Analyzing the Relationship Between Car Generation and Severity of Motor-Vehicle Crashes in Denmark

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Analyzing the Relationship Between Car Generation and Severity of Motor-Vehicle Crashes in Denmark

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Background

In Denmark, road fatalities are on the decrease. This is due to legislation changes, enforcement measures, technological enhancements, infrastructural improvements and human factors. However, research has not investigated the contribution of each factor to the significant road safety improvement.

Aim

To assess the relationship between car generation and conditional accident severity of drivers in car crashes in Denmark.

Method

Crash severity is recorded in four naturally ordered categories:

- No injury/material damage (1)
- Light injury of driver (2)
- Severe injury of driver (3)
- Death of driver (4)

Because of the ordered response discrete variable, an ordered logit-model approach was chosen with a relaxation of the proportional odds assumption:

$$P(y_i > j) = \frac{\exp\left[\alpha_j - \left(X_i^{'}\beta + T_i^{'}\gamma_j\right)\right]}{1+\exp\left[\alpha_j - \left(X_i^{'}\beta + T_i^{'}\gamma_j\right)\right]} \qquad j = 1,\dots,J$$

Where *P* is the probability of having an accident with a driver injury greater than *j* given that the accident has happened. The probability of occurrence of severity category *j* (1,2,3,4) relates to a vector T_i of observed explanatory variables for which the proportional odds asumption **does not** hold and to a vector X_i for which the proportional odds assumption **does** hold. A Brant test investigated whether the variables violated the proportional odds assumption. α_j, β_j and γ_j were estimated by maximum likelihood in Stata.

Data

In the analysis we included drivers of passenger cars and vans in police-recorded accidents in Denmark in the period 2004-2010. Thus we included:

- 80,502 observations of drivers in 49,405 accidents (single + multiple vehicle accidents)
- Driver injury as the response variable
- The following explanatory variables:

Car characteristics	
carmaker-specific	Dummies for the 20 most sold car makes in Denmark
cargen04, …, cargen10	2004,…,2010 minus year of 1st registration
Logownweight	Logarithm of the own weight of the car (kg)
Relativeweight	Own weight relative to (average) weight of other car(s) involved in the accident
Driver characteristics	
Male	Dummy for male driver
age26	Piece-wise linear function for driver age (22≤age≤26)
age43	Piece-wise linear function for driver age (27≤age≤43)
age65	Piece-wise linear function for driver age (44≤age≤65)
age99	Piece-wise linear function for driver age (66≤age)
Legallicense	Dummy for valid license of the driver at the time of accident
alcohol_male1	Piece-wise linear function of BAC for male drivers (0≤ BAC ≤50)
alcohol_male2	Piece-wise linear function of BAC for male drivers (50< BAC ≤100)
alcohol_male3	Piece-wise linear function of BAC for male drivers (100< BAC)
Seatbeltmiss	Dummy for seatbelt not used by driver
seatbelt21	Dummy for seatbelt use and 18≤age≤21
seatbelt26	Dummy for seatbelt use and 22≤age≤26
seatbelt43	Dummy for seatbelt use and 26≤age≤43
seatbelt65	Dummy for seatbelt use and 44≤age≤65
seatbelt99	Dummy for seatbelt use and 66≤age
Crash characteristics	
d04,…d10	Dummy for year of accident
Leftback	Dummy for "left back" point of collision
Rightback	Dummy for "right back" point of collision
Front	Dummy for "front" point of collision
Rear	Dummy for "rear" point of collision
Alone	Dummy for single-vehicle accident
Motorway	Dummy for accident occurring on a motorway
road_2track	Dummy for accident occurring on a two-lane road
road_1track	Dummy for accident occurring on a one-lane road
Urban	Dummy for accident occurring in an urban area
Logspeedlimit	Log transformed speed limit (km/h)

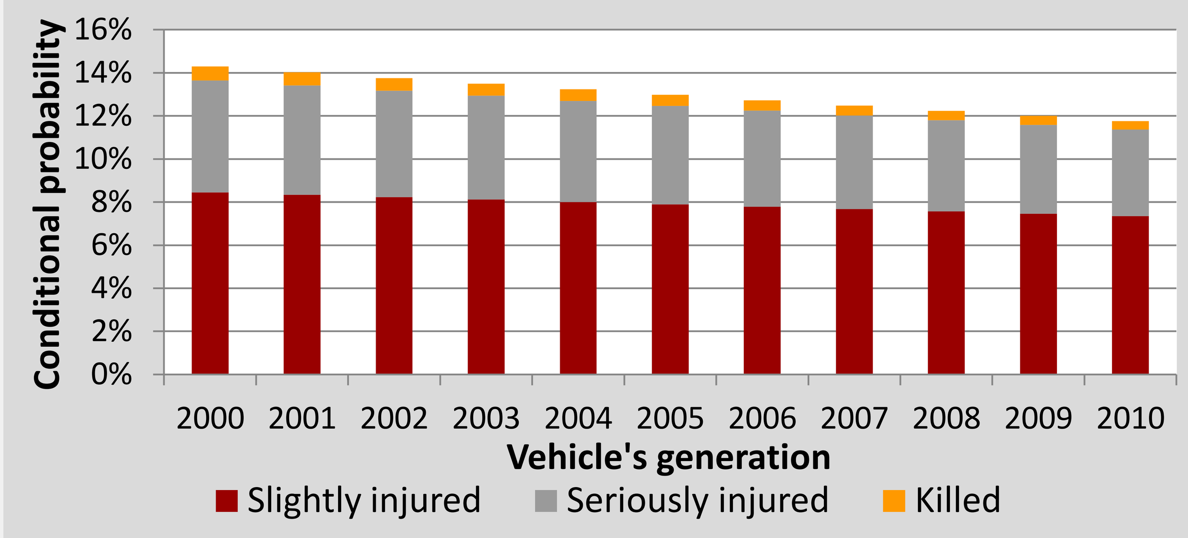
The explanatory variable of main interest was car generation; the rest of the variables correct for conditions related to the driver, the vehicle and the accident.

Results

Associated with the most severe driver injuries were:

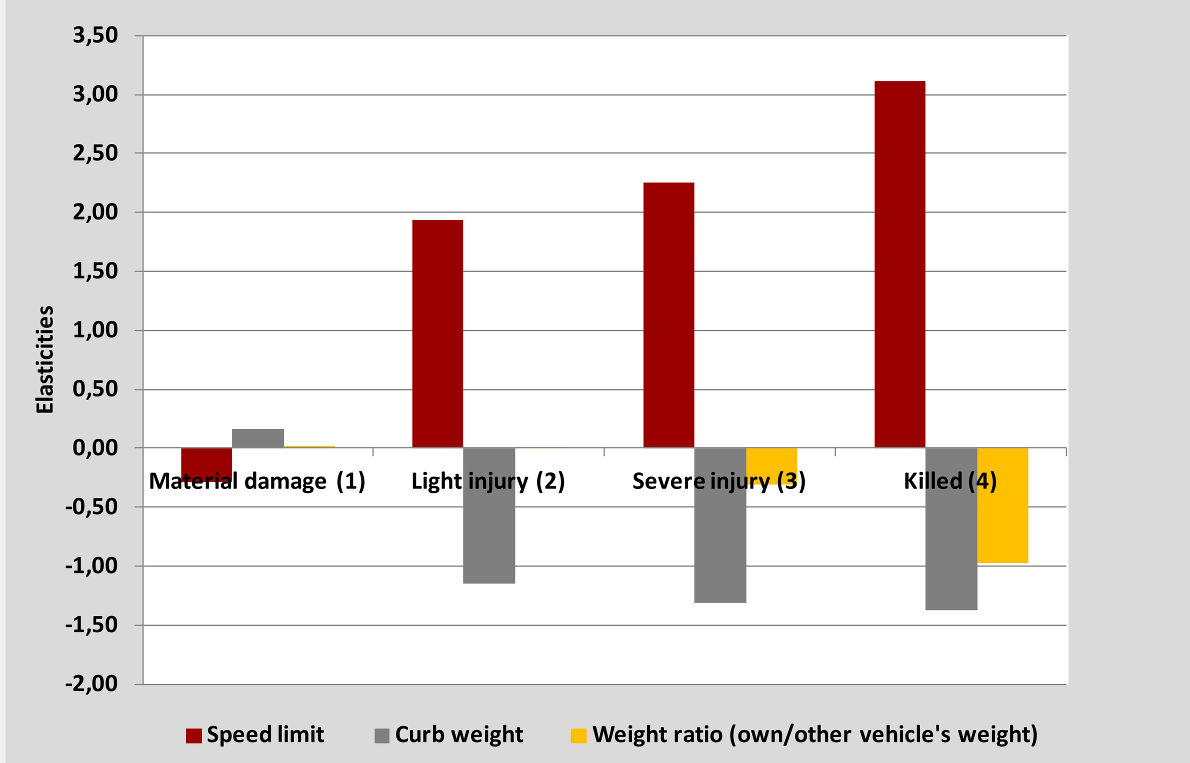
- Older cars, lighter cars.
- Higher car speed proxied by the speed limit.
- Older drivers and female drivers.
- A blood alcohol concentration above 1.0 (male drivers).
- Single-vehicle accidents.
- Accident on rural roads as opposed to motorways (freeways) and urban roads.
- Frontal collisions.

The effect on driver injury severity of the vehicle's generation



- Newer cars: lower probability of driver injury or death
- Newer cars: higher probability of material damage only accidents (not shown).

Elasticities for speed limit, curb weight and weight ratio



- Higher speed (limit) in accident: higher probability of driver injury or death (red bars).
- Heavier car: lower probability of driver injury or death (grey bars).
- Heavier car relative to the other car in accident: lower probability of driver injury or death (yellow bars).

Scenarios

To illustrate the relations found we calculated the lives and injuries saved if older cars were removed and hypothetically redistributed proportionately among younger cars:

Driver injury severities, accidents from 2004 to 2010, N=80,502.

	Fatalities	Severely injured	Slightly injured	Material Damage
Basis model calculation (real life)	642	4,659	7,168	68,032
Scenario 1: # cars > 10 years reduced by half	571	4,401	6,980	68,550
Difference	*-71*	*-258*	*-188*	*518*
Difference in percentage	*-11.1%*	*-5.5%*	*-2.6%*	*0.8%*
Scenario 2: # cars > 15 years reduced by half	607	4,537	7,083	68,275
Difference	*-36*	*-122*	*-85*	*243*
Difference in percentage	*-5.5%*	*-2.6%*	*-1.2%*	*0.4%*
Scenario 3: # cars > 20 years reduced by half	631	4,624	7,146	68,100
Difference	*-11*	*-35*	*-22*	*68*
Difference in percentage	*-1.8%*	*-0.8%*	*-0.3%*	*0.1%*

The results indicate that when correcting for a number of variables relating to the driver, the vehicle and the accident, a clear safety potential by renewing the car fleet remains. The potential is probably even larger than indicated here, since this study only analyzed potential in injury reduction given that the accident had happened (conditional severity). Renewal of the car fleet will most likely reduce the number of accidents as well, since newer cars are more likely to have more active safety equipment than older cars. Moreover, by including the effect of newer cars on passenger injury, the safety potential would be even larger.

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