Simultaneous route and ferry choice in the Danish National Model

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1 Introduction

Denmark has many islands and sea crossings, and ferries and bridges are an important part of the transport network. The modelling of route choice and choice of bridges/ferries are hence an important part of the new national transport model.

Whilst bridges in a model can be considered as roads with toll, ferries are more complicated, since they have different schedules, required time of arrivals and comfort levels. Ferries are slower than roads, but time on board can be used for relaxing, shopping and eating.

Prior Danish models have typically modelled ferries by discrete choice models for specific projects, e.g. the Great Belt and Øresund models. However, a general national model is more complicated, since international traffic may pass several sea crossings, some of which are correlated and some of which are in sequence.

For a given OD-pair there is thus a combination of different correlated routes, sequences of crossings, and choices of ferries versus bridges. A discrete choice modelling approach would thus necessitate that the choice and correlation structure for all main OD-relations should be revealed. Much likely, the resulting model would include alternative specific constants as well as parameters defining nests and correlation. In such a context it would be difficult to introduce new alternatives, e.g. bridges instead of ferries or new links at new locations.

The national model including the international hinterland models 275 different ferry lines, which would be very cumbersome to structure in a discrete choice model configuration. The attached figure 1 shows the central modelling area.

It was thus decided to model the road route choice and ferry/bridge choice as a simultaneous route choice. This was inspired by the Copenhagen Harbour Tunnel Project [1], where it was also decided to model route and bridge choices simultaneous [2].

3 Data

The network includes 51,172 road links, ferry data, and 3321 traffic counts. Ferry data has especially proven difficult, since the ticket price varies significantly from high season prises, over standard prices to various discounts, and many ferry companies gives secret discounts to unions and big trucking firms.

The passenger trip matrices (between 1,244 zones) were estimated from the national transport survey (commuting, education, business, shopping, vacation house, vacation and leisure/other) as well as a new overnight trip survey (business, summerhouses, vacation, others). A particularity is that many van trips are used for passenger transport. Van matrices with freight purposes, as well as four categories of trucks were estimated from different freight surveys and statistics.

4 The route choice model

The route choice model itself is a stochastic multiclass user equilibrium route choice model, which allow for both random variation (Probit-based error term) and random distributed coefficients. Since users with high value of driving times must be expected to have high ferry value of times as well, an enveloped utility function was used, where different random coefficient are multiplied. This secures logical signs and relationships. As LogNormal distributions are multiplicative, the resulting value of times are LogNormal distributed as well.

The utility function looks as follow, where the indices *a* is link-related and *k* is related to trip purpose;

$$Length_a \ x \ Drive\ cost_k +$$

$$+Cost\_Disc\_Car_a \ x \ CoeffCost\_Disc_k$$
$$+Cost\_Low\_Car_a \ x \ CoeffCost\_Low_k$$
$$+Cost\_High\_Car_a \ x \ CoffCost\_High_k$$

$$+(FFTimeCoefficient_k) \ x$$
$$(FFtime_a + (1+CCTimeCoefficient)CCtime +$$
$$[\ Avg\_HEAD\_Low_a \ x \ CoeffHEAD\_LOW_k + Avg\_HEAD\_High_a \ x$$
$$CoeffHEAD\_HIGH_k] \ x \ CoeffHead_k +$$
$$Arr\_Pre\_Dep_a \ x \ CoeffArr\_Pre\_Dep_k +$$
$$Ferry\_Travel\_Time_a \ x \ Coeff\_Ferry\_Travel\_Time_k)$$

$$+Errorterm_{a(k)}$$

There is here both a length-related driving cost, and costs related to bridges/ferries/charging distributed to high and low season as well as discounted price which are weighed together depending upon trip purpose.

The FreeFlow (FF) time coefficient is LogNormal distributed. This multiplied free flow time as well as all other time components with an extra value added/multiplied. This secures that Congestion Time (CCTime) always has a higher VoT than free flow time (the CCTimeCoefficient is also LogNormal distributed). Ferry attributes includes headway (inconvenience of the hidden waiting time of ferries), ferry travel (sailing time) and pre departure arrival time requirements.

4 Model estimation and calibration

The model estimation builds on prior Danish models and data collection that was adapted to the national level. [2] was thus used for the general short distance choice functions and [3] for the estimation of correlation of value of times for free flow time and congested value of time.

The adapted model fitted well concerning route choice and counts in East and West Denmark separately. The sea crossings were calibrated toward aggregated data (counts), since no disaggregate exists. This revealed a higher value of time for the long distance transport, which was explained by 1) less marginal leisure time for the long trips, 2) a selection towards high income and thus high value of time users due to the very high charge of ferry/bridge crossings, and 3) more persons per car for these trips (counting for 60% of the higher VoT).

The final model was thus segmented into long trips (defined as international trips and any trip with a crossing costing more than 80 DKK). With short and long trips, passenger car, vans and truck trip purposes, the final model had 22 trip purposes/matrices.

5 Results

The main result is that is was possible to estimate and calibrate a simultaneous route choice model for road route and ferry choice. A key reason for this is the distributed value of times that explains both choices of high value of time users and low value of time users.

Furthermore, the model parameters revealed much insight into ferry choice. Passenger car users seem to appreciate the break. For ferries more than two hours, passengers start having a higher VoT again. However, for overnight ferries, the cabin cost hardly influence the route choice compared to non-overnight routes.

Truck drivers seem to have a preference for motorways and main highways to a higher extend than pure time and cost can explain. A link-type length depending parameter had thus to be added to the model. For the long ferry route, trucks had a quite low value of time, which can be explained with the fact that the truck drivers do not go with the ferry, but another driver collect the truck (typically hanger) on the other side.

References

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[2] Nielsen, O.A., Frederiksen, R.D. & Daly, A. (2004). A stochastic Route Choice Model for Car Travellers in the Copenhagen Region. *Networks and spatial economics*. No 2. pp. 327-346. Kluwer.

[3] Nielsen, O.A. Behavioural responses to pricing schemes: Description of the Danish AKTA experiment (2004). *Journal of Intelligent Transportation Systems*. Vol. 8(4). Pp. 233-251. Taylor & Francis

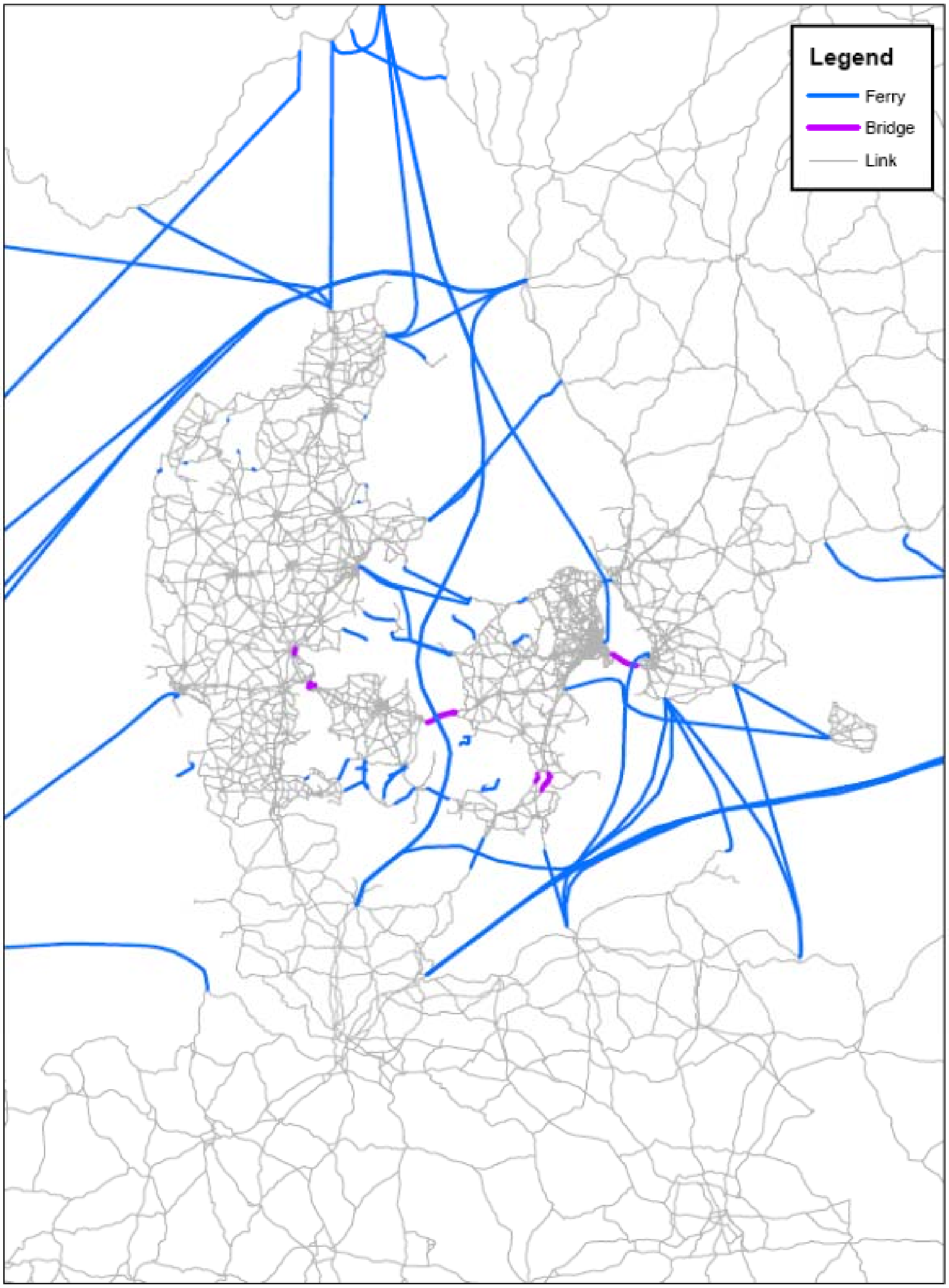

Figure 1. The road (grey) , ferry (blue) and fixed link (purple) network in Denmark and near hinterland.