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Estimation of Car Mileage and Fuel Consumption in Germany

Transmitted by the Department of Energy, Transportation, Environment,
German Institute for Economic Research (DIW), Germany

1. Aim

There is a lack of empirical information on the mileage of motor vehicles registered in Germany. Mr. Kossman from the Federal Highway Research Institute (Bast) already gave an overview on the surveys on car mileage, and on the analysis of average daily traffic information (daily traffic volume DTV), collected at federal roads.

Every year, the German Institute for Economic Research (Deutsches Institut für Wirtschafts forschung, DIW) gives an estimation of the volume of road traffic (vehicle-kilometres), the use of fuel, and the CO_2-emissions, differentiated by fuel type (gasoline or diesel) and by eight vehicle categories: mopeds, motorcycles, cars, busses, light and heavy trucks, tractors, others. Focus in this report will be on private cars.

These data are primarily related to the national road vehicles (vehicles registered in Germany), regardless of where they made their mileage. The “inland road mileage”, the vehicle kilometres driven on roads in Germany are of importance e.g. for road accidents exposure, but need additional assumptions to be calculated and are not considered here.

2. Database and method

DIW mainly uses the two surveys on car mileage conducted in 1993 and 2002. Both followed (nearly) the same method: a sample was taken from the cars registered at the Kraftfahrt-Bundesamt (Federal Bureau of Motor Vehicles and Drivers) and the car holders were asked to submit two consecutive odometer readings in a 10-week interval. DIW was able to match these survey data with technical vehicle data and data on specific fuel consumption by manufacturer, model and engine, so had an enriched set of variables. In addition, DIW used data from the nationwide travel survey conducted in 2002 (MiD 2002) and the German mobility panel (MoP 2003).

The basic idea of the model is to calculate the fuel consumption in a disaggregated model (about 5,000 types of passenger cars are included) as a product of the number of registered cars by type, the average mileage of cars by type, and the average fuel consumption of cars by type of car. Average mileage is estimated by analysis of the mileage surveys of 1993 and 2002 and extrapolated for new models. The average fuel consumptions are estimations of real consumption on the road. The dynamics in change of behaviour cannot fully be included in these calculations. So these results are contrasted to an aggregated calculation of yearly fuel consumption based on fuel sales in Germany and estimations for fuel bought abroad. Differences between the calculated volumes of fuel of the two different approaches have to be explained by plausible qualitative assumption on change in car use, supported by the analysis of different survey data sources. So the dynamics of the model lay in the determination of the equilibrium between the two calculations of fuel consumption.

3. Components of the model

The **fleet** of registered passenger cars has grown steadily by 5.5 million cars, compared to 1993, up to 45.3 million vehicles (1 July 2004). The number of passenger cars with gasoline engines has increased until 2001 has been decreasing since, in 2004 by half a million vehicles compared to the previous year. The number of diesel-engine passenger cars increased steadily especially after the year 2000; in the meantime, one in five passenger cars in Germany has a diesel motor. The structure of the fleet diversified towards more small cars, but mainly towards bigger cars like SUV-vehicles with more weight and higher engine ratings. The average engine performance of cars increased from 61 kW in 1993 to 73 kW in 2004.

The **average mileage** of cars in the year 2002 is almost the same level as 1993, comparing the results of the surveys. This is surprising, since fuel prices did increase in 1999 and 2000 already, and the rising multi-car status of private households let less kilometres for the second and third car in the household be expected. But apparently the opposing tendencies – such as the greater degree of urban sprawl – are so powerful that overall the average annual mileage per passenger car has remained nearly the same.

The **average fuel consumption** of motor vehicles did decrease by 8%.[1] Since freight vehicles have fewer options of providing for fuel economization, this is mainly due to less fuel

[1] This takes account of the actual average consumption on the roads, factoring in that large passenger vehicles are generally driven more than smaller ones and that everyday driving conditions do not correspond to those on the test bench. These consumption values are thus customarily higher than the norm consumption values ascertained under specific conditions, which do not provide, to quote an example, for trips at a greater speed than 120 km/h and trips with a roof luggage rack.

thirst of passenger cars. However, the mentioned trend towards heavy, high motorized cars and additional vehicle features (comfort, climate, safety) increased consumption, so overall the effective average consumption of passenger cars sunk in the 10 years analyzed by 10 % – from 9.0 to 8.1 l per 100 km.

The **total fuel consumption** can be calculated from the vehicle stock and average consumption, but can be derived from aggregated data, too. Both calculations being set in contrast, DIW get hints to the volume of changes not yet included in the disaggregated model.

The domestic sales of **diesel fuel** from mineral oil in road traffic rose from 23.6 litres in 1993 to 29.5 billion litres and has remained at this level since 1999. To be added to this, is diesel fuel obtained from vegetable raw materials, which is partially sold as an additive and partially as pure bio-diesel. Production and sales of this regenerative fuel rose in the last four years from 0.4 billion litres to 1.2 billion litres. Because of the difference in price of fuels as compared to Germany's neighbouring countries, "grey" imports are likely to play an increasing role. DIW Berlin published an estimate of the magnitude of these amounts last year (2 billion l of diesel fuel). In the estimation for 2004, the current price relation to the neighbouring countries was taken into consideration. In addition, with the accession of the Czech Republic and Poland into the European Union on 1 May 2004, the import restriction of 20 litres at the borders of these countries no longer was applicable. The grey imports of diesel fuel in 2004, primarily in the fuel tanks of freight trucks and semi trailers, are now estimated by DIW Berlin to be 2.2 billion litres. For overall transnational traffic, including the diesel fuel tanked abroad by German cars for international distances, another 2.9 billion litres must be added to domestic sales, thus nearly 8 % more than in the previous year. Overall, as compared to 2003, diesel consumption increased by almost 6 % for diesel motor vehicles registered domestically results.

The domestic sales of carburetor fuels in road traffic has been on the decline since 2000. In 2004, this trend continued; sales regressed by 2.6 % to 33.1 billion litres. The causes can be seen, on the one hand, in the reduction in the number of passenger cars with gasoline engines, which consume the bulk of carburetor fuels. On the other hand, along with diesel, gasoline is also being increasingly imported in the fuel tanks of German motor vehicles as grey imports. For 2004, DIW Berlin estimates the quantity at 1.4 billion litres, 8 % more than in 2003. Together with the carburetor fuel quantities for distances tanked abroad by German motor vehicles, primarily during vacations, a domestic consumption of 35.8 billion litres results, 2.1 % less than the previous year. This calculation confirms the consumption quantities determined from vehicle data which result in a comparable figure given the decrease of gasoline engine passenger cars by a total of 1.4 % and a decrease of the average consumption of these passenger cars by 0.6 %.

The updated **model** is based on the number of cars of private and business holders differentiated by about 5,000 models and types. The results of a log linear regression analysis of the survey data were used to estimate the average mileage of each car type. It turned out, that car ownership (private or business holder), car size, car age, and type of engine are main factors. However, there was a highly significant effect of year on car mileage age, too. For each year, therefore, separate estimations for business and private, gasoline and diesel cars are made to determine the average mileage for the car types. But DIW adopted the hints and results of other data sources also and compares, as mentioned, the resulting overall fuel consumption with an independently made estimation based on fuel sales and imports. In the calculation for 2004 based on the disaggregated data, it fortunately met with the increasing sales of diesel and bio fuels.

4. Conclusion

The new survey results of 2002 led to a substantial recalibration and refinement of the model. Empirical data are necessary for an update from time to time, especially when there are changes in the structure of the fleet (like an increase of diesel share with no empirical information on their use) and underestimated changes in the data used for controlling (like increasing "grey" imports). As far as DIW can say now, there is no trend reversal in the increase of German passenger car mileage, yet, and almost no reduction in the use of energy and emissions of greenhouse gas CO_2, in spite of increasing fuel prices. Thus analyses are confirmed in which an only marginal price elasticity of fuel and traffic demand was determined.[2]

[2] International literature states the short-term elasticity of the passenger car mileage in relation to the fuel price as approximately -0.15 and long-term as approximately –0.30. The price elasticity of fuel demand amounts to approximately double those amounts for each figures. Current meta studies on the elasticity of fuel and transportation demand are offered by Daniel Graham and Stephen Glaister: Road Traffic Demand Elasticity Estimates: A Review. In: Transport Reviews, Vol. 24, May 2004, pp. 261–274; Phil Goodwin, Joyce Dargay and Mark Hanly: Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. In: Transport Reviews, Vol. 24, May 2004, pp. 275–292; Rainer Hopf and Ulrich Voigt: *Verkehr, Energieverbrauch, Nachhaltigkeit* (Traffic, Energy Consumption, Sustainability). Heidelberg among others, 2004, p. 52 et seq.. For Germany, a current empirical study determined a value of –0.30 for the fuel price elasticity; cf. *Institut für angewandte Verkehrs- und Tourismusforschung* (IVT, Institute for Applied Transport and Tourism Research), ProgTrans AG and STASA (*Steinbeis Transferzentrum Angewandte Systemanalyse*): *Analyse von Änderungen des Mobilitätsverhaltens – insbesondere der Pkw-Fahrleistung – als Reaktion auf geänderte Kraftstoffpreise* (Analysis of Changes in Mobility Behavior – Especially Passenger Car Mileage - as Reaction to Altered Fuel Prices). Final report to research project No. 96.0756/2002 of the *Bundesministerium für Verkehr, Bau- und Wohnungswesen* (Federal Ministry for Traffic, Construction and Housing). Heilbronn 2004.

Mileage and Consumption Calculation for Vehicles in Germany 1994 to 2004

Group	Unit	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Motorized two-wheelers[1]												
Fleet[2]	1,000	3,750	3,995	4,138	4,351	4,673	4,920	4,933	5,215	5,227	5,399	5,600
Average mileage[3]	1,000 km	3.4	3.4	3.5	3.4	3.4	3.4	3.4	3.4	3.0	3.0	3.0
Total mileage[3]	Mill. km	12,812	13,615	14,299	14,871	15,692	16,662	16,845	17,816	15,921	16,457	16,971
Averg. consumption /100 km	Litre	3.7	3.7	3.8	3.8	3.9	4.0	4.1	4.1	4.1	4.1	4.1
Consumption CF[4] total[5]	Mill. l	472	505	539	569	611	668	688	728	659	680	696
CO_2 discharge	Mill. t	1.1	1.2	1.3	1.3	1.4	1.6	1.6	1.7	1.5	1.6	1.6
Passenger vehicles												
Fleet[2]	1,000	39,765	40,405	40,988	41,372	41,674	42,324	42,840	44,307	44,605	44,916	45,258
Of these, CF consumption[4]	1,000	34,407	34,860	35,357	35,785	36,187	36,691	36,879	37,608	37,297	36,950	36,446
Of these, DF consumption[4]	1,000	5,358	5,545	5,631	5,587	5,487	5,633	5,961	6,699	7,308	7,966	8,812
Average mileage[3]	1,000 km	13.3	13.2	13.2	13.1	13.2	13.4	13.1	13.0	13.1	12.9	13.1
Averg. m. of CF cars[4]	1,000km	12,5	12,5	12,4	12,4	12,4	12,4	12,0	11,7	11,6	11,3	11,3
Averg. m. DF cars[4]	1,000 km	18,6	18,0	17,9	17,9	18,5	19,7	19,6	20,4	20,8	20,0	20,3
Total mileage[3]	Mill. km	528,142	535,131	539,473	542,727	550,779	566,222	559,467	575,539	583,560	577,848	591,158
Total. m. CF cars[4]	Mill. km	428,477	435,423	438,564	442,957	449,475	455,080	442,855	438,928	431,246	418,325	411,831
Total. m. DF cars[4]	Mill. km	99,665	99,708	100,909	99,771	101,304	111,142	116,612	136,611	152,315	159,523	179,327
Averg.consumption /100 km	Litre	8.9	8.8	8.7	8.7	8.6	8.5	8.3	8.1	8.1	8.0	7.9
Avrg. cons. CF cars[4]	Litre	9.2	9.1	9.1	9.0	8.8	8.8	8.6	8.5	8.5	8.4	8.4
Avrg. cons. DF cars[4]	Litre	7.5	7.5	7.4	7.3	7.3	7.2	7.1	6.9	6.9	6.9	6.9
CF consumption[4], total[5]	Mill. l	39,579	39,816	39,691	39,679	39,747	39,895	38,129	37,380	36,633	35,332	34,583
DF consumption[4], total[5]	Mill. l	7,467	7,447	7,498	7,332	7,389	8,050	8,260	9,494	10,529	10,958	12,383
CO_2 discharge	Mill. t	113	113	113	113	113	115	111	113	114	112	114
Trucks, Semitrailors[6]												
Fleet[2]	1,000	1,876	1,994	2,074	2,134	2,207	2,323	2,405	2,535	2,547	2,539	2,537
Average mileage[3]	1,000 km	29.6	29.3	28.7	28.6	28.8	29.0	28.4	27.8	27.1	27.2	27.6
Total mileage[3]	Mill. km	55,604	58,369	59,551	61,092	63,604	67,402	68,420	70,558	68,900	69,050	70,141
Averg.consumption[4]/100 km	Litre	25.0	25.3	24.9	24.7	24.6	24.5	24.3	23.9	23.6	23.0	23.1
DF consumption[4], total[5]	Mill. l	13,900	14,760	14,807	15,061	15,637	16,547	16,598	16,889	16,231	15,848	16,200
CO_2 discharge	Mill. t	37	39	39	40	41	44	44	45	43	42	43
Other vehicles[7]												
Fleet[2]	1,000	1,558	1,604	1,643	1,680	1,708	1,754	1,793	1,831	1,879	1,891	1,923
Of these CF consumption[4]	1,000	536	518	496	475	454	438	419	414	389	362	335
Of these DF consumption[4]	1,000	1,022	1,086	1,146	1,204	1,254	1,316	1,374	1,417	1,491	1,529	1,588
Total mileage[3]	Mill. km	17,045	17,369	17,572	17,896	17,964	18,335	18,570	18,828	18,943	18,859	18,877
CF consumption[4], total[5]	Mill. l	805	784	746	714	675	644	616	600	560	519	478
DF consumption[4], total[5]	Mill. l	3,119	3,233	3,351	3,500	3,571	3,696	3,804	3,886	3,987	4,039	4,123
CO_2 discharge	Mill. t	10	10	11	11	11	11	11	12	12	12	12
Total motor vehicles												
Fleet[2]	1,000	46,949	47,998	48,843	49,537	50,262	51,321	51,970	53,888	54,258	54,744	55,318
Of these, CF[4]	1,000	38,693	39,373	39,992	40,611	41,314	42,048	42,231	43,237	42,913	42,711	42,381
Of these, DF[4]	1,000	8,256	8,626	8,851	8,926	8,948	9,272	9,739	10,651	11,345	12,034	12,937
Total mileage[3]	Mill. km	613,602	624,484	630,895	636,586	648,038	668,620	663,302	682,740	687,325	682,215	697,148
CF consumption[4], total[5]	Mill. l	40,857	41,105	40,977	40,962	41,032	41,207	39,433	38,709	37,852	36,531	35,757
DF consumption[4], total[5]	Mill. l	24,486	25,439	25,656	25,893	26,597	28,293	28,662	30,269	30,748	30,846	32,707
CO_2 discharge	Mill. t	161	164	164	165	167	171	168	171	170	167	170

1 Motorized bicycles, kick-start mopeds, mopeds and motorcycles.
2 Number of vehicles in the fleet at halfway through the year, including the temporarily deregistered vehicles; from January 1, 2001 onwards decommissioning notice period increased from 12 to 18 months.
3 Domestic mileage (including distances abroad).
4 CF = Carburetor fuel; DF = Diesel fuel.
5 In reference to domestic mileage.
6 Only diesel vehicles. Trucks and tractors with gasoline engines (less than 10 % of the truck numbers) are contained in the other motor vehicle [segments].
7 Including omnibuses, trucks with gasoline engines and working trucks released from registration without owner certificate with official registration number; without farming vehicles.