Frontal Impact Protection

German Accident Data Analysis

Geneva 25.05.2009

Claus Pastor

Bundesanstalt für Straßenwesen

Objectives

Real World Accident Issues of Frontal Car Impacts

1. Two Car Accidents („TCA")

2. Single Car Accidents („SCA")

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Real World Accident Issues of Frontal Car Impacts

1. Two Car Accidents („TCA")

    1.1. Injury Risk Assessment

    1.2. Generic Benefit Assessment

    1.3. Test-based Benefit Assessment

2. Single Car Accidents („SCA")

Real World Issues of Frontal Impacts

Analysis of German National Accident Data with personal injury
 (Accident years 2005 -2007)

1. Two Car Accidents   (253.690 accidents)

2. Single Car Accidents   (108.525 accidents)

Separate analysis due to different nature of accidents

1. Two Car Accidents („TCA")

Importance of Two Car Accidents (253.690 accidents)

Two Car Accidents cover:

- **51%** of all car accidents **with personal injury** to the driver
- **37%** of all car accidents with **serious injuries** to the driver
- **23%** of all car accidents with **fatal injuries** to the driver

1. Two Car Accidents („TCA")

Importance of „Front to Front" Two Car Accidents

(21.764 accidents)

„Front to Front" Two Car Accidents cover:

• **6%** of all car accidents **with personal injury** to the driver

•**11%** of all car accidents with **serious injuries** to the driver

•**14%** of all car accidents with **fatal injuries** to the driver

Front to Front Two Car Accidents make

−less than 10% of all Two Car Accidents, <u>but</u> they produce

−more than 50% of all Two Car Accidents Driver Fatalities!

1.1. „TCA" Injury Assessment

„Front to Front" Two Car Accidents   (21.764 accidents)

Redo:

„LAB" Approach with German ‚Front to Front' 2-Car Accidents

$$SR(\text{Severity Rate}) = \frac{\#(\text{Driver Fatalities}) + \#(\text{Seriously inj. Drivers})}{\#(\text{Personally injured Drivers})}$$

SR: „Conditional Risk of fatal/serious injury given accident with personal injury"

1.1. „TCA" Injury Assessment

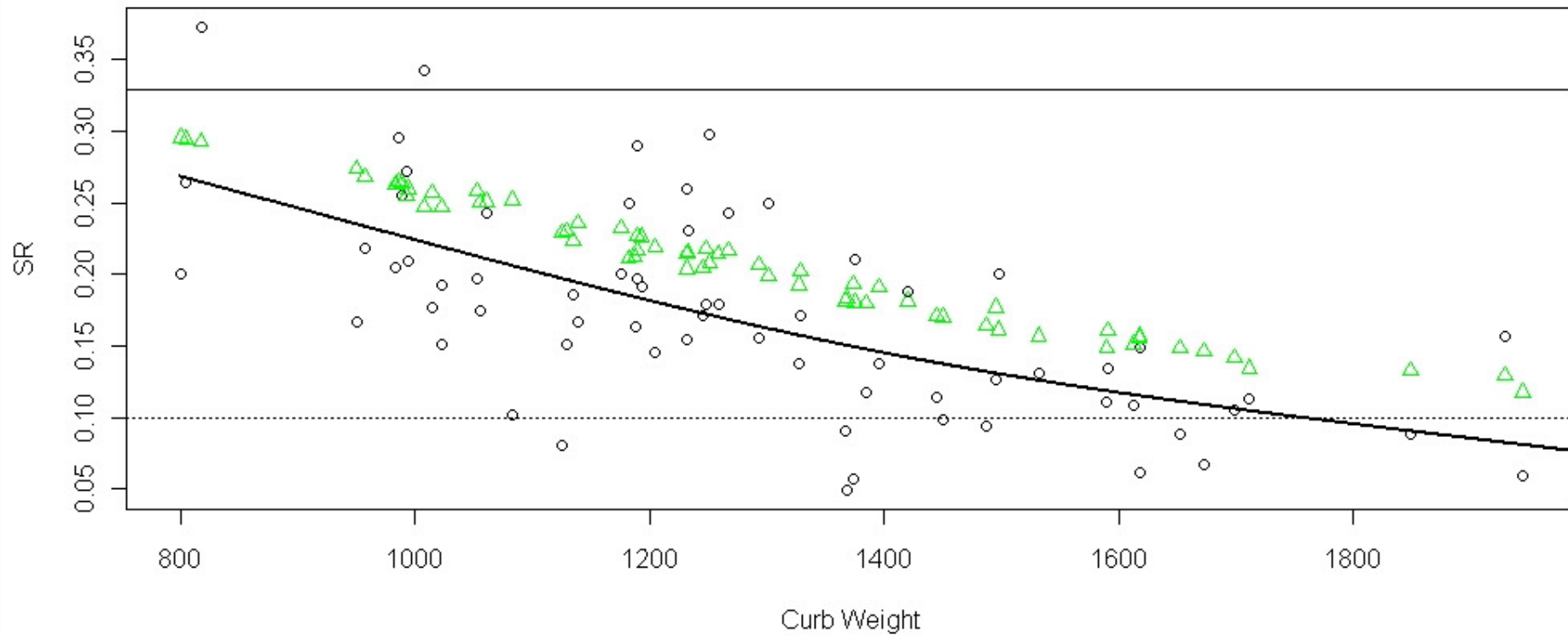## Severity Rate (SR) in Two Car „Front to Front" Accidents
All Models with Year of first Registration >= 2000 (German data)
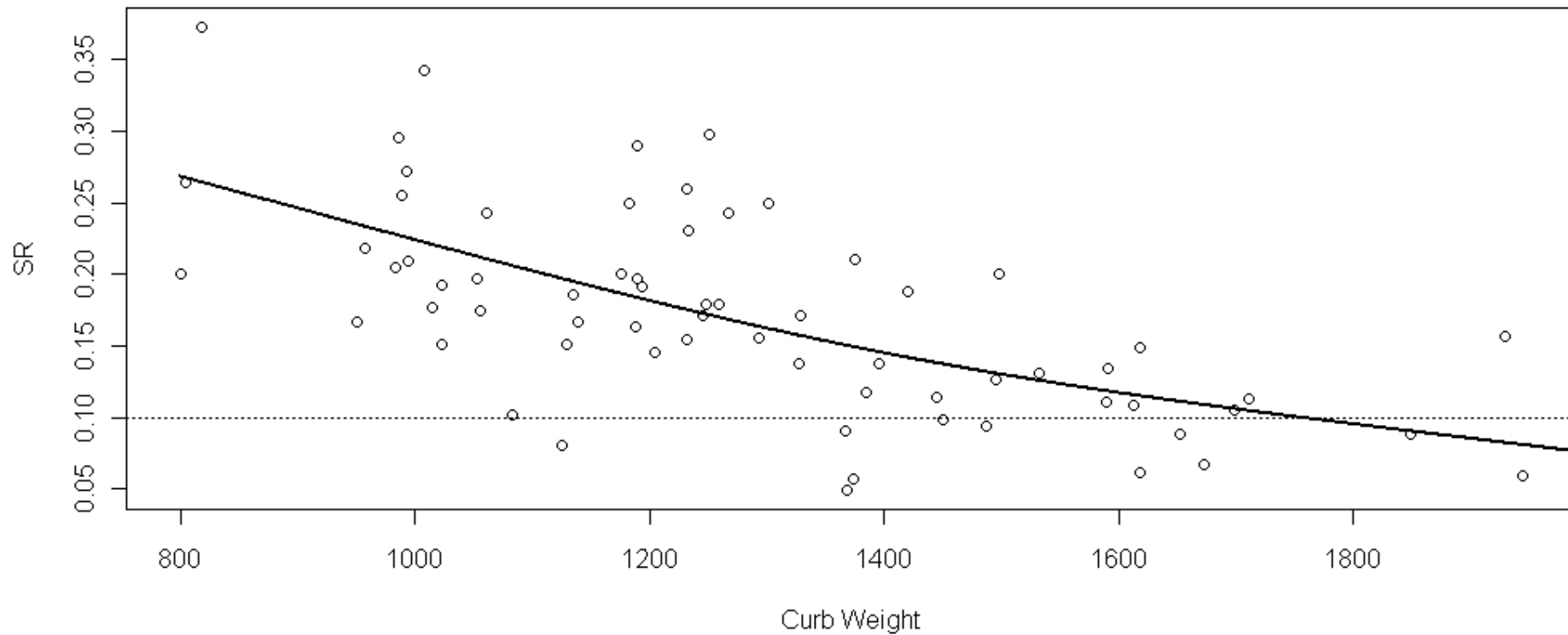
Each dot represents one model, with at least 30 valid cases per model
(66 models, 4131 drivers)

1.1. „TCA" Injury Assessment

Adjusted Severity Rate (SR) in Two Car Front to Front Accidents
All Models with Year of first Registration >= 2000 (German Data)

Adjusted SR Plot, adjusted for: gender, age, place of accident, accident causing party

1.1. „TCA" Injury Assessment

- The data shows a **clear weight dependency** towards the conditional risk of fatal or serious injury to the driver

- But, **influence of the impact partner** remains unclear.

- **Simple analysis** rejects the structure of two car road accidents (-> cars in the same accident are no independent observations)

- **Go on with some appropriate statistical methods** (-> here: Matched Pairs analysis)

1.1. „TCA" Injury Assessment

- **Go on with some appropriate statistical methods**

ACCIDENT DATA

⟹ a. Estimate „Crashworthiness" (CW) of a car,
(as a function of car related parameters)

⟹ b. Estimate „Severity distribution" among 2 cars in crash
(as a function of cars' crashworthiness rating)
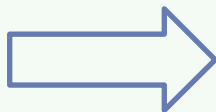
⟹ c. Statistically model injury risk and by

- Crashworthiness
  (d) Change Crashworthiness, by introducing measures

- Severity distribution
  (d) Change Severity Distribution, by introducing measures

BENEFIT
of introducing measures

1.1. „TCA" Injury Assessment

(a) „Crashworthiness estimation" by Matched Pairs Analysis

What does a Matched Pairs Analysis:

• Matching Car A and Car B involved in the same accident

CARS {A, B, C, D, E ...}   establish **RANKING**

CAR A versus CAR B	CAR A	*is more safe than*
CAR A versus CAR C	CAR D	*is more safe than*
CAR A versus CAR D	CAR C	*is more safe than*
CAR C versus **CAR D**	CAR B	*is more safe than*
CAR C versus CAR B	CAR E	*is more safe than*
	...	...

... **... less injured**

1.1. „TCA" Injury Assessment

(a) „Crashworthiness estimation" by Matched Pairs Analysis

<u>What does a Matched Pairs Analysis:</u>

- Matching Car A and Car B involved in the same accident

<u>Question</u>: „Who gets better off?"   **or**

> „How is the crash severity distributed between A and B"

<u>Model Parameters:</u>

- Age
- Gender
- Frontal Impact NCAP Rating
- Car Mass
- other technical car parameters

1.1. „TCA" Injury Assessment

(a) „Crashworthiness estimation" by Matched Pairs Analysis

Model Parameters:

- Age
- Gender
- Frontal Impact NCAP Rating
- Car Mass
- other technical car parameters

- Wheelbase/total length
- Total width
- Specific power
- Total height | bodytype
- Manufacturer
- Axle of propulsion

1.1. „TCA" Injury Assessment

(a) „Crashworthiness estimation" by Matched Pairs Analysis

<u>What does a Matched Pairs Analysis?</u>

- It attaches to each car a number, which represents its

  <u>ability to survive in an accident</u> -> CW=CRASHWORTHINESS

CARS {A, B, C, D, E ...}   establish numerical **RANKING**

CAR A versus CAR B   CAR A $CW_A=0.3$

CAR A versus CAR C   CAR D $CW_D=0.19$

CAR A versus CAR D $\Longrightarrow$ CAR C $CW_C=0.14$

CAR C versus **CAR D**   CAR B $CW_B=-0.2$
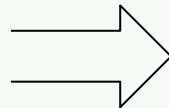
CAR C versus CAR B   CAR E $CW_E=-1.2$

                                          ...   ...

... less injured

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(a) „Crashworthiness estimation" by Matched Pairs Analysis

Crashworthiness is mass dependent.
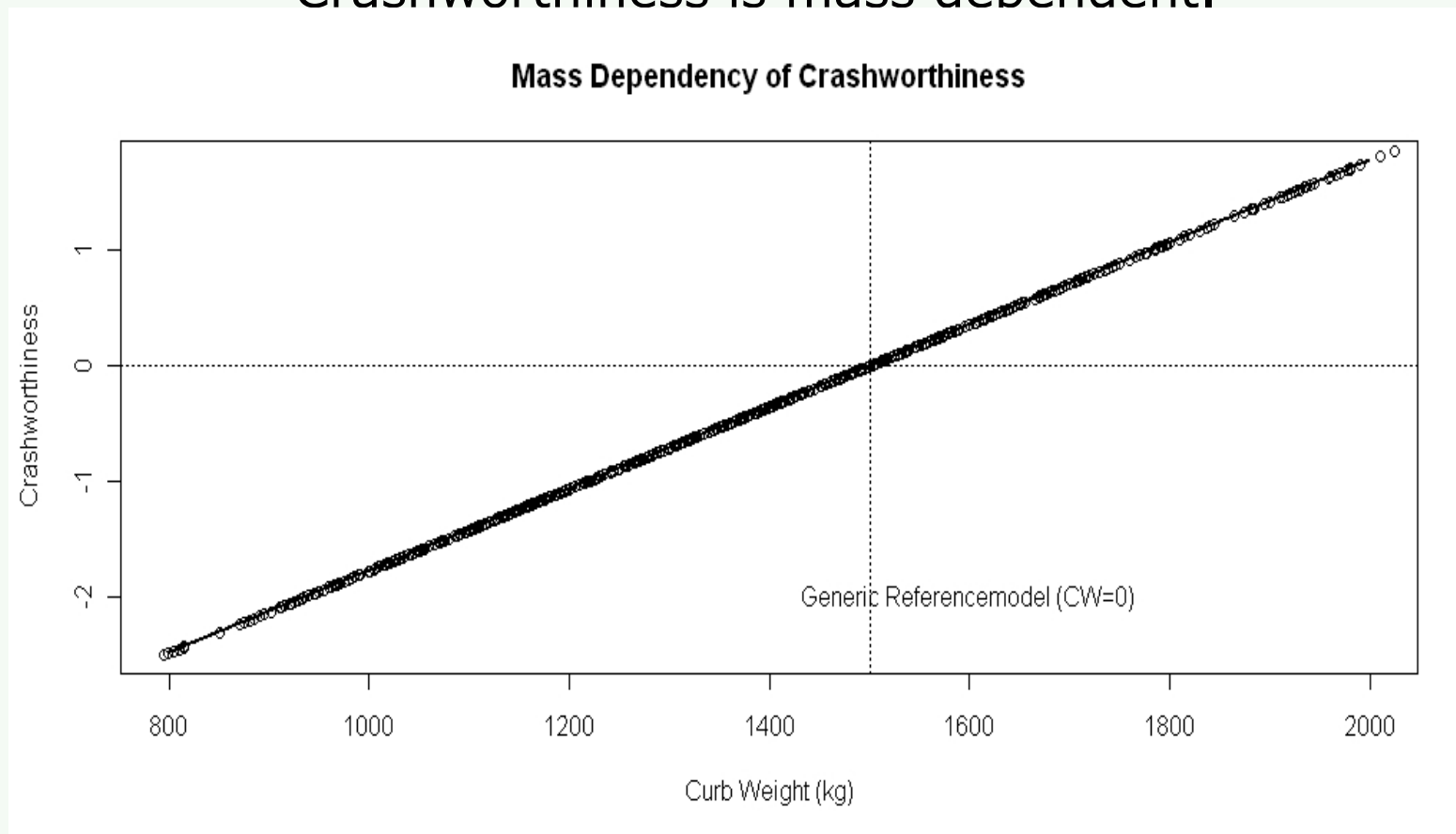
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(b) „Severity distribution" by Matched Pairs Analysis

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crashworthiness ↑
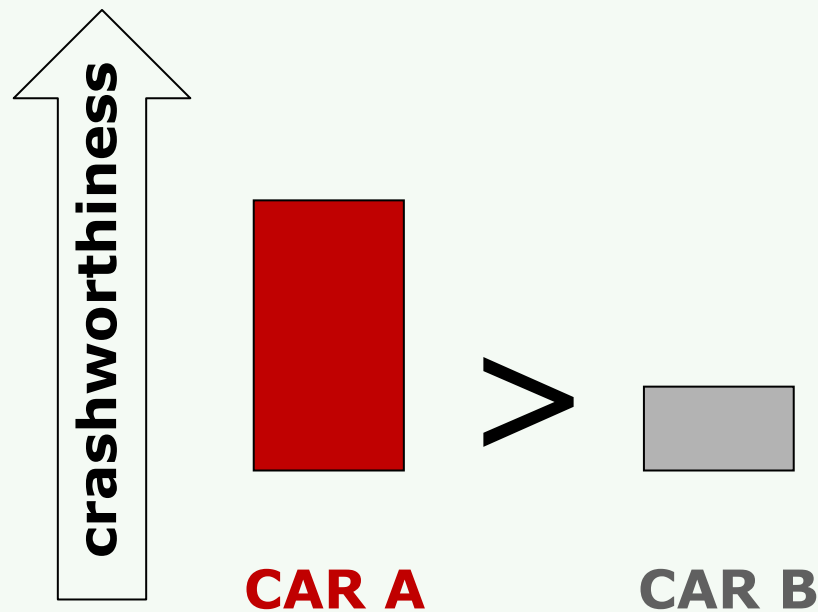
CAR A > CAR B

Car A will be better of, because:

$CW_A > CW_B$ *or*

$D_{AB} = CW_A - CW_B > 0$

(D_{AB} ~ Severity Distribution)

1.1. „TCA" Injury Assessment

(c) Statistical Model of Injury Risk

<u>Putting it all together:</u>

Car to Car Accident (Car A – Car B):

$$\textbf{\textit{Injury Risk}}_A = \textbf{\textit{function}}\ (S, D_{AB}, CW_A)$$

Accident Severity, **S**   *(Given accident Severity)*

Partner Protection, $\boldsymbol{D_{AB}}$ *(is distributed among partners)*

Self Protection, $\boldsymbol{CW_A}$ *(has to be absorbed)*

1.1. „TCA" Injury Assessment

„Front to Front" Two Car Accidents   (21.764 accidents)

Importance of factors driving Injury Risk $_A$

Injury Risk $_A$ = function (CW$_A$, D$_{AB}$, S)

Partner Prot. D_{AB}

Self Prot. CW_A

Accident Sev. S

1.2. „TCA" Generic Benefit Assessment

„Front to Front" Two Car Accidents   (21.764 accidents)

a. **Do nothing**

   (let CW of cars adopt to low NCAP safety level = 9-12 points FIR)

b. Just add „crashworthiness" to small cars to reach high NCAP level

   (increase CW to upper NCAP level, sliding scale [1000kg – 1600kg])

c. Increase „crashworthiness" of all cars to high NCAP level

   (increase CW to upper NCAP level = 13-16 points FIR)

d. Do nothing but adjust restraint system to female

   (increase CW by removing gender effect)

e. Do nothing but adjust restraint system to female and elderly occupants

   (increase CW by removing gender and reduce age effect)

f. Better „crash energy distribution"

   ($D_{AB} \sim 0 \Leftrightarrow CW_A \sim CW_B$)

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1.2. „TCA" Generic Benefit Assessment

Now	100,0%	100,0%	100,0%	100,0%
a	**98,2%**	**100,1%**	**100,0%**	**100,4%**
b	95,0%	100,0%	100,7%	100,8%
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Claus Pastor   BASt, Germany

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slight

1.3. „TCA" Test-based Benefit Assessment

„Front to Front" Two Car Accidents   (21.764 accidents)

To many open questions   ...   to end up with some benefit

- How does which test force small cars to become stronger?

- What test is suitable to adapt the restraint systems for woman and elderly car occupants?

- What test can implement „energy distribution" assessment?

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Thank you for attention!

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