Summary:

Travel demand models on the edge

Exploring the NTM5 model's limits of extrapolation

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The national Norwegian long distance travel demand model has been subjected to various stress tests. We explore the predicted effects of a € 12 fuel price, of a 100 kilometres per litre fuel efficiency, and of a drastically improved road infrastructure between major cities. The model appears to handle fairly large changes in input rather well. However, the most extreme scenarios do not engender credible results. As the fuel cost of travel is reduced to 1/7, car travellers are predicted to choose radically more distant destinations, as if the time cost of travel were of only minor importance.

The NTM5 model for long distance travel demand in Norway

Covering trips longer than 100 km one way, the national Norwegian travel demand model for long distance trips, NTM5, is part of larger modelling apparatus available to transport planners in Norway. Being fully segmented by travel purpose, the model predicts long haul travel frequency, mode and destination choice in a network with 1428 zones. The underlying behavioural choice models have been estimated on data from the national travel survey of 1998, while network data have, in this application, been updated to 2010 (Figure E.1).

Scenarios

The purpose of the exercise is to explore whether the model can provide useful predictions when input variables are extrapolated far outside their observed empirical range. To this end, we have run, *inter alia*, the following scenarios:

0. Reference (business-as-usual)
1. Extreme fuel efficiency in passenger cars: 0,01 litres per km
2. Extreme fuel price: NOK 100 per litre, i. e. more than € 12, due (a) to a sudden increase in the fuel tax paid by private motorists, or (b) to a higher crude oil price.
3. Motorways allowing for 120 km/h travel speed between the four major cities.

In the extreme fuel efficiency scenario 1, the overall long haul trip frequency increases by 14 per cent, while aggregate passenger kilometres travelled go up by 38 per cent. For the car mode, the corresponding rates of impact come out at 33 and 97 per cent. In the Oslo-Bergen and Oslo-Trondheim corridors, long distance travel by car is predicted to grow by 264 and 248 per cent, respectively.

The extreme fuel price scenario 2 produces very different results depending on the origin of the price increase. If the price increase results from a sudden increase in the fuel tax, so that car owners do not have time to replace their vehicles by more energy efficient ones, and so that other modes of travel escape an increase in energy costs, vehicle kilometres travelled on long haul trips by car fall by 53 per cent.

Figure E.1: NTM5 model network. Roads marked in red, railroads in black, sea routes in blue, air routes in gray. Certain Swedish roads are included, as they sometimes offer faster routes on Norwegian origin-destination pairs.

If, on the other hand, one imagines that the fuel price increase is due to a 20-fold surge in the world market price of crude oil, which has developed over a certain period of time, the effect will be very different. In this case, one must assume that cars as well as coaches, airplanes and ships, being exposed to rising energy costs, have become drastically more energy efficient than today. In summary, we assume that air fares increase by 146 per cent, coach fares by 61 per cent and boat fares by 72 per cent. The mean per kilometre fuel consumption of private cars is assumed to decrease to 0,01 litre, i. e. to roughly 1/7 of today's level. In this case, overall long distance travel demand, as measured in passenger kilometres, goes down by 14 per cent. The air mode shrinks by 56 per cent, while the car mode actually grows by 8 per cent, as the energy efficiency improvement more or less offsets the fuel price increase.

While the cities of Bergen, Trondheim and Stavanger are no more than 500 km by road apart from Oslo, the present state of the national road network does not allow for shorter travel times by car than 6-8 hours. If, on the other hand, we imagine four-lane motorways allowing for 120 km/h travel speed throughout the Oslo-Bergen, Oslo-Trondheim and Oslo-Stavanger corridors (see Figure E.2), the model predicts a 5 per cent increase in national overall long distance travel demand and a 12 per cent increase in passenger kilometres travelled by car. In the Oslo-Bergen and Oslo-Trondheim corridors specifically, long distance car travel demand is predicted to grow by 52-54 per cent. In the Bergen-Stavanger corridor, where no road improvement is assumed to take place, overall long distance travel demand is predicted to shrink by 5-6 per cent, as is also the vehicle kilometres travelled by car.

Figure E.2: Alignment of hypothetical motorways between four major cities (in green).

Assessment

Extreme input assumptions must be expected to produce extreme output. In view of the rather drastic changes in relative prices and travel times that underlie our scenarios 1-3, the aggregate changes in travel demand, compared to the reference scenario, do not appear unreasonable.

However, when a closer look is cast on the less aggregate origin-destination flows, which add up to the national totals, a number of puzzling results come to light.

In the extreme fuel efficiency scenario 1, a major shift in destination choice is predicted to take place, so as to increase the average length of haul (on trips longer than 100 km) by 48 per cent. According to the model, when fuel becomes sufficiently cheap, road users find it worthwhile to travel considerably longer for the same purpose, implicitly accepting an increase in their time costs more or less in proportion to the added journey length.

This observation gives rise to a suspicion that the generalised cost functions implicit in the mode and destination choice models places too little weight on the time component and too much weight on the out-of-pocket expenditure. On account of this, destination choice comes out as quite elastic in response to changes in fuel cost. Such a diagnosis seems reasonable in view of the rather obsolete travel behaviour data underlying the model. Since 1998, subjective values of time have probably increased considerably among the Norwegian population, in line with rising income.

Another indication of this apparently exaggerated elasticity is visible in the travel demand predictions for specific corridors. In the extreme fuel price scenario 2a, overall long distance travel demand in the Oslo-Bergen and Oslo-Trondheim corridors *increase* by 22 and 18 per cent, respectively, although the car mode shrinks by 35 and 40 per cent. The coach, rail and air mode expand by 59, 47 and 50 per cent, respectively, in the Oslo-Bergen corridor. Similar changes take place in the Oslo-Trondheim corridor.

When the car mode becomes exorbitantly expensive, the model predicts a change in mode and destination choice favouring destinations that are easily accessible by other modes than the car. Unlike most other destinations in Norway, those located in the two main corridors are often served by a number of different modes. The model assumes these destinations to become comparatively much more attractive when private car use becomes very expensive.

In a situation with a very high kilometre cost of car use, one would expect the occupancy rate to increase. A number of car trips will not take place unless there are several persons to share the cost. But the NTM5 model does not contain any behavioural relations capturing this phenomenon. Occupancy rates are set at a fixed level within each travel purpose and distance band.

In the NTM5 model, driver's license holding and car ownership are set at certain levels. But when large changes in exogenous variables occur, one might want to take account of the medium and long term effects on car ownership, which in turn affects trip frequency and mode and destination choice. The absence of such relationships makes the model less useful for the study of scenarios that are radically different from the present situation.

Last, but not least, a major drawback of the Norwegian travel demand apparatus is the arbitrary distinction made between trips shorter or longer than 100 km. The shorter trips are handled by a set of regional travel demand models (RTM), with no interaction with NTM5. Separate coefficients and implicit values of time are estimated for the two distance bands. The modelling system ignores the fact that trips 95 and 105 km long may have a number of common characteristics. More seriously, it ignores the fact that destinations 95 and 105 km away from the origin may well be in competition with each other. In the NTM5 model, nearby destinations simply do not exist.