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Summary:

BIG 1

Vehicle Generation Model Version 1

Central transport policy issues are associated with the development of the automobile population and composition.

Forecasting models such as the National Model System for Travel Demand only estimate *the total* number of registered private cars and use in Norway on the basis of macro-economic data and the growth of the population in general. However, vehicles of different size and age possess different features pertaining to fuel type and consumption, accident rate, exhaust levels, etc.

In order to be able to evaluate the effect of various transport policy measures such as taxes, an improved model of the structure of the vehicle population is required.

In this report, the first version of a Vehicle Generation Model (BIG1)[1] is presented. The aim has been to develop a forecasting model wherein the vehicle population composition according to categories (models, weight, fuel requirements) is considered and analysed.

This version of BIG1 considers vehicles under 3500 kg classified under ten headings:

Table S.1: Vehicle categories in the model by vehicle model, fuel, and weight.

Vehicle model	Weight (kg)
Diesel private vehicles	Under 901
	901-1 200
	1 201-1 400
	Over 1 400
Petrol-driven cars	Under 901
	901-1 200
	1 201-1 400
	Over 1 400
Diesel goods vehicles	Under 3 500
Petrol-driven goods vehicles	Under 3500

We consider the individual groupings and age of vehicle separately such that each separate year's vehicle population emerges within a matrix. In the base year for the

[1] An anachronym of the Norwegian equivalent term, *BilGenerasjonsmodell versjon 1*.

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calculations, 1996, the composition matrix is known. With the aid of *transfer rates*, which are an expression of the possibility that a vehicle within the group and of a specific age will "survive" to the following year, the vehicle population for the following year is estimated. The import of used vehicles is also included as well as new-registrations. The calculations are repeated for every year up to the year 2020, the horizon for this model.

After the future population matrix has been established, the total effect may be calculated using data relating to annual mileage, fuel consumption and other variables for the individual vehicle and age group. In this version traffic levels (measured as carriage-kilometres) and energy consumption is calculated for each vehicle and age group, individually and in aggregate.

The forecasting implements have been developed as a system of Excel work books where comparisons are made between a basic alternative referred to as BIG1-zero, and an alternative development pattern for the vehicle population. Central factors or statistical variables that may be changed are: new car sales (absolute numbers, models), numbers of scrapped vehicles, and annual mileage in the various categories.

Alternative base

The basis alternative is a "business-as-usual" alternative based on available forecasts and data. Importance is attached to document input data and to confirm that the forecast model's total results in this alternative are in accordance with the prognoses in the National Transport programme and the National Model System for Travel Demand developed by the Institute of Transport Economics.

The results show that the number of light vehicles in this alternative will increase from 1 846 695 in 1996 to 2 840 274 in 2020 simultaneous to an increase on the total traffic from 29.9 billion to 40.6 billion carriage km.

Further, the calculations show that the structure of the car population is changing in the direction of more diesel cars and heavier vehicles, and that the mean age is increasing. By 2020 about 12% of private cars will be diesel-driven as opposed to about 6% in 1996.

While both the number and proportion of cars under 900 kg is decreasing, the results show that the share of heavy private cars above 1400 kg is increasing significantly. In total, the car population will experience an increase of 53% over the period. By comparison the heaviest diesel-driven private cars will have increased by more than 500% and petrol-driven private cars exceeding 1400 kg will have more than tripled.

In the total car population this development is also seen as an increase in the mean weight of private cars from 1090 kg in 1996 to an estimated 1200 kg by 2020.

The growth of goods vehicles in the period under consideration is clearly less than that of private cars, i.e. 25% as against 57% for the latter. Similarly to private cars there is a significant difference in the development of diesel- and petrol-driven vehicles. The number of petrol-driven goods vehicles is estimated to decline from 98 041 in 1996 to 73 152 in 2020, while diesel-driven goods vehicles will increase from 71 877 to 160 343 over the same period, an increase of 80%.

The trends are thus towards a change in the car population's structure with a higher proportion of private diesel-driven vehicles, larger (heavier) private cars, and a considerable reduction in the number of cars under 900 kg. This reflects the trend that was clearly seen in the period 1993-1996.

The mean age of light cars will increase from 9.6 years to 11.9 years in the period 1996-2020.

We have chosen to compare this basic alternative with two hypothetical development trends.

Increased scrapping (permanent scrapped vehicle deposit)

The introduction of the scrapping arrangement whereby a scrap deposit was introduced in 1996, resulted in a significant turnover in the car population. The net result was a reduction in the total car population in 1996. In our model this is expressed in an increased replacement rate in comparison to the base-alternative where the rates are based on changes in 1993-94 and 1994-95. In the alternative model we have calculated the replacement rate based on the actual changes occurring in 1995-96 as a result of the scrap deposit arrangement. Multiplying the successive annual replacement rates we are able to calculate the possibility for a car obtaining a certain age. Figure S.1. shows the successive replacement rates (all sections of the car population) for the two alternatives.

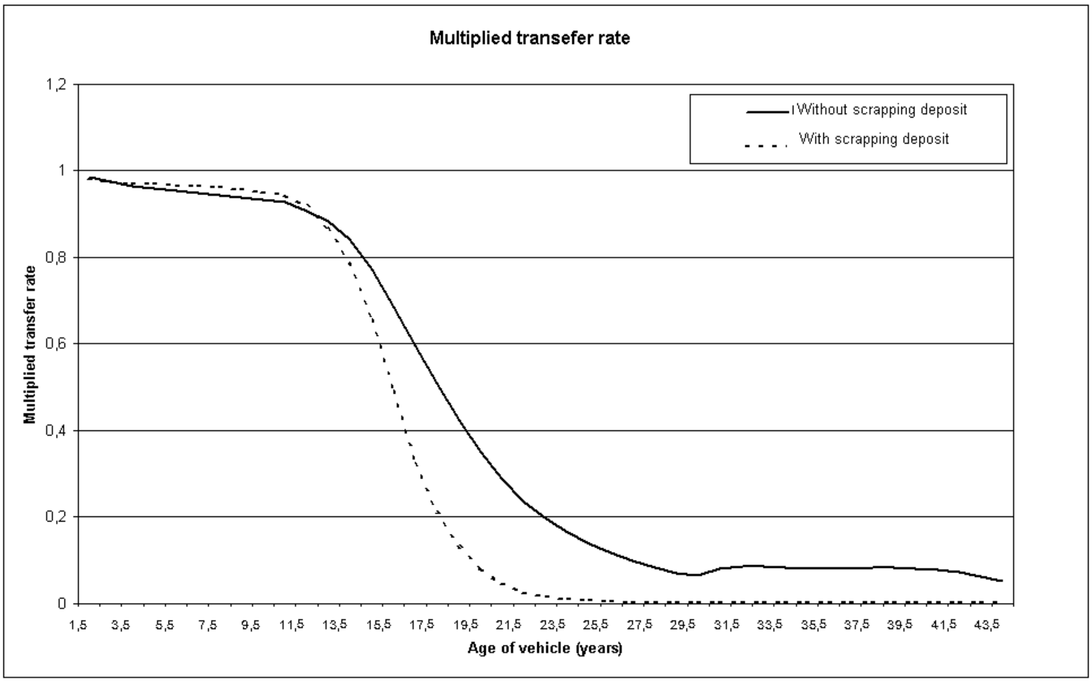

Figure S.1: Multiplied replacement rates for the entire car populations. Alternatives with and without the scrap deposit.

The accumulated replacement rate in the basic model – without the scrap deposit – is higher than in the alternative development model. In the basic model about 80% of the car population will be replaced after 23 years. The corresponding period in the model with a scrap deposit is about 18 years. In order to isolate the effect of the increased scrapped vehicle deposit we have chosen not to change new car sales and used imports, but to set this at the same level as in the basic model. Other input data is also similar to the basic model.

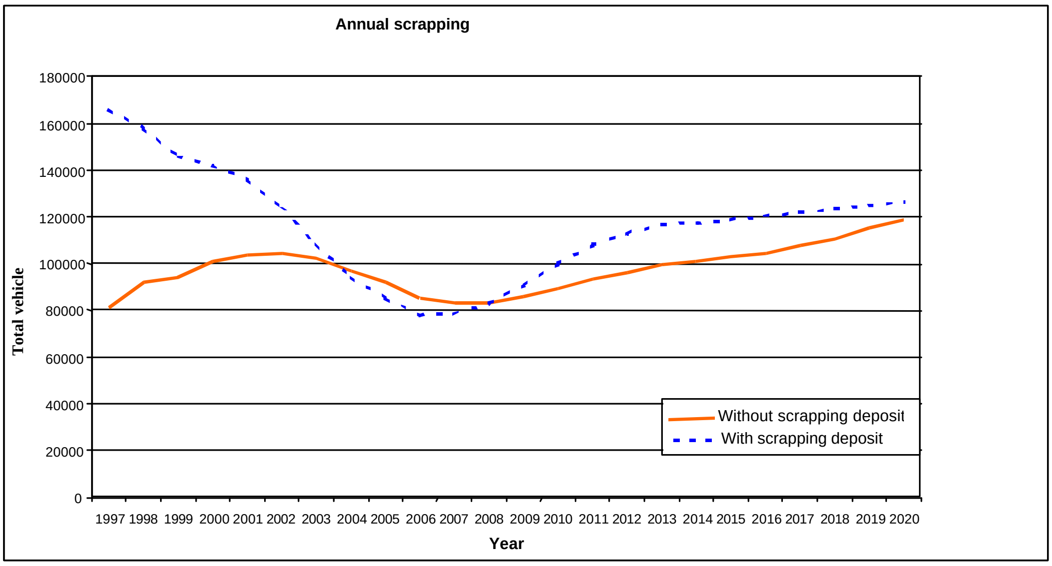

Figure S.2: Total annual scrapped vehicles. With and without the scrapped car deposit

It will be observed that particularly during the early years from 1997 – 2003, an alternative high rate of scrapping will have a positive effect. While the basic model incorporates scrapping some 80 000 vehicles, the alternative model with the scrap deposit will result in almost 170 000 vehicles being scrapped. After 6 years the annual scrap level in the two models will be about 100 000 vehicles.

After the year 2003 the system of a permanent high scrap premier will have a significantly reduced effect.

As scrapping increases and new sales and used imports are identical with the basic model, the car population and associated traffic levels will increase more slowly in this alternative than in the basic model. By 2020 the difference will amount to 433 839 cars and 2716 million vehicle-kilometres.

Increased scrapping and increased new car sales

In the second alternative we use the replacement rates from 1995-96 but have changed new car sales so that the car population and structural composition are the same as in the basic model at each point of time. In practice this means that should a car in one particular category be scrapped during the year under consideration, it will be immediately replaced by a new car in the same category.

Naturally, new car sales will influence the mean age of the car population. In the basic model the mean age increases from 9.6 in 1996 to 11.9 in 2020. In the alternative model the mean age is reduced to 9.0 years in 2020. In other words, the car population is 2.9 years younger in the alternative model. The difference amounts to 3.1 years for private cars and 0.8 years for goods vehicles.

The mean annual mileage used in both models is dependent, among other things, on the age of the vehicle. Newer vehicles have a higher annual mileage than older vehicles. When the car population's mean age is reduced, this also implies that total traffic volume in the alternative model increase. By 2020 the difference between this and the basic model would be 5491 million carriage-kilometres. The increase in traffic between 1996 and 2020 is 50.9% in the basic model, and 71.3% in the alternative model. The net difference amounts to 20.4% as compared to the traffic volume in 1996.

Correspondingly, the difference in total fuel consumption between the two alternatives is equivalent to 14.9% of total consumption in 1996.

The increase in the total fuel consumption is, in other words, less than the corresponding increase in traffic might suggest. The change in the age structure of the car population has resulted in a more energy-effective car population. By the year 2020 the specific fuel consumption in the entire car population in the basic model is calculated to 0.076 litres/km (37.2 miles per gallon). In the alternative model consumption was calculated at 0.0749 litres/km (36.7 miles per gallon), a reduction of about 1.5%.

For the period as a whole the difference in the specific fuel consumption between the two models is calculated at 1.6%.

Energy efficiency and changes in the car population

The specific fuel consumption (shown in litres/10 km) for various types of vehicle is reduced in the basic model by between 11 and 20 percent in the period 1996 – 2020, dependent upon the type of fuel. The differences between the specific consumption in the basic model and the two other alternatives are however, relatively modest.

Figure S.3 illustrates the specific fuel consumption for petrol-driven private cars in the basic model, the alternative model with increased scrapping, and the alternative with both increased scrapping and increased sales of new cars.

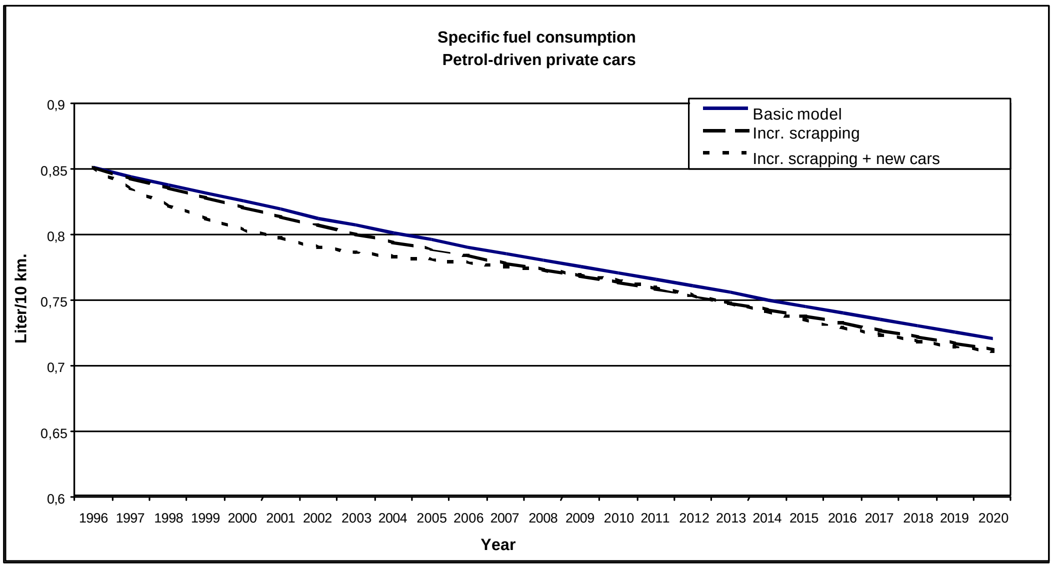

Figure S.3: Specific fuel consumption (litres/10 km) for petrol-driven private cars in the basic model and the alternative models with increased scrapping and increased new car sales.

Our calculations show that the largest contribution to reduced specific fuel consumption is achieved through the normal replacement of the car population as described in the basic model. Special measures which result in increased levels of scrapping and any increase in the sales of new cars provide a relatively modest addition. Increased scrapping results in an increased number of older models being removed from the population, something which naturally results in reduced levels of specific fuel consumption. A further reduction is achieved when those older models which are scrapped are replaced by new models where specific fuel consumption is lower.

While the specific consumption for petrol-driven private cars in the basic model is reduced by 15.2% in the period covering these calculations, this may be increased by a further 1.3% following increased levels of scrapping. A further modest reduction of 0.2% may be added when scrapped cars are substituted by new cars, giving a total of 16.7%.

As a result of scrapping and new car sales, the period over which this development may take place can be reduced by 2 years regarding petrol-driven private cars. In other words, by increasing the numbers of scrapped cars and of new car sales such as we have anticipated, the same specific fuel consumption levels estimated in the basic model for the year 2020 may be achieved by the year 2018. The largest displacement difference occurs between the basic model and that alternative model employing both increased scrapping and increased car sales. The specific fuel consumption of 0.0795 litres/km [2] in the basic model in 2005 may be achieved 4 years earlier with a combination of increased scrapping and increased new car sales. This suggests that by 2001 the specific fuel consumption in the basic alternative is reduced by 2.7%, from 0.0819 litres/km to 0.0797 litres/km. Later in the period for the calculations the differences will be less and the displacement difference will be 2 years on average.

The energy efficiency described here occurs in spite of the increase in the mean weight of the car population and that fuel consumption increases in consequence. If in addition to the increased levels of scrapping and new car sales, we had introduced measures restricting all new private car sales to a maximum weight of 900 kg, our calculations would then suggest that the specific fuel consumption in 2020 would be about 0.0560 litres/km, or some 34% higher than in 1996.

Further development of the model

The objective with the first version of the Vehicle Generation Model (BIG1), was to develop the calculation scale, to ensure the quality of the data and to test this, as well as to gain experience with the use and application of this type of forecasting model. In contrast to traditional forecasting models for car populations and use,

[2] The diagram shows consumption in litres per 10 km and where, for example, 0.8 litres/10 km = 35.3 mpg.

BIG1 has the possibility to estimate the effects of different parameters affecting the car population and structure.

The most important and demanding work in further development of the forecasting model lies in preparing estimates of new car sales and ages of vehicles, and for the various categories in the model which describe annual imports.

Our aim is to develop a macro model based upon the TRULS model which forecasts the total private car population in Norway in a hypothetical equilibrium and as a function of the population (inhabitants), income development, interest rates, car prices and fuel prices.

In the next stage we will consider a logit model for the distribution of new car sales and used car imports in the various categories, dependent upon the relative prices – and in this connection the taxation and excise system. In this manner it will be possible to develop a tool for analysing how the car taxation policy will influence the level and structure of the vehicle population over a longer periode, and in consequence its effect on safety and the environment.

In carrying out the development and improvements outlined here, the vehicle generation model will be a complementary contribution to the private transport model and TRULS model currently used by the Institute of Transport Economics.