Before and after analysis of the bridge to Askøy

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Askøy is an island near the city centre of Bergen, consisting of about 20 000 residents. Bergen is the second largest city of Norway consisting of about 250 000 inhabitants including the commuting area. Until the bridge "Askøybroen" was opened in December 1992, the only transport option between Askøy and Bergen was a ferry.

Three travel surveys are used in this study, the first was carried out just before and the second just after the opening of the bridge. The third was carried out a few years later, giving the travel habits time to settle. The three travel surveys give us a rare opportunity to check out how the bridge influenced the travel patterns in real life, compared to how the changes were calculated in a typical four-step transport model.

This paper describes problems in the transport model regarding several issues, among them how ferries are described and the relation between car-availability and car-density used in the model.

Before and after studies

A main objective for carrying out ex-post evaluation of projects are, according to the road departement (The Directorate of Public, 2006), to improve the basis for decisions and calculation-tools. Transport models are examples of the latter.

For transport models, ex-post evaluation of projects are parts of a validation process, interliked to, or following, a calibration phase in model devlopment. The validation phase in the process of making new transport models are however carried out with a lot less effort, often consisting only of comparing traffic counts or transit boardings to corresponding model values, too often according to an American model validation manual (TMIP, 1997, page 4).

Deviations between calculated results from a transport model and measured numbers can come from (at least) two sources. One main source is the input data: the zonal data, the transportation network data, or other corresponding input. The other is the predictive capability of the transport models, what kind of input it is based on, and how the model is defined and estimated. In addition there are always some measuring errors, making the "set answers" uncertain as well.

Model validation with survey data before and after gives us a chance to weed out (most of) the errors in input data, since we didn't have to make prognosis for them but could use

historical, registered data, and merely check the predictive capability of the model. Of course - measuring errors could still cause problems.

Activities in before and after studies are:

- Decide indicators
- Collect before-and after data
- ? Build a transport model or other tool ?
- Run the transport model
- Compare output
- Improve the transport model

The grey dots are activities interlinked to, but not parts of, before and after analysis.

These activities are successive and this often cause problems in before and after analysis as illustrated in the Askøy-bridge examle: The transport model in question had input data that were not collected or available at the time when the before- and after analysis took place. This can partly be solved by all along collecting and storing all kinds of data that might be useful.

A successful before and after study should indicate the strenghts and weeknesses of the transport model including which presumptions made in the transport model are adequate and which are erroneous. This should little by little leed to increased knowledge about peoples decisions, leeding to changes in the transport models, giving better transport models, thereby giving better tools for decision-making and hopefully better descisions.

The transport system before and after the bridge

Until the bridge "Askøybroen" was opened in December 1992, the only transport option between Askøy and Bergen was a ferry (Figure 1). The new bridge is financed by tolling. The public transport system consists of buses driving across the bridge and a fast boat link in operation on workdays and Saturdays.

The ferry between Askøy and Bergen took 17 minutes according to the time table. The ticket costed Nkr 32 (≈ 4 E) for adult passengers, Nkr 18 (≈ 2,25 E) for children and Nkr 93 (≈ 11,5 E) for a private car (with the driver), but only one way. Ticketing took place only from Bergen to Askøy. A car-ride from Askøy to the centre of Bergen crossing the new bridge takes about 15-20 minutes, and costed Nkr 100 (≈ 12,5 E) in 1993 from Bergen to Askøy, or Nkr 60 (≈ 7,5 E) with a discount coupon. The fast boat uses 10 minutes on the crossing, has a frequency of two or three departures an hour, regarding whether the trip takes place during rushhours or not. A fast boat link ticket costed Nkr 23 (≈ 3 E) in 1993 and Nkr 32 (≈ 4 E) in 2000.

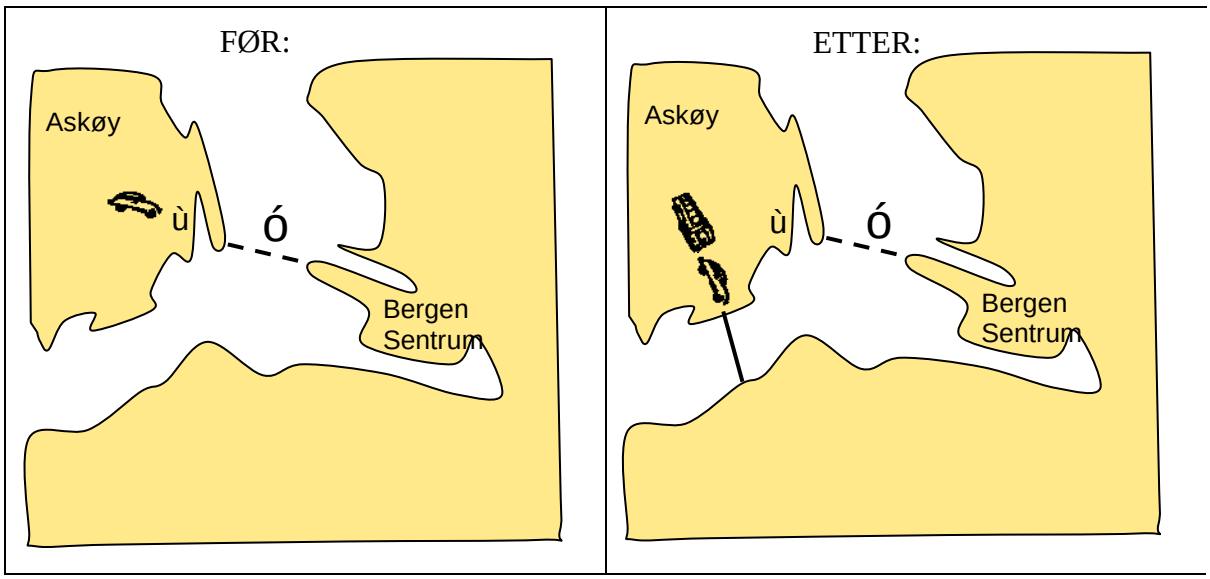

Figure 1: The transportation system between Askøy and Bergen city centre before (to the left) and after (to the right) the opening of the Askøy bridge.

The transport model

This study was carried out in 2004 and 2005, when a new transport model for the Bergen area had just been finished. The new model is called TASS version 5 (TASS5). It is a traditional four-step model with the following qualities:

Area-internal travel puroses made by private individuals are:

1. Residence – work
2. Residence – elementary school
3. Residence – college and universities
4. Residence – shopping/service
5. Residence – Other
6. Other (= the non-home based parts of trip chains)

In addition there are external traffic (one or more trip-end outside the model boundary area) and commercial traffic (trips carried out while working).

The TASS5 model gives transport results for an average work day. The day is divided into four time-periods, two low-traffic-periods, evening/night and mid-day, and morning and evening rushhours. This helps recreate the varying traffic situation and toll pricing meeting the road-users during the day. Network assignment is carried out for each hour in the rushhours.

Zonal data for 1992 and 1993 was not available, but zonal data for 1990 was used in scenarios for 1992 and 1993. The zonal division was higher for 2000 than for 1990, so the zonal data for 2000 was aggragated according to the 1990 zonal data. The geographical boundaries for the 2000-model was also adjusted according to the earlier models.

Two travel purposes, *Residence – shopping/service* and *Residence – Other*, was designed and estimated as hierarchical logit models in TASS5, but the zonal data connected to the destination choice variables was not available for 1992 and 1993 (or 1990). Therefore older choice models from the previous TASS-model (TASS version 3) was used instead.

The mode spesific constants in the mode choice models were adjusted to match the mode choice observered in the travel survey from 2000.

All prices in the three scenarios were given in 2000 price-level.

The three surveys

Three phonebased travel surveys from the Bergen area are used in this study, from 1992, 1993 and 2000. The three travel surveys correspond well to the project – the new bridge opend dec. 1992. We have thus a description of the travel pattern before and after the bridge opened and a few years later, giving the the travel pattern enough time to settle. The travel surveys from 1992 and 2000 included people from several municipalities around Bergen, while the travel survey from 1993 only included people residing in Askøy. About 500 people from Askøy reported details about their trips the previous day in each of the travel surveys. The two first surveys included trips carried out on saturday, but the survey from 2000 did not include saturday-trips. Thus the study only includes trips carried out monday to friday. Only people 13 years or older were asked to participate in the survey.

Table 1: Number of trips and interviewees resided in Askøy and included in the study

Travel survey year	Number of interviewees (monday-friday)	Number of trips (monday-friday)
1992	493	1674
1993	473	1680
2000	523	1916

Results

Changes in the presumptions for the transport model calculations

Looking into the input data, there have been some changes on Askøy that could affect the travel pattern.

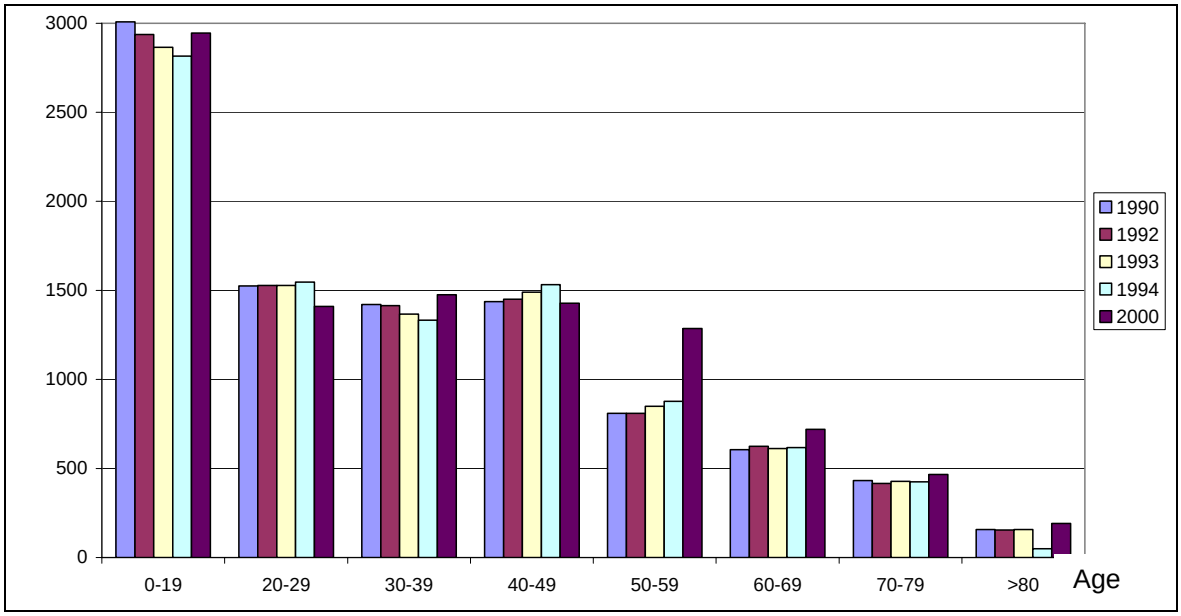

Figure 2: Number of men in age categories on Askøy for given years

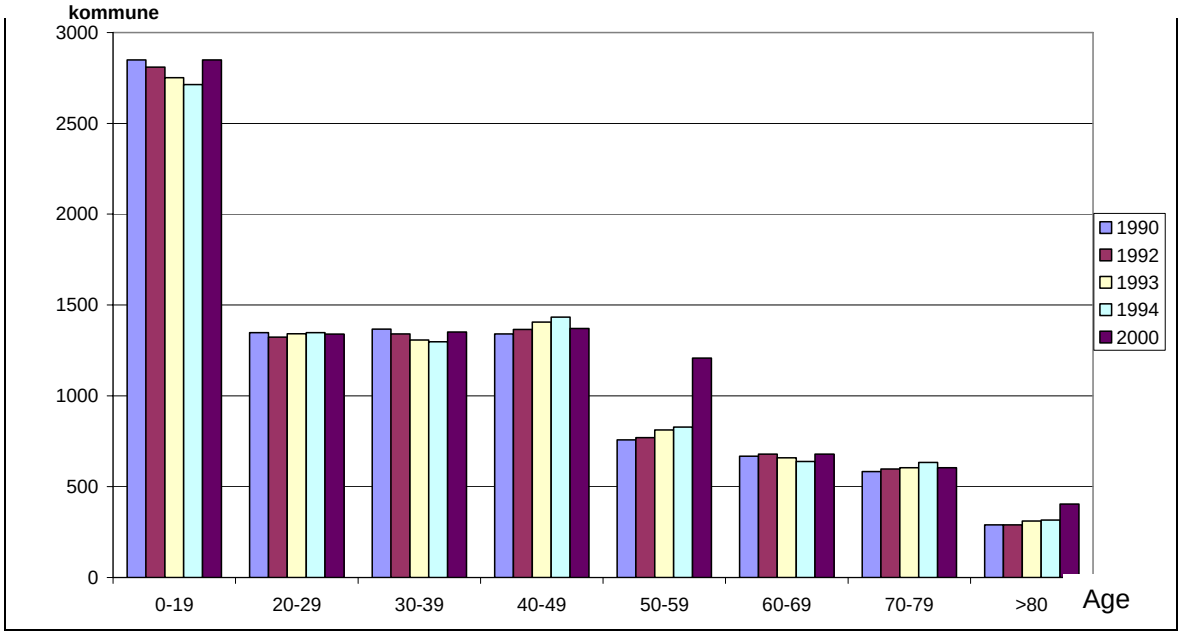

Figure 3: Number of women in age categories on Askøy for given years

The number of pople in theirs fifties has increased in Askøy indicating that they have moved to Askøy.

The transport model has the following input data:

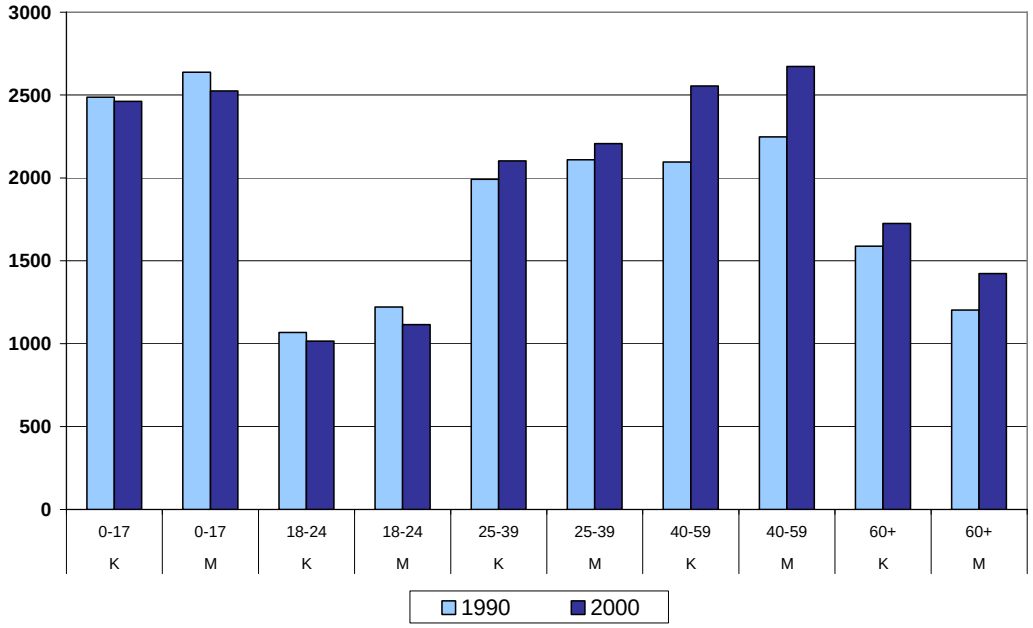

Figure 4: Number of people living i Askøy in age categories from the zonal data in the transport model.

The same change is viewed in the transport model (Figure 4).

The employment situation has also changed. A higher share of the people are employed (Figure 5) and they work more (Figure 6) according to the travel surveys.

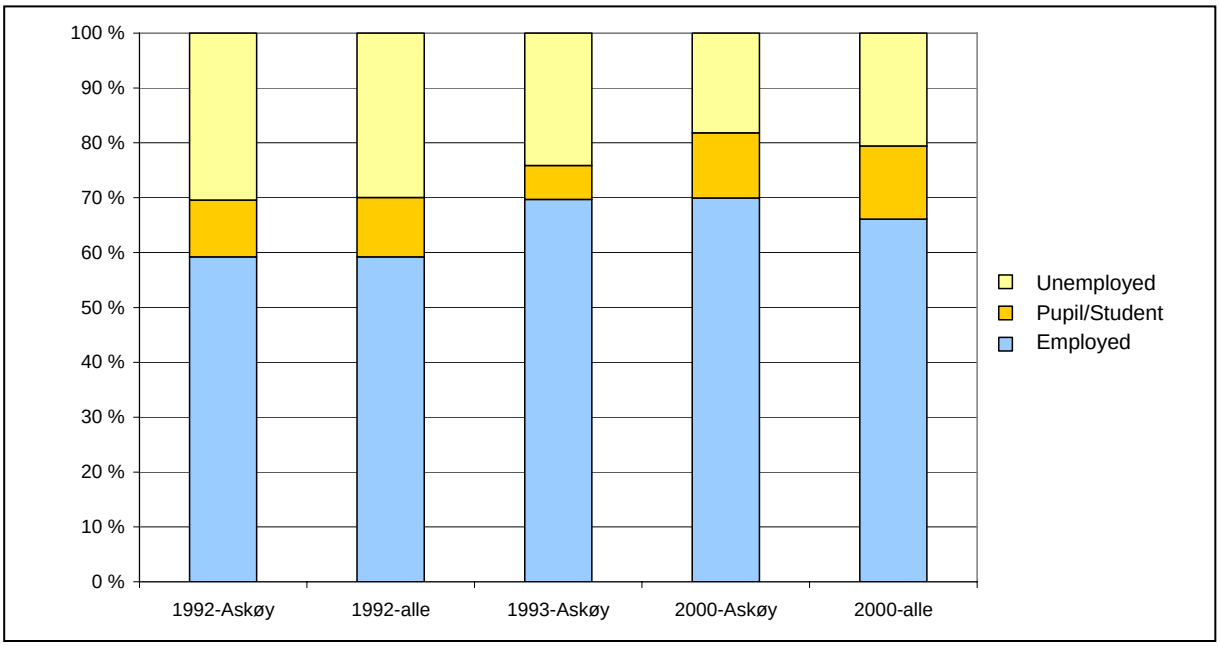

Figure 5: Distribution of employment from the travel surveys

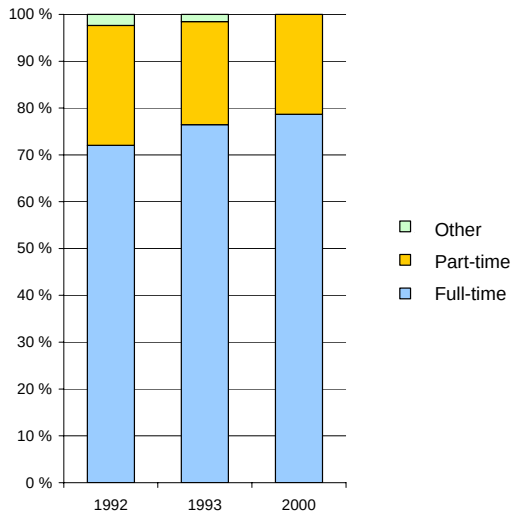

Figure 6: Employment structure on Askøy from the travel surveys. Shares of the workers working full or part time.

This is also mirrored by the zonal data in the transport model:

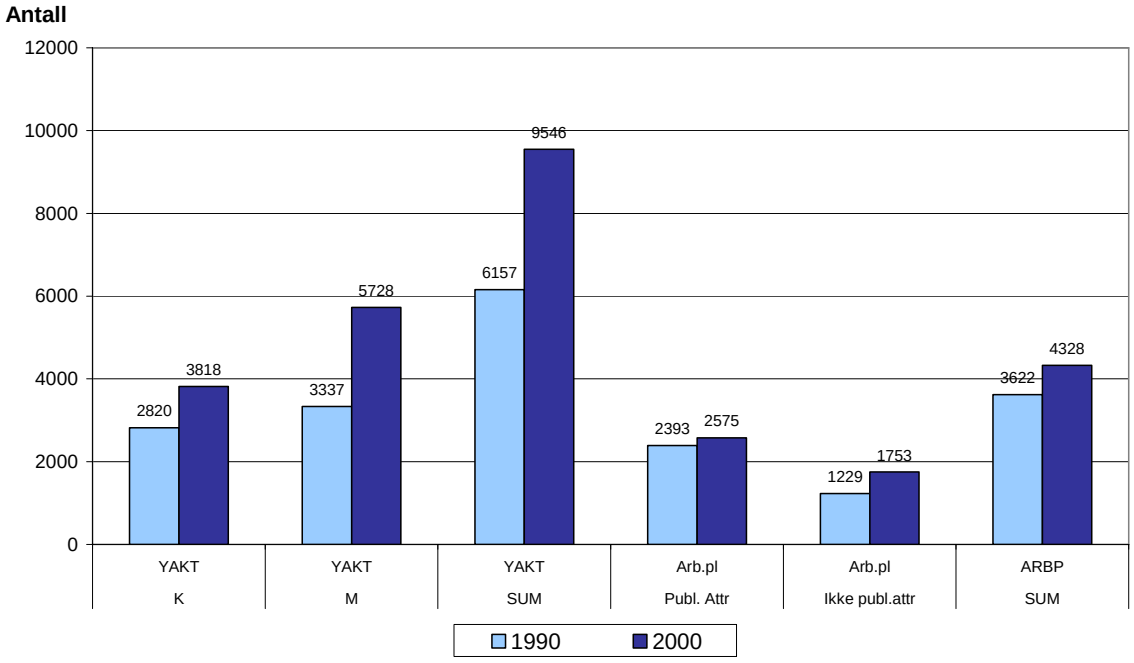

Figure 7: Number of working women, men and total, number of visited work places (have customers, typically shops or public offices, number of not visited work-places (for instance industry) and total number of work places in Askøy.

The number of workers has increased by 50 % (!) in Askøy according to the zonal data from 1990 to 2000.

The car ownership has changed in the Bergen aerea. Fewer pople live in a household without a car, and it is more common to have two or more cars in a household. The same tendency can be observed in Askøy, but stronger (Figure 8).

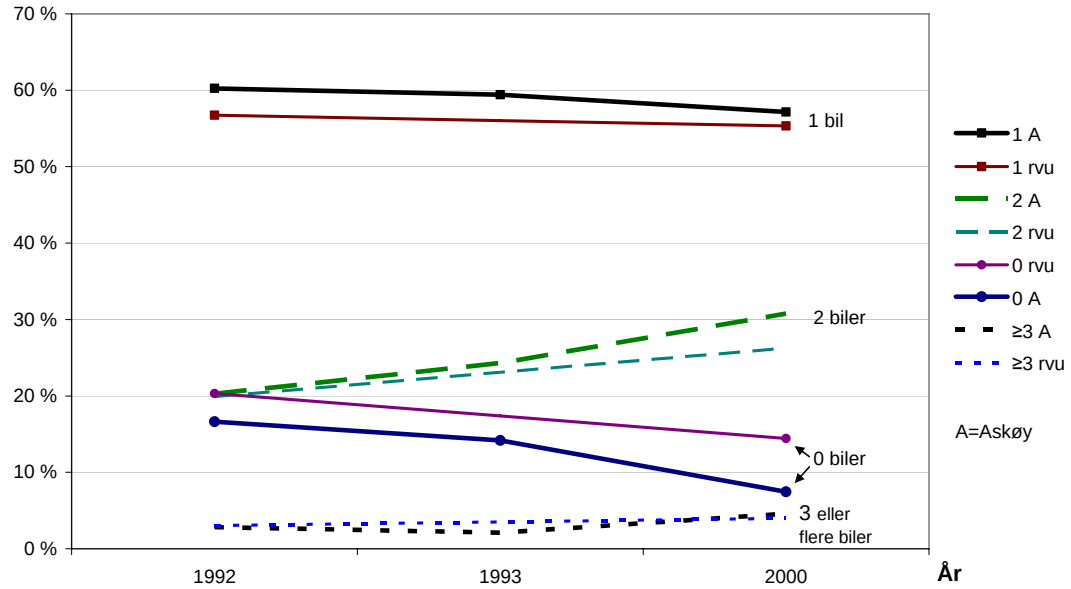

Figure 8: Development in car ownership from the travel surveys (A=Askøy, rvu=travel survey numbers, only those from municipalities participating in travel surveys both in 1992 and in 2000.

The car ownership development indicates a higher car availability among the Askøy residents. They were also asked about their car availability, and the results can be viewed in Figure 9.

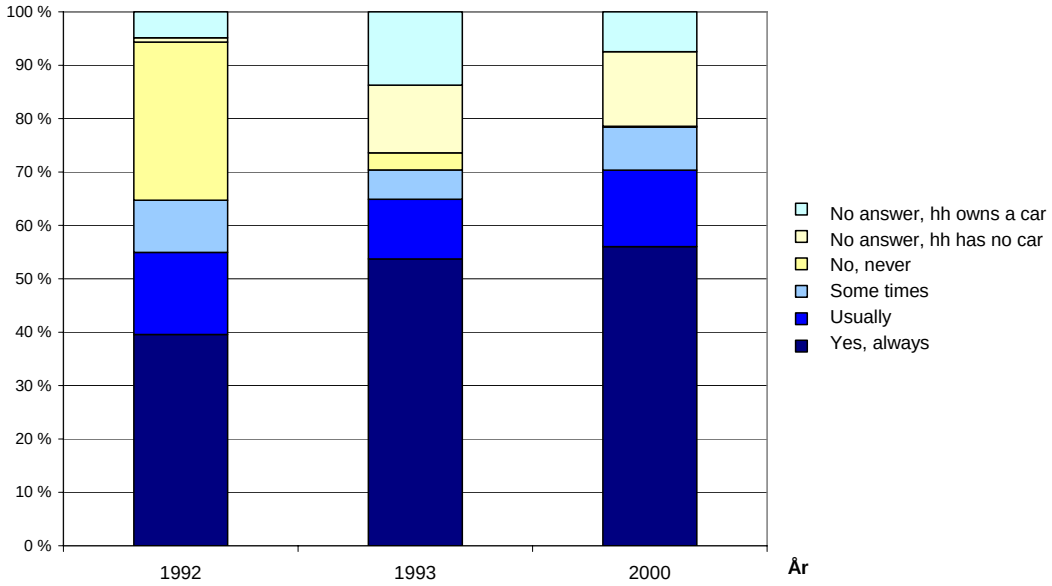

Figure 9: Access to car for people living on Askøy

The yellow aerea has diminished from 1992 to 1993. In 1992 nearly 30 % answered that they never had access to a car. In 1993 this share was only about 3 %. If we add those without a car in the household the share with no access to a car was about 15 % in 1993 and was almost at the same level in 2000. It is clear that the bridge affected the car ownership and thereby the car availability.

Car ownership in the model:

Car density in the population is a variable that goes in to the model. The trips (in the trip production, step 1 in the model) are distributed in three groups – carownership groups: households without a car, with one car in the households and with two or more cars in the households. The relation in the transport model between car density and the distribution in car-ownership groups is shown i Figure 10 (long lines). The figure also shows some shorter lines which are the car ownership from the travel survey hold together with the car density for those municipalities.

The figure indicate that the relation between car density and distribution in car ownership groups is erroneous in the transport model.

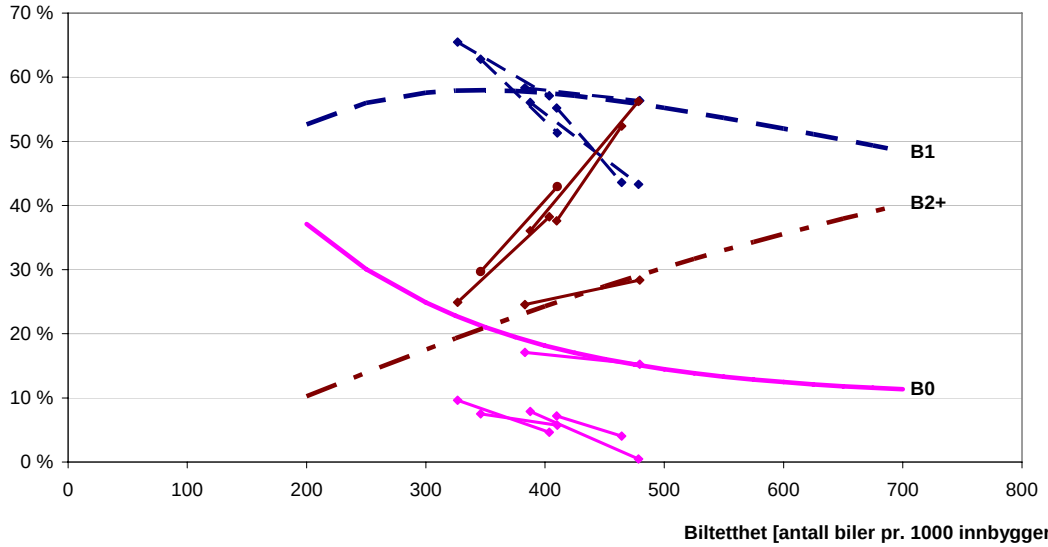

Figure 10: Sammenhengen mellom biltetthet og fordeling på bilholdsgrupper fra RVU (korte linjer) og forutsatt utvikling i transportmodellen

In the transport model there are too many *without* access to a car, and living in a household with *one* car at their disposal, and the transport model gives too few living in a houshold with *two or more* cars available. This means that the car availability is worse in the transport model in general compared to the real world, especially for the 2000 scenario. For the Askøy municipality the difference is even worse.

Trip production

Table 2: Tripfrequency in the travel surveys compared to the transport modell

Årstall	Reisevane-undersøkelser	Transportmodell-scenarier
1992	3,23	3,19
1993	3,43	3,19
2000	3,58	3,63

The trip production calculation are almost correct. This conclusion is valid even for the age and sex segmentation in the model and for different trip purposes. There is one exeption and that is the caused by the growth in employment that took place from 1992 to 1993, and since

the transport model used identical zonal data for the two situations there was no difference while the travel surveys showed increased working activity.

It seems like the transport model is able to recreate the trip production from the travel surveys. The requirement is that the input data in the transport model are updated (which was not done for the two situastions before and after the bridge opened). This is a problem when, as in Askøy, some of the effects of the project affects the input data (work activity, where people live, how many cars they have, where the work places are located).

Trip distribution

The share of trips between Askøy and Bergen city centre increased when the bridge opened. In the model the trip distribution cost function was based only on distance, and this resulted in a decrease in trips in the transport model from 1992 to 1993. Changes in zonal data to the 2000-scenario in the model led to an increase again.

The travel surveys showed that the share of trips between Askøy and the city centre was reduced from 1993 to 2000, possibly as a consequence of impaired attraction due to new shopping centres and work places located south of the city centre. The southern areas of Bergen also increased its attraction because the connection to the main land came there.

What we could learn from this is that a cost function should always consist af generalized cost. Travel time and monetary cost should always affect where the trips go in the model.

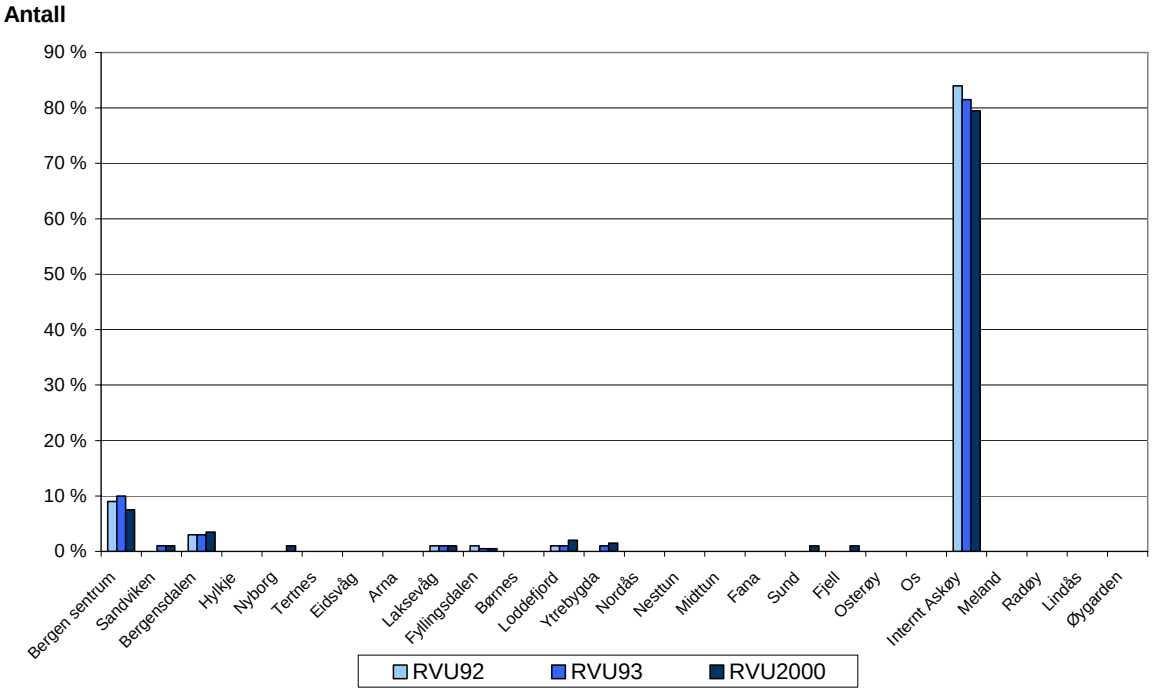

Figure 11: Trip end shares to/from districts/municipalities from the travel surveys. Trips carried out by people living in Askøy

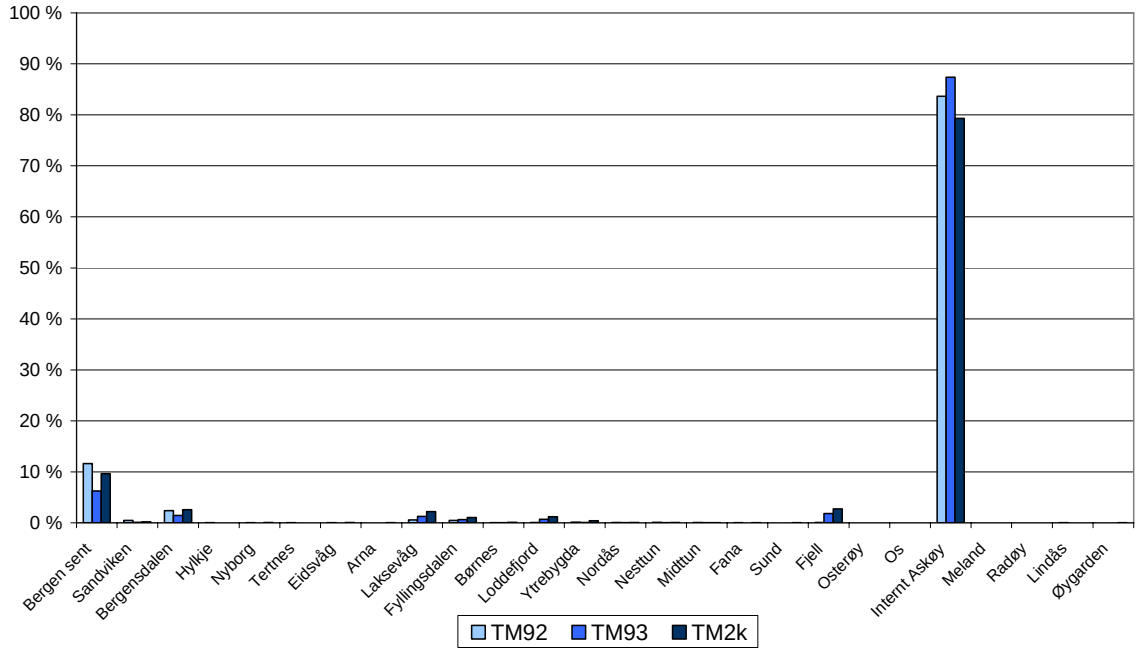

Figure 12: Trip end shares to/from districts/municipalities from the transport model.

Mode shares

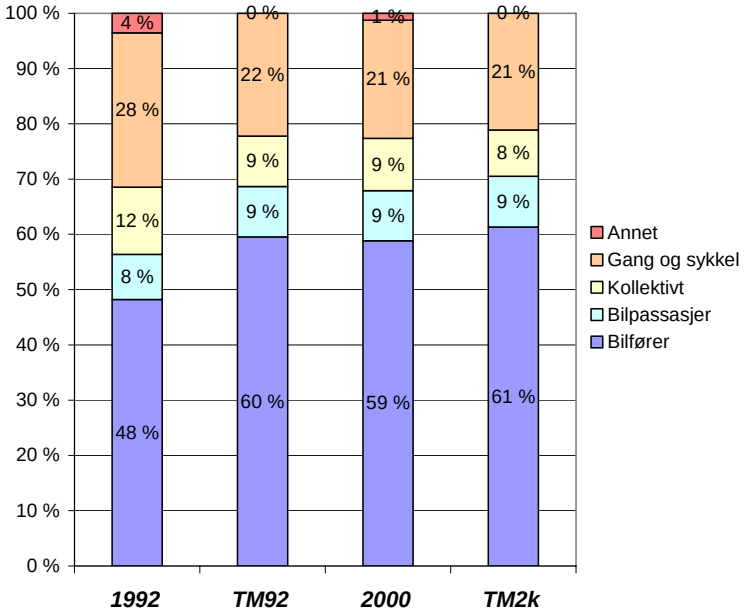

Figure 13: Reisemiddelfordeling for summen av reisehensikter unntatt Bo-skoleturer og tjenestereiser fra RVUer fra 1992 og 2000 sammenlignet med reisemiddelfordeling fra modellscenariene TM92 og TM2K

In general the mode changes from 1992 to 2000 are too small in the model. The observed change in the car driver mode is 10 percentage points, while only 1 percentage point in the model.

For traffic to and from the island:

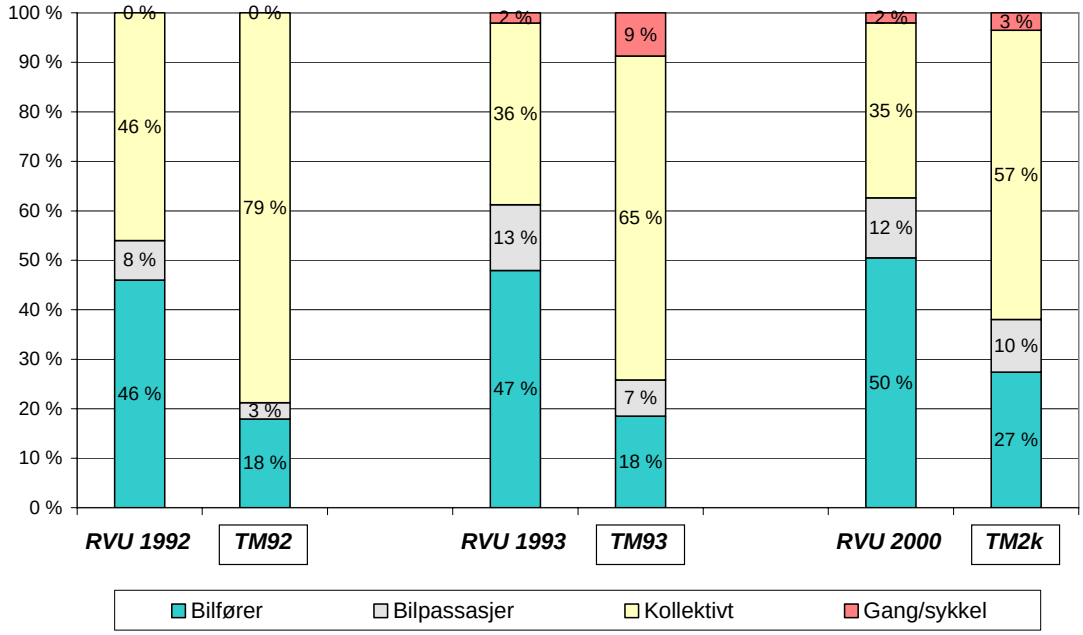

Figure 14: Mode shares for trips with one of the trip ends (O or D) in Askøy from the travel surveys and from the transport model. (Travel purposes left out are R-school, Comercial trips and external traffic)

The reason for the low car driver share for trips to and from Askøy is connected to how the ferry is represented in the transport model. The ferry is modeld as a regular road link with tolling and low capasity (corresponing to the ferry capasity). It has a volume-delay curve wich gives very low speed and higher travel times as e demand exceeds the capasity. This is to represent that you risk beeing left behind somtimes, and must wait to the next turn. The waiting time for cars made the total time for some of the passengers up to several hours.

Also there was a parking place at the ferry landing making it propitious to drive the car there, park the car and go by the ferry to Bergen city centre. Combined modes are not represented in the model whereas these trips would be counted as car trips in the travel survey (as we have defined it). The combined alternative (car/ferry) amount to 41 % points of the 46 % in 1992, but we don't have any information of whether they took the car on the ferry or if they parked near the ferry quay.

Net assignment

The number of passengers with a car was registered on the Askøy ferry. Traffic counts on the bridge was also carried out in 1993 and 2000.

Table 3: Link results from the transport model (WDT) compared to counts on the ferry (1992) and on the bridge (1993 og 2000).

Year	Transport model	Counts
1992	5 700	2 500
1993	4 500	4 000
2000	8 600	7 000

There is an apparent antagonism between the results from 1992 in Figure 14 (too few cardrivers) and the results from Table 4 (too many cardrivers). There are two reasons. One is the combined modes, where car+ferry are counted as car in the travel survey while this is not an available choice in the transport model. The other are the composition of travel purposes within the numbers. We took out some travel purposes, *residence- elementary school* (not likely to use the ferry, they have closer schools) comercial traffic (the count indicated that the commercial traffic were around 500-1000 vehicles on the ferry while the transport model gave 2 800) and external traffic (likely to be small, 100 in the transport model on the ferry). The results now are shown in Table 4.

Table 4: Link results from the transport model (Travel purposes left out are R-elementary school, Comercial trips and external traffic) (WDT) compared to counts on the ferry and on the bridge.

Year	Transport model	Counts
1992	2 000	2 500
1993	1 600	4 000
2000	5100	7 000

Changing the carownership distribution calculation and the ferry representation in the transport model would improve these results.

Conclusion

The objective of the study was to test the forecasting ability of a transport model. The situation before and after the opening of the bridge were compared. An existing transport model was adapted for this purpose, and the situations before, just after, and seven years after the bridge opened were recreated in the transport model. The years of the scenarios correspond to those of three travel surveys. Results from the model were compared to changes obtained from the travel surveys.

The computation of trip production from the transport model corresponds well to the development shown in the travel surveys. The trip production is stable for trips having leisure and shopping as their purpose. The level of leisure and shopping trips in the transport model just depend on the number of people in different age and sex categories. Trips with the purpose of working and Non-home-based trips are more closely linked to business development and are well reflected in the model.

According to the travel surveys, the number of trips increased between Askøy and the centre of Bergen when the bridge opened. Results from the transport model show the opposite development. This is a consequence of the variables influencing trip distribution, and follows from the fact that time used is not one of these variables. Only distance travelled and monetary expenses connected to a potential trip is evaluated in this particular transport model. The transport model is not able to compute changes in mode choice correctly. A better description of the relationship between car density and car-availability groups would probably

improve the transport model. This would influence the results of trip distribution and mode choice.

Even if the transport model has weaknesses in some of the steps of the computation process, the network assignment results ended up at about the right level. The transport model also gives the number of ferry passengers correctly, when compared to the survey from 1992. The computations illustrate the necessity of looking more closely at the representation of cargo- and business-trips in the transport models.

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