Correlation between pedestrian injury severity in real-life crashes and Euro NCAP pedestrian test results

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Paper Number 13-0308

ABSTRACT

In Germany the number of casualties in passenger car to pedestrian crashes has been reduced by a considerable amount of 40% as regards fatalities and 25% with regard to seriously injured pedestrians since the year 2001. Similar trends can be seen in other European countries. The reasons for that positive development are still under investigation. As infrastructural or behavioral changes do in general take a longer time to be effective in real world, explanations related to improved active and passive safety of passenger vehicles can be more relevant in providing answers for this trend. The effect of passive pedestrian protection – specified by the Euro NCAP pedestrian test result – is of particular interest and has already been analyzed by several authors. However, the number of vehicles with some valid Euro NCAP pedestrian score (post 2002 rating) was quite limited in most of those studies. To overcome this problem of small datasets German National Accident Records have been taken to investigate a similar objective but now based on a much bigger dataset.

The paper uses German National Accident Records from the years 2009 to 2011. In total 65.140 records of pedestrian to passenger car crashes have been available. Considering crash parameters like accident location (rural / urban areas) etc., 27.143 of those crashes have been classified to be relevant for the analysis of passive pedestrian safety. In those 27.143 records 7.576 Euro NCAP rated vehicles (post 2002 rating) have been identified. In addition it was possible to identify vehicles which comply with pedestrian protection legislation (2003/102/EG) where phase 1 came into force in October 2005.

A significant correlation between Euro NCAP pedestrian score and injury outcome in real-life car to pedestrian crashes was found. Comparing a vehicle scoring 5 points and a vehicle scoring 22 points, pedestrians' conditional probability of getting fatally injured is reduced by 35% (from 0.58% to 0.37%) for the later one. At the same time the probability of serious injuries can be reduced by 16% (from 27.4% to 22.9%). No significant injury reducing effect, associated with the introduction of pedestrian protection legislation (phase 1) was detected. Considerable effects have also been identified comparing diesel and gasoline cars. Higher engine displacements are associated with a lower injury risk for pedestrians. The most relevant parameter has been "time of accident", whereas pedestrians face a more than 2 times higher probability to be fatally injured during night and darkness as compared to daytime conditions.

INTRODUCTION

In Germany the number of fatal and severe pedestrian to passenger car crashes decreased by a considerable amount in the first decade of 2000. Comparing police recorded passenger car to pedestrian accident records from the years 2001 to 2003 with data records from 2009 to 2011, the number of fatally injured pedestrians dropped by 40%. The number of seriously injured pedestrians decreased by 25% and the number of slightly injured pedestrians was reduced by 11% (see Figure 1). The reasons for that positive trend are still under investigation. As infrastructural or behavioral changes do in general take a longer time to be effective in real world, explanations related to improved active and passive safety of passenger vehicles can be more relevant in providing explanations to this appreciable trend.

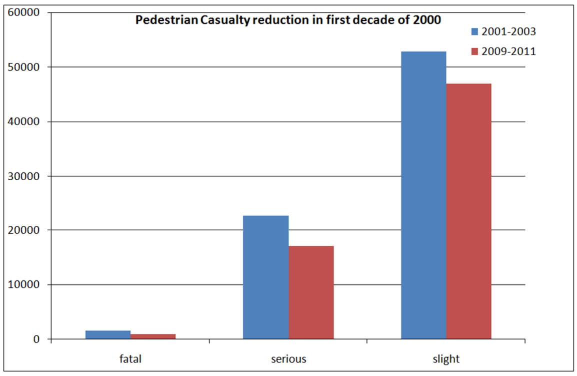

Figure 1. Reduction of pedestrian casualties in first decade of 2000.

The effect of passive safety can be extracted by looking at the proportion of killed or seriously injured (KSI) pedestrians. In the years 2001 to 2003 the share of KSI pedestrians was 31.3% and has been reduced to 27.8% for the data records from the years 2009 to 2011. This means that the probability of pedestrians in getting seriously injured or killed in a crash with a passenger car was reduced by 11% (assuming that the share of underreported cases did not change).

Passive Pedestrian Protection Requirements

In Europe passive pedestrian protection for M1 vehicles is mainly driven by legislation and Euro NCAP. Passive pedestrian protection for M1 vehicles in Europe is compulsory required by the European directive 2003/102/EG, starting with phase 1 for all new models introduced since October 2005.
The European consumer testing program Euro NCAP provides scores on passenger car pedestrian protection since 1997. However, in June 2002 Euro NCAP changed the way pedestrian impact test sites were selected. The limit values and the way points were awarded were also changed [1].
Whereas legislation is compulsory for all M1 vehicles with a gross vehicle weight up to 2.5t the Euro NCAP test program will consider the majority of the most popular cars in Europe.

Field Effects of Passive Pedestrian Protection

The effect of passive pedestrian protection – specified by the Euro NCAP pedestrian test result – has been analyzed by several authors. Based on real world data from Australia, UK, Germany and France no Euro NCAP - effect has been seen by the European Commission funded SARAC 2 project in 2003. However, the data could only consider "pre 2002" tested vehicles and the number of vehicles with some valid Euro NCAP pedestrian score was limited. Strandroth et al. presented a positive correlation at the ESV conference 2011 [2]. Unfortunately, the number of valid datasets used for this analysis was only 488. Euro NCAP scores from pre and post 2002 had to be included which makes the interpretation of the results difficult as the pedestrian rating was changed in June 2002. To overcome these problems German National Accident Records have been taken to investigate a similar objective now based on a much bigger dataset of several thousand records.

Only limited work has been done on studying the effect of legislative pedestrian protection enforcement. In general it must be stated that it is difficult to distinguish effects in the field which are attributed to Euro NCAP and effects attributed to legislation.

DATA SOURCES

The paper uses a set of German Police reported accident records which occurred in between 2009 to 2011.

Data selection process

In order to address the passive safety performance, the following selection criteria have been applied to the dataset of originally 65.140 pedestrian accident records:

- only urban crossing accidents
- only accidents with sustainable pedestrians (aged 6 to 64)
- only accidents with one passenger car (M1) and one pedestrian

Based on that selection, 27.143 (42%) records remained to be available for the analysis. This comes up to 20% of the fatal accident cases, 45% of the serious ones and almost 41% of the slight injury cases.

Many accidents got lost during the age criteria selection process. Figure 2 shows that a rising share of today more than 50% of pedestrian fatalities happen to people being 65 years of age and older. This highlights the importance of the development of active pedestrian protection systems, which shall be able to avoid a collision.

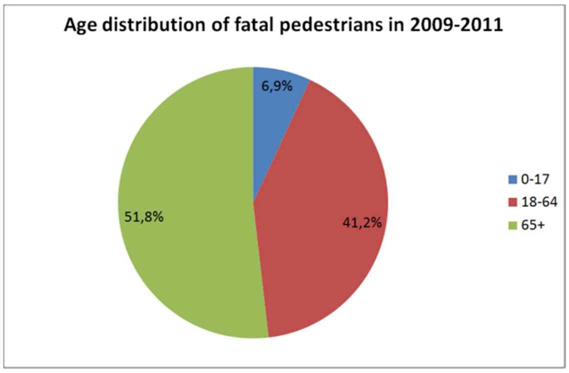

Figure 2. Age distribution of fatal pedestrians in 2009 to 2011.

Furthermore a considerable amount of the accidents dropped out based on the fact that they happen in rural areas. Here it is assumed that the speed is too high for passive protection measures. 50% of the fatal accidents which happened to the age group of 18-64 year old occurred in rural locations.

Identification of NCAP Scores

NCAP scores for 203 vehicles have been taken from the Euro NCAP homepage [3]. The list of cars is attached in the Appendix. To be consistent and as the NCAP pedestrian scoring changed in June 2002, only post 2002 Euro NCAP scores have been used. 7.576 cars have been identified, which is up to 28% of the cars in the dataset. For the identification of the car, the cars trade name, platform, the German Type Approval number and the year of initial registration has been used. The distribution of Euro NCAP scores in the dataset is depicted in Figure 3.

19.567 vehicles in the dataset containing pedestrian casualties from 2009 to 2011 have no valid post 2002 Euro NCAP score. This is explained by the fact that 56% (58%) of the fatal (serious) cases occurred with cars having an initial registration before the year 2003. This is depicted in Figure 4.

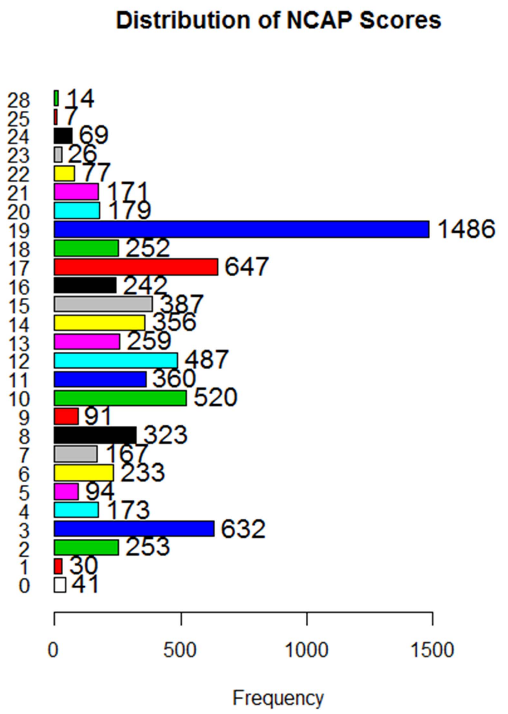

Figure 3. Frequency of NCAP Scores in the accident dataset 2009-2011 (scores ranging from 0 points to 28 points).

This means that 50% of all cars registered in 2003 and thereafter have a valid NCAP score and have been used for the analysis.

Identification of regulatory compliance

Regulatory compliance of vehicles was identified by using the German type approval number. By chance the coding of German type approval numbers for new approvals was changed in October 2005, which is coincident with the enforcement of 2003/102/EG, phase 1. Thus, any car having a type approval number which belongs to the new coding system is supposed to be compliant with the new pedestrian protection legislation.

75% of the cars having a valid Euro NCAP score comply also with legislation, whereas only 25% of non Euro NCAP tested cars – firstly registered after 2002 – do fulfill legislation. Finally only datasets

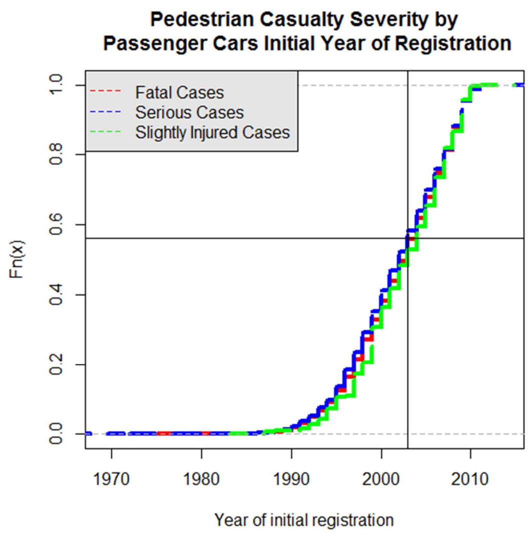

Figure 4. Cummulative share of pedestrian causualty by year of initial registration of the involved passenger car. 44% of the fatal pedestrians had a crash with a passenger car initially registrated after 2002.

with Euro NCAP scored vehicles have been used for the analysis.

METHOD

To establish a correlation between the pedestrians' casualty severity and some possible explanatory variables an ordinal probit model has been used. This was done by using the software package R, version 2.15.2. The function "polr" is provided and documented in the R package "MASS" [4].
We rejected from using a proportional odds model, which – for the sake of simplicity and being less computationally expensive - is often used for modeling ordinal response data. The NCAP test program and scoring is established to prevent quite serious and fatal consequences from road users. Thus, the NCAP score is more relevant for the fatal injury level. This means that the proportional odds assumptions would be violated and thus the proportional odds model shall not be used.

Within the model the pedestrians' casualty severity has been interpreted as the latent response variable, showing three specification on an ordinal scale - "fatally inj." > "seriously inj." > "slightly inj.".

Based on experience we expected the injury outcome in real world to be dependent on the following parameters:

- Light condition
- NCAP score
- Engine size
- Gender
- Regulatory compliance

The parameters have been chosen for the following reasons.
Light condition: Less reaction time and probably higher impact speeds because of less braking.
Engine size: Less deformation space and hard contact of pedestrians during impact
Gender: Higher vulnerability of females

Setting up the ordinal probit model we found significant effects for three of the above mentioned parameters (see Table 1). No effect has been found for Gender and Regulatory Compliance.

To estimate the effect of engine size, an interaction effect of engine type (diesel / gasoline) and engine displacement has been considered.

The final model formula looked as follows:

Pedestrian Inj. Severity ~ Light Condition + NCAP + Engine Type | Engine Displacement (1)

RESULTS

Table 1 shows the results of the ordinal probit regression model.

Explanatory Var.	Estimator	St. Error	t value
Light Condition = *Dark*	3,065E-01	3,336E-02	9,188
Engine Type = *Gasoline*	1,703E-01	4,091E-02	4,162
Engine Displacement/ccm	-4,278E-05	2,280E-05	-1,877
NCAP Score	-8,571E-03	2,467E-03	-3,474
Engine Type = *Gasoline* : Engine Displacement/ccm	-1,510E-04	3,543E-05	-4,263
Intercepts			
Fatal -> Serious	4,020E-01	4,440E-02	9,0506
Serious -> Slight	2,348E+00	6,970E-02	33,6842

Table 1. Results of the Ordinal Probit Regression Model.

Positive estimators indicate an effect increasing the risk, whereas negative estimators can be assessed to be protective factors, reducing the risk of getting fatal and serious injuries. As expected light condition is a very strong and significant effect. Therefore the influence of light condition always needs to be addressed as a significant confounder when dealing with risk models for pedestrian accidents. The engine displacement is given in ccm, thus letting the effect of engine displacement look to be small, however it isn't. All standard errors and t values indicate a significant correlation at a 95% level, at the least.

Correlation of Euro NCAP Score and Injury Outcome in real world

A significant correlation between Euro NCAP pedestrian score and injury outcome in real-life car to pedestrian crashes was found. Each additional point in the NCAP score can have a reduction in probability of fatal injury by as much as 2.5%. The respective reduction of serious injury probability is about 1.0%. Comparing a pedestrian hit by a vehicle scoring 5 points and a vehicle scoring 22 points, pedestrians' probability [daytime accident with a 1600 ccm gasoline car] of getting fatally injured is reduced from 0.58% to 0.37% (-35%) for the later one. The probability of serious injuries is reduced from 27.4% to 22.9% (-16%); see also *Figure 5*.

It can also be seen that the reduction potential is higher for fatal injuries as compared to serious injury outcomes. Whereas the probability reduction can be up to 50% for fatalities "only" 30% reduction can be achieved for serious injuries. It can also be seen that the correlation between NCAP Score and Serious Injury Risk is almost linear, whereas the Fatal Injury Risk Curve is slightly convex.

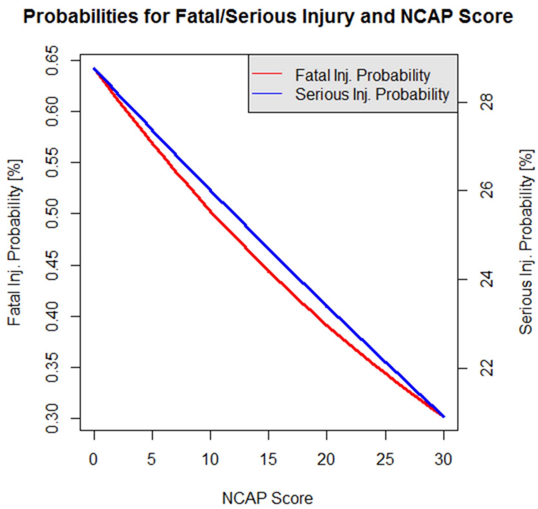

Figure 5. Pedestrians' probability of becoming fatally / seriously injured being impacted with cars of various NCAP score; [referenced to daytime accident with 1.600ccm gasoline car].

Impact of Engine Size

The impact of engine size on the injury outcome is depicted in Figure 6 . The interpretation of the effects is complex.

In the model an interaction term between engine displacement and engine type needed to be introduced. Wherefore either for diesel-type engines and for gasoline-type engines the injury probability decreases with increasing engine displacement. However, the slope of that decrease is different.

The reason for that injury reduction effect is rarely an effect of engine characteristics. Initially it was anticipated that with bigger engines (higher engine displacements) the probability of severe and fatal injuries was going to increase.

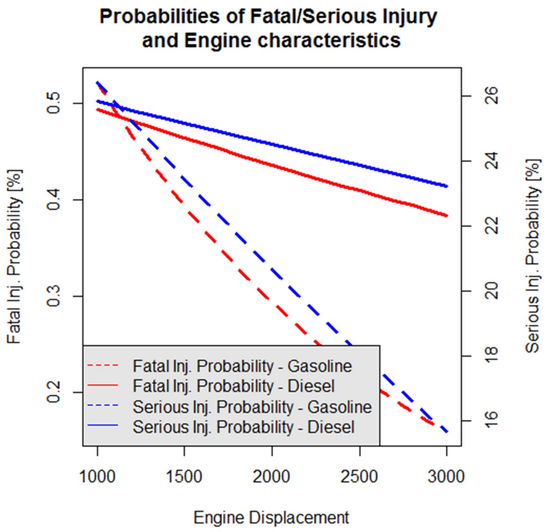

Figure 6. Pedestrians' probability of getting fatally / seriously injured having impacts with cars of various engine characteristics; [referenced to daytime accident with 22 Euro NCAP score car].

It is assumed that the effect of injury probability reduction with increasing engine displacement is associated with some driver behavior characteristics. Drivers of a bigger engine sized cars are expected to drive more carefully and also having more driving experience. In future studies it shall be tried to use vehicle segments as additional variable to isolate this effect. Although it is still expected that the engine size is a relevant factor which shall increase the injury probability, it cannot be proofed with the data available, now.

The importance of driver characteristics can also be seen in Figure 7. Here, the influence of engine displacement is exactly opposite, when looking at just one popular make & model in the German fleet. It can be seen that the highly motorized gasoline variant shows a much higher probability of causing fatal and serious injuries to pedestrians.
It is expected that this effect is however again to a great extend attributed to the driver characteristics. The highly motorized gasoline variant of this car is taken to be the sportive variant, implying a more sportive and sometimes aggressive driving style. In future studies it shall be tried to use specific power as additional variable to isolate this effect.

Such reverse local effects do however not disturb the general trend being depicted in Figure 6.

Hence, looking again at the general effects in Figure 6 it can be observed that diesel-type cars imply in general a higher risk for pedestrians. It is assumed that this is finally related to the different engine size. Taking this information into account it should also be said, that the pedestrian NCAP score for a particular gasoline car needs to be adjusted (reduced) for the diesel version of that car.

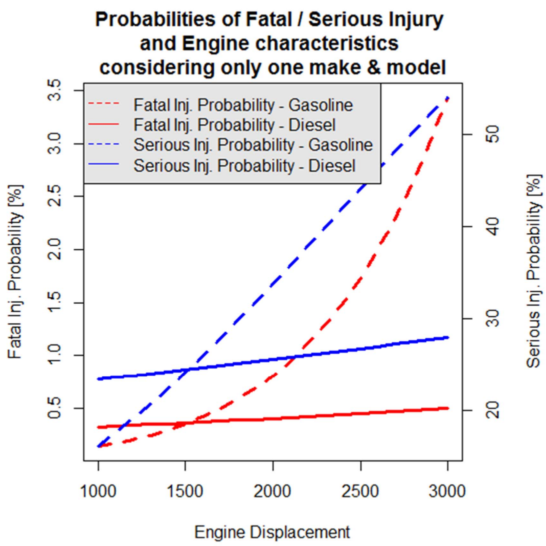

Figure 7. Pedestrians' probability of getting fatally / seriously injured having impacts with cars of various engine characteristics; [referenced to daytime accident with one particular Euro NCAP scored car].

Injury reduction potential of passive safety

Finally we estimated the injury reduction potential of passive pedestrian protection in the fleet. We assumed that each car will have a 22 Point Euro NCAP Score for passive pedestrian protection. Introducing this assumption into the real world dataset we got a reduction of 56 fatalities and 1543 seriously injured in the dataset containing accidents from the years 2009 to 2011. Having had a total number of 953 fatalities and 17.069 seriously injured, that comes up to a reduction of 6% of the fatal cases and 9% of the serious cases.

CONCLUSION

German police recorded traffic accident files have been used to investigate pedestrian to passenger car (M1) impacts. The analysis was in particular interested in the effect of Euro NCAP pedestrian test scores on the injury outcome in real world.

A significant correlation between Euro NCAP scores and real world injury outcome has been found. The conditional probability of fatal and serious injuries to a pedestrian, given the pedestrian is involved in an accident within the target group of accidents, that is:

- urban crossing accidents
- with personal injury
- with pedestrians aged 6 to 64 years,

can effectively be reduced.

As a rule of thumb each point in NCAP score relates to a relative reduction in probability of 2.5% for fatalities, and 1% for serious injuries.
Example: Some score difference of 9 Points between a vehicle A (scored at 13 points) and a vehicle B (scored at 22 points) will give

$0.975^{(\text{score B} - \text{score A})} = 0.975^9 = 0.80$

Thus, the probability of getting fatally injured being hit by vehicle B is just 80% of the respective probability when being hit by vehicle A.
The equivalent computation for the probability of getting seriously injured would be

$0.99^{(\text{score B} - \text{score A})} = 0.99^9 = 0.91$

Thus, the probability of getting seriously injured being hit by vehicle B is 91% of the respective probability when being hit by vehicle A.

Provided every car on German roads would comply to a standard of 22 Euro NCAP point score in pedestrian protection, an injury reduction potential of 6% as regards the number of fatalities and 9% with regard to the number of seriously injured pedestrians in passenger car impacts could be estimated.

As expected, we found a strong correlation between light conditions and injury severity. Probably accidents under adverse light conditions lead to higher injury severities, due to less reaction time and less speed reduction before impacting the pedestrian. Referring to active pedestrian protection systems emerging into the market - frequently mono camera based systems - robustness in adverse light conditions will be needed to make those systems work efficiently.

We found a correlation between engine characteristics - engine type and engine displacement – and injury outcome. Diesel type cars imply a higher thread to pedestrians. The reason could well be the bigger engine size of diesel variants. Thus, it shall be noticed that the NCAP pedestrian rating for a tested gasoline variant is not necessarily valid for the diesel variant of the same car make and model. This should in principal be true vice versa, however testing the diesel variant can be taken as a "worst case" test.

Increasing the engine displacement was linked to a protective – thus injury reducing – effect in real world. This phenomenon can be explained by the characteristics of drivers associated with higher motorized gasoline vehicles, which are expected to drive more carefully and also having more driving experience.

REFERENCES

[1] van Ratingen, M.:"The changing outlook of Euro NCAP", in Airbag 2008 – 9th International Symposium & Exhibition on Sophisticated Car Occupant Safety Systems, Karlsruhe, 2008.
[2] Strandroth J., Rizzi M., Sternlund S., Lie A., Tingvall C.: „The correlation between pedestrian injury severity in real-life crashes and Euro NCAP pedestrian test results", in ESV 2011 - 22nd International Technical Conference on the Enhanced Safety of Vehicles (ESV), Washington D.C., USA, Paper no 11-0188, 2011.
[3] http://www.euroncap.com
[4] http://cran.r-project.org/web/packages/MASS/MASS.pdf

APPENDIX – LIST OF VEHICLES

CAR	FREQ	SCORE
ALFA_ROMEO_159	10	9
ALFA_ROMEO_GIULIETTA	1	23
ALFA_ROMEO_MITO	6	18
AUDI_A1_2010	5	18
AUDI_A3_2003	188	8
AUDI_A4_2008	74	14
AUDI_A6_2004	91	3
AUDI_Q5_2008	11	12
AUDI_Q7_2006	14	15
AUDI_TT_2003	15	0
BMW_1er_2004	108	2
BMW_1er_2004_Facelift	20	2
BMW_3er_2005	140	4
BMW_3er_2005_Facelift	9	4
BMW_5er_2004	62	2
BMW_5er_2010	13	28
BMW_X3_2008	7	5
BMW_X5_2003	10	2
BMW_Z4_2004	8	14
CHEVROLET_AVEO_2006	10	19
CHEVROLET_CAPTIVA_2007	12	17
CHEVROLET_CRUZE_2009	1	12

CHEVROLET_KALOS_2006	15	11
CHEVROLET_MATIZ_2005	63	13
CHEVROLET_SPARK_2009	9	16
CHRYSLER_VOYAGER_2007	7	0
CITROEN_BERLINGO_2005	38	10
CITROEN_BERLINGO_2008	12	10
CITROEN_C1_2005	63	14
CITROEN_C2_2003	38	12
CITROEN_C3_2009	3	12
CITROEN_C3_PICASSO_2009	4	16
CITROEN_C3_PLURIEL_2003	4	13
CITROEN_C4_2004	17	22
CITROEN_C4_2010	2	15
CITROEN_C4_PICASSO_2006	19	16
CITROEN_C5_2004	14	8
CITROEN_C5_2008	10	11
CITROEN_C6_2005	1	28
CITROEN_DS3_2009	6	13
CITROEN_NEMO_2010	2	20
DACIA_DUSTER_SUV_2011	1	10
DACIA_LOGAN_2005	31	5
DACIA_SANDERO_2008	26	6
DAIHATSU_CUORE_2008	4	12
DAIHATSU_MATERIA_2007	1	16
DAIHATSU_SIRION_2005	19	15
DAIHATSU_TERIOS_2008	1	19
DODGE_CALIBER_2007	2	5
FIAT_500_2007	32	14
FIAT_BRAVO_2007	7	16
FIAT_CROMA_2005	4	6
FIAT_DOBLO_2004	17	1
FIAT_GRANDE_PUNTO_2005	80	19
FIAT_IDEA_2006	9	8
FIAT_PANDA_2004	83	6
FIAT_STILO_2005	41	8
FORD_CMAX_2010	2	18
FORD_FIESTA_2008	94	20
FORD_FOCUS_2004	198	15
FORD_FOCUS_CMAX_2003	60	14
FORD_FUSION_2003	43	11
FORD_KA_2008	32	11
FORD_KUGA_2008	19	20
FORD_MONDEO_2007	55	18
FORD_S-MAX_2006	36	13
HONDA_ACCORD_2003	10	16

HONDA_ACCORD_2008	3	19
HONDA_CIVIC_2006	41	24
HONDA_CRV_2007	12	13
HONDA_CRZ_2010	1	25
HONDA_FRV_2005	2	20
HONDA_JAZZ_2004	62	19
HONDA_JAZZ_2009	22	22
HYUNDAI_GETZ_2004	50	5
HYUNDAI_I10_2008	31	21
HYUNDAI_I20_2009	6	23
HYUNDAI_IX20_2011	1	23
HYUNDAI_IX35_2010	5	20
HYUNDAI_SANTA-FE_2006	7	0
HYUNDAI_SONATA_2006	2	12
HYUNDAI_TRAJET_2003	4	9
HYUNDAI_TUCSON_2006	24	4
JAGUAR_XF_2010	1	16
JEEP_CHEROKEE_2003	1	3
JEEP_GRAND_CHEROKEE_2005	12	0
KIA_CARENS_2007	5	9
KIA_CARNIVAL_SEDONA_2006	4	3
KIA_CEED_2007	27	11
KIA_CERATO_2006	5	8
KIA_PICANTO_2004	42	6
KIA_RIO_2005	12	13
KIA_SORENTO_2003	8	3
KIA_SORENTO_2009	1	16
KIA_SOUL_2009	3	14
KIA_SPORTAGE_2010	3	18
KIA_VENGA_2010	3	23
LANDROVER_DISCOVERY_2006	4	8
LANDROVER_FREELANDER_2007	1	7
LEXUS_IS_2006	2	15
MAZDA_2_2003	34	10
MAZDA_2_2007	31	18
MAZDA_3_2006	44	15
MAZDA_3_2009	10	18
MAZDA_5_2005	37	12
MAZDA_6_2003	65	7
MAZDA_6_2009	14	18
MAZDA_CX-7_2010	3	16
MERCEDES_A-KLASSE_2005	136	17
MERCEDES_B-KLASSE_2006	147	12
MERCEDES_C-KLASSE_2007	112	11
MERCEDES_E-KLASSE_2010	75	21

MERCEDES_GLK_2010	16	17
MERCEDES_M-KLASSE_2008	30	6
MINI_COOPER_2007	49	14
MINI_COUNTRYMAN_2010	15	23
MITSUBISHI_ASX_2011	3	22
MITSUBISHI_COLT_2005	50	7
MITSUBISHI_LANCER_2009	6	12
MITSUBISHI_OUTLANDER_2007	4	17
MITSUBISHI_PAJERO_PININ_2003	5	1
NISSAN_JUKE_2011	1	15
NISSAN_MICRA_2003	83	12
NISSAN_NOTE_2006	27	15
NISSAN_PATHFINDER_2006	2	18
NISSAN_QASHQAI_2007	29	18
NISSAN_X-TRAIL_2007	3	12
OPEL_ASTRA_2004	267	3
OPEL_ASTRA_2009	23	16
OPEL_CORSA_2006	190	19
OPEL_INSIGNIA_2008	21	14
OPEL_MERIVA_2003	164	3
OPEL_MERIVA_2010	11	20
OPEL_SIGNUM_2003	8	1
OPEL_TIGRA_2004	13	10
OPEL_ZAFIRA_2005	143	16
PEUGEOT_1007_2005	6	10
PEUGEOT_207_2006	91	19
PEUGEOT_207CC_2006	6	16
PEUGEOT_3008_2009	2	11
PEUGEOT_307CC_2006	1	10
PEUGEOT_308_2007	16	19
PEUGEOT_407_2004	23	15
PEUGEOT_807_2003	7	6
RENAULT_CLIO_2005	64	9
RENAULT_ESPACE_2003	12	10
RENAULT_GRAND_SCENIC_2009	4	15
RENAULT_KANGOO_2003	51	2
RENAULT_KANGOO_2008	10	14
RENAULT_KOLEOS_2008	2	14
RENAULT_LAGUNA_2003	47	12
RENAULT_LAGUNA_2007	7	10
RENAULT_MEGANE_2008	14	11
RENAULT_MODUS_2004	41	6
RENAULT_SCENIC_2003	55	11
RENAULT_TWINGO_2003	270	10
RENAULT_TWINGO_2007	50	11

RENAULT_VEL_SATIS_2005	2	2
SEAT_ALTEA_2004	25	22
SEAT_EXEO_2010	1	18
SEAT_IBIZA_2008	30	19
SEAT_LEON_2005	22	24
SKODA_FABIA_2007	106	17
SKODA_OCTAVIA_2004	101	17
SKODA_ROOMSTER_2006	34	14
SKODA_SUPERB_2008	10	18
SKODA_YETI_2009	5	17
SMART_FORFOUR_2005	24	7
SMART_FORTWO_2007	115	10
SUZUKI_ALTO_2009	11	13
SUZUKI_GRAN_VITARA_2007	9	19
SUZUKI_SPLASH_2008	11	19
SUZUKI_SWIFT_2005	46	20
SUZUKI_SWIFT_2010	1	22
SUZUKI_SX4_2006	9	22
TOYOTA_AURIS_2006	39	21
TOYOTA_AVENSIS_2003	62	8
TOYOTA_AVENSIS_2009	10	19
TOYOTA_IQ_2009	11	19
TOYOTA_PREVIA_2003	4	5
TOYOTA_PRIUS_2004	12	13
TOYOTA_PRIUS_2009	6	24
TOYOTA_RAV4_2006	26	21
TOYOTA_URBAN_CRUISER_2009	2	19
TOYOTA_VERSO_2010	6	25
TOYOTA_YARIS_2005	79	18
VOLVO_C30_2007	8	9
VOLVO_S40_2004	5	18
VOLVO_V70_2007	11	16
VOLVO_XC60_2008	6	17
VOLVO_XC90_2003	11	10
VW_CADDY_2007	90	13
VW_EOS_2007	13	13
VW_FOX_2005	105	12
VW_GOLF_2004_2008	683	19
VW_PASSAT_2005	222	17
VW_POLO_2009	53	15
VW_SCIROCCO_2009	7	19
VW_SHARAN_2010	4	16
VW_T5_2008	97	3
VW_TIGUAN_2007	39	17
VW_TOUAREG_2004	27	7

VW_TOURAN_2003	270	19

Table 2. List of vehicles used for the analysis; including trade name with valid NCAP pedestrian score and frequency in the dataset.