed to focus on the choice of time of travel, preferences for fast ferries and preferences for the fixed link, taking account of a wide range of possible tariff levels in the final experiment.

In addition to the newly collected data, data from a 1994 SP survey in the corridor was used. To increase the reliability of the model, Revealed Preference data from the long-distance component of the Danish National Travel Survey (TU) was also used; data from 1994-1996 was employed. The three-stage estimation procedure of Daly and Rohr (1998) was used to accommodate the various forms of data within a consistent estimation framework. 'Inertia' variables were included in the models to represent travellers' unwillingness to change their mode or route alternative in the short term.

Mode and route choice model estimation based on these data sets gave good results, particularly in terms of the relative values of the various aspects of the journey that influence travellers' choices. 'Values of time', measured in monetary units, increased with increasing income in a way that mirrored the findings of other studies; business values were at least twice leisure values, again consistent with other studies, and the overall values were, as expected, rather higher than those observed in urban studies. The values for time spent in different circumstances (e.g. on a ferry, in a car, flying, etc.) also varied in plausible ways.

The model system also included the choice of time of travel, the exogenous growth of traffic (mainly resulting from income growth) and the generation of traffic brought about by accessibility changes. The entire system was implemented in a user-friendly 'shell' interface for application on Windows computers and is currently in use by the client.

## ENDNOTES

i This is because model forms with linear utility functions consider absolute differences in variable values between alternatives: changes in half-headway are less as frequencies increase; e.g. the difference in half-headway between alternatives with frequencies of 2 and 3 per day is 80 minutes (based on a 16 hour day) whereas the difference in half-headway between alternatives with a frequency of 5 and 6 is 16 minutes; the frequency difference in each case is 1.

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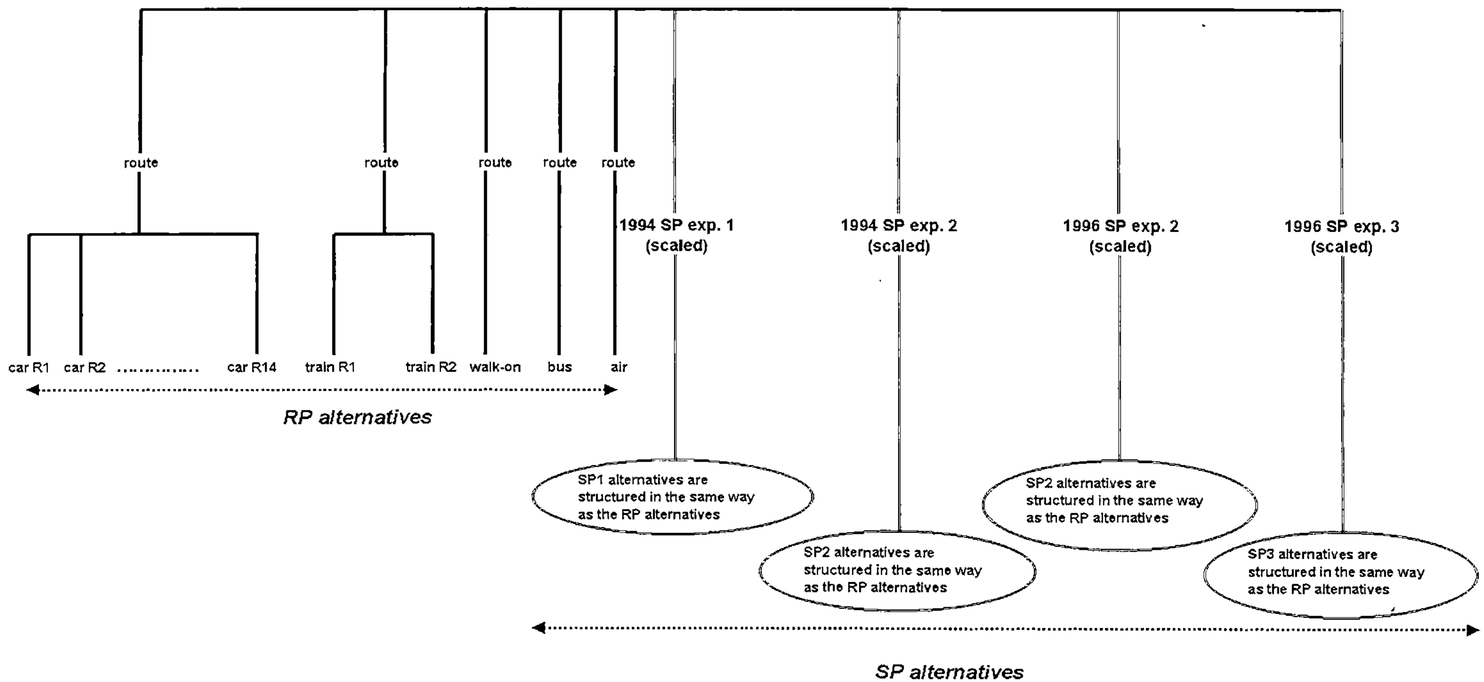


**Figure 1: The Tree Structure of the Great Belt Passenger Mode/Route Choice Passenger Model**

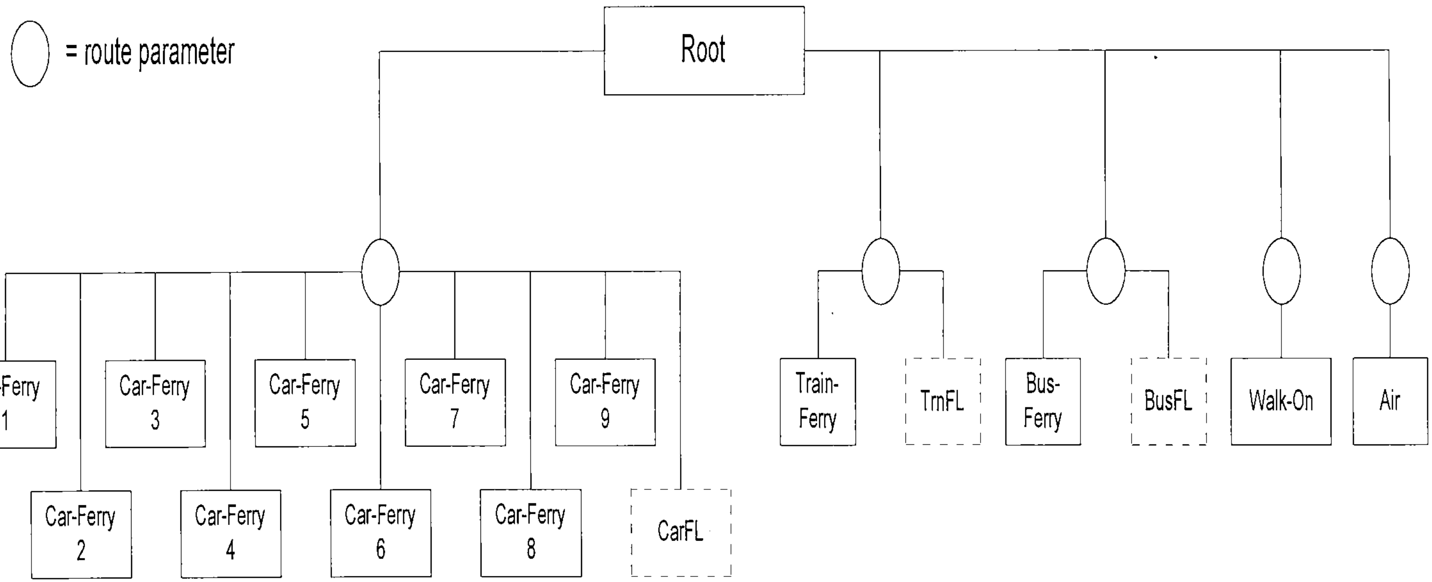


**Figure 6: Forecast Tree Structure**