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The sensitivity of the crash rate of Finnish road traffic for bad weather circumstances

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Introduction

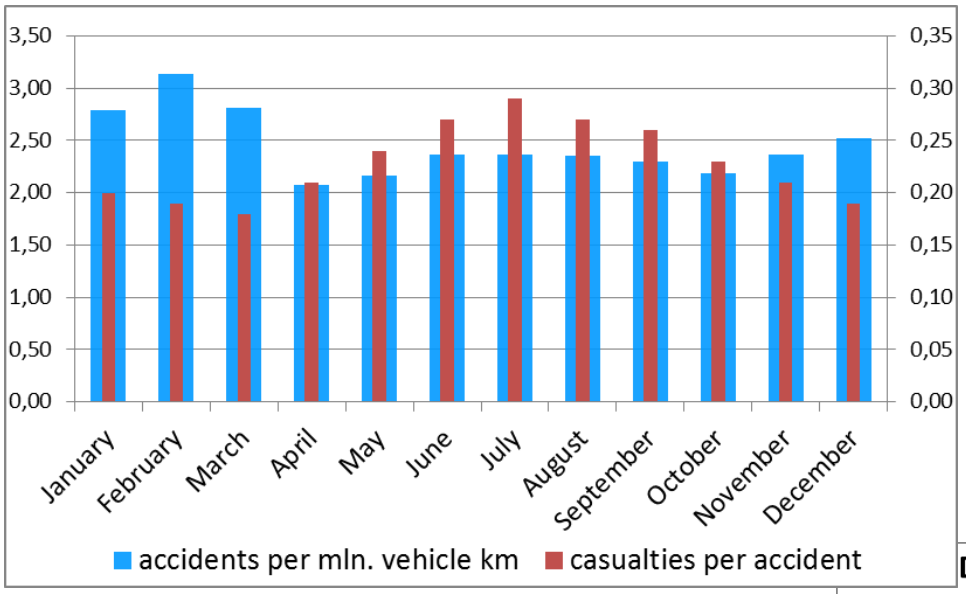
- Crash rate studies involve various disciplines
  - Even if focus on weather effects, there are interactions
- Europe: bad weather is main cause in ~ 10% of crashes
  - USA / Canada: this is 15% ~ 20%
- Furthermore, bad weather is supplementary cause in 20% ~ 30% of crashes
- *This* study focuses on crash rates and weather at *regional level* in Finland 2000-2010
  - Warning effectiveness is hard to assess:
    - very small number of non-warned events
    - ‘automatic’ and selective responses of drivers

Approach

- Registered crashes 2000-2010 (~72000 records), incl. date, Ncars, Ncasualties, type of collision, type of vehicles, province (excl. Lapland)
- Merged with daily weather conditions, occurrence of warnings, traffic levels, weighed share of motorways – all by region
- OLS estimates by region and nationally for winter months
  - November-December; January-March; whole year
  - Monday-Thursday; Friday; Saturday; Sunday
  - other options e.g. instrumental variables, Poison regression not applicable/useful with current data

Variable types and degree of inclusion in the model

Types of Factors	Factors in the Model
Physical Environmental Conditions:	
Resistance of the road surface (slipperiness due to frost, snowfall, heavy rain)	YES
Visibility (fog, dense precipitation, night/day)	YES
Strong cross-winds	NO*
High wind speeds (aggravating precipitation effects)	YES
Very low or very high temperatures	YES
Situational complexity (difficult terrain; distractive landscape features, etc)	NO
Road Quality:	
Allowable speeds	NO**
Speed limit enforcement	NO
Separation of lanes	NO**
Traffic density	YES
Road side information systems	NO
Vehicle and Driver:	
Condition of the car fleet (age, presence of technical condition inspection cycles, obligatory safety measures (e.g. winter tires), *etc.*)	NO
Share of non-experienced drivers	NO
Condition of the driver (intoxication, age, general condition)	NO
Experience level of driver(s); known or unknown route	NO
Number and conduct of co-travellers	NO
Information interface in the car	NO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October
November
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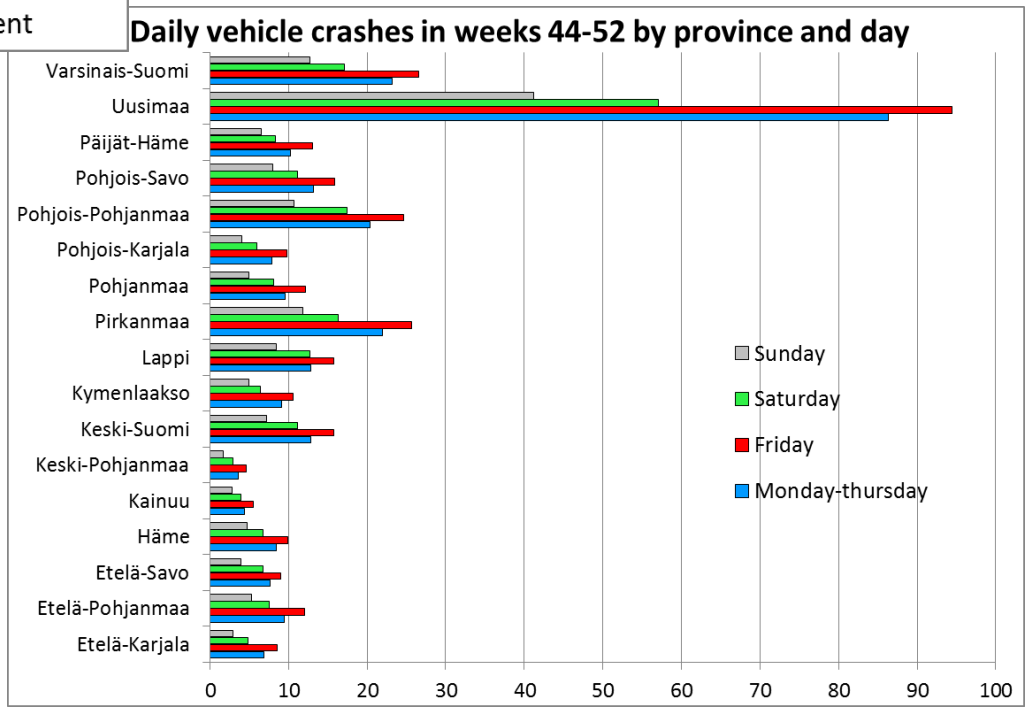
accidents per mln. vehicle km
casualties per accident


Daily vehicle crashes in weeks 44-52 by province and day
Varsinais-Suomi
Uusimaa
Päijät-Häme
Pohjois-Savo
Pohjois-Pohjanmaa
Pohjois-Karjala
Pohjanmaa
Pirkanmaa
Lappi
Kymenlaakso
Keski-Suomi
Keski-Pohjanmaa
Kainuu
Häme
Etelä-Savo
Etelä-Pohjanmaa
Etelä-Karjala
Sunday
Saturday
Friday
Monday-thursday
0
10
20
30
40
50
60
70
80
90
100

A selection of estimation results

Dependent Variable: *Crash Rate*	Monday–Thursday November–December			Monday–Thursday January–March			Friday November–December		
Explanatory Variables:	**Coefficient**	**Standard Error**	**t Statistic**	**Coefficient**	**Standard Error**	**t Statistic**	**Coefficient**	**Standard Error**	**t Statistic**
Intercept	0.85216	0.8685	0.98	−5.41001	0.4874	−11.10	0.37749	1.3623	0.28
$W_{idsr:}$									
ln_Tave	0.03511	0.0081	4.34	0.10520	0.0063	16.65	0.04802	0.0162	2.97
ln_RRmax	0.01244	0.0133	0.93	0.02594	0.0116	2.23	0.04863	0.0258	1.89
ln_Wsavg	0.03011	0.0106	2.83	0.06744	0.0082	8.22	0.05482	0.0193	2.84
ln_Rhmax	−0.62942	0.1882	−3.35	0.76484	0.1060	7.22	−0.30317	0.2948	−1.03
ln_snowdp	0.07360	0.0042	17.45	0.08694	0.0055	15.75	0.01530	0.0084	1.82
ln_prepxwind	0.05606	0.0102	5.48	0.05949	0.0090	6.58	0.00696	0.0195	0.36
$T_{ldsr:}$									
ln_tcarsperday	0.40566	0.0123	33.08	0.37779	0.0103	36.70	0.26676	0.0241	11.08
ln_pchighways	−0.11191	0.0221	−5.06	−0.11448	0.0177	−6.46	−0.01859	0.0432	−0.43
$D_{jdsr:}$									
D_Thaw	0.11245	0.0171	6.59	0.01607	0.0136	1.18	0.08029	0.0339	2.37
N	6942			9657			1698		
R^2	0.192			0.184			0.104		

Illustration of impact of raising severity on crash rates; climate change

Input Values	Normal	Bad	Very Bad
Wsavg average wind speed (m/s)	3	13	17
Tave average temperature (°C)	–3	–7	–7
RRmax maximum precipitation (mm/day)	5	15	25
Rhmax maximum humidity	97	97	97
Thaw occurrence of freeze-thaw cycle	1	1	1
Snowdp snow depth (cm)	22	42	42
Prepxwind (RRmax x Wsavg)	15	105	221
Tcarsperday traffic intensity	1020	1020	1020
Pchighways % share of highways in traffic performance	13	13	13
Resulting crash rate (N/million vkm)	*2.7374*	*3.2043*	*3.3894*
N crashes (on one day)	*271*	*317*	*336*

Climate change effect next 30 years: small

e.g.: +1 very bad day + 2 bad days: ~ 150 more crashes/year (~2% ↑)

Also compensatory trends: intelligent road weather systems, automated cars, road clearing, ..

Wrap - up

- bad weather can raise the number of accidents significantly (by 20% or more over the base rate)
- key factor is the *combination of strong winds and precipitation* (notably snow)
- drivers have to re-learn every winter
- changes in daily schedules (24/7 economy) may affect crash proneness and effectiveness of weather information
- effect of climate change on crash rates remains probably modest
- plan to redo the study with spatial and temporal resolution + exploring link to physical road condition model

References

- Perrels, A., Votsis, A., Nurmi, V., Pilli-Sihvola, K. (2015), Weather conditions, weather information and car crashes, ISPRS International Journal of Geo-Information, Vol.4, pp.2681-2703. doi:10.3390/ijgi4042681
- Pilli-Sihvola, K., Nurmi, V., Perrels, A., Harjanne, A., Bösch, P., and Ciari, F. (2016), Innovations in weather services as a crucial building block for climate change adaptation in road transport, European Journal of Transport Infrastructure Research, Vol.16, issue 1, pp.150-173