Time-Varying Risk Aversion? Evidence from Near-Miss Accidents

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Time-Varying Risk Aversion

- Risk aversion is key preference parameter determining economic choices
 - Investment decisions, saving behavior
 - Insurance plans (health, auto)
 - Adoption of new goods, technologies, etc.
- Recent (mainly survey) evidence that risk aversion varies over time, shaped by *recent (adverse) experiences*:
 - Financial crisis: Guiso et al. (2018), Cohn et al. (2015), etc.
 - Natural disasters: Cameron and Shah (2015), Hanaoka et al. (2018), etc.
 - Violent conflicts: Jakiela and Ozier (2019), Brown et al. (2019), etc.
- We seek field evidence for time-varying risk aversion
 - Unique high-frequency data on driving behavior.
 - Do adverse events (driving mishaps) trigger change in risk preferences? (in which direction? welfare implications?)

Near-Miss

- We observe near-miss accidents/ "close calls"
 - Driving mishaps hard brakes and/or hard turns.
- Unlike real accidents:
 - More frequent, *do not* trigger a change in insurance contracts.
 - No pecuniary incentive to adjust driving behavior.
- Lab evidence that NM's induce behavior change. (Dixon and Schreiber (2004), Clark et al. (2012), Billieux et al. (2012), etc.)
- NMs attenuate risky behavior if they "can be recognized and interpreted as disasters that *almost happened*" (Tinsley et al., 2012).

Institutional Background

- A Chinese insurance tech firm:
 - produces a mobile phone app that tracks users' driving patterns using phone functions. Screenshots of the app Trip start and end pages
- While firm serves as a "front-end" auto ins brokerage, few users utilize this.
 - 6.25% of users actually request insurance quotes
- Information on users' driving patterns is not used in insurance pricing; drivers know this.
 - Drivers have little incentive to improve driving based on feedback from app.

Data

- Detailed trip-level info:
 - A nationwide representative sample of 56,000+ drivers, 2015–2018.
 - Observe starting and ending time and location
 - Observe driving mishaps ("near-misses", "close-calls"): hard brakes/turns, aggressive accelerations.
 - Observe risky actions: use of cellphones while driving, driving at night, driving on highways (risk factors for accidents)
- For a subset of these users, who *request insurance quotes* via the app:
 - We observe demographics, characteristics of their vehicles, insurance quotes/purchase decisions.
 - We match with insurance claims data: filed claims, repair history (use in robustness checks, evaluating welfare implications)

Measures of Near-Miss

Variable	Mean	Std. Dev.	Min	Max	Obs	
	(a) Hard brakes					
No agg in the trip	0.3171	0.4654	0	1	1,602,177	
No agg in the last 5 min	0.5812	0.4934	0	1	1,602,177	
Original	0.7410	0.4381	0	1	1,602,177	
	(b) Hard turns					
Left turns	0.1504	0.3575	0	1	1,602,177	
Right turns	0.0905	0.2869	0	1	1,602,177	
U turns	0.1589	0.3656	0	1	1,602,177	
Any turns	0.2659	0.4418	0	1	1,602,177	
	(c) Have both hard brakes and turns					
No agg in the trip	0.1033	0.3044	0	1	1,602,177	
No agg in the last 5 min	0.2035	0.4026	0	1	1,602,177	
Original	0.2419	0.4282	0	1	1,602,177	

- Preferred measures: hard brakes/turns unaccompanied by aggressive acceleration – More likely to be *preventive actions*.
- NM's coincident with real accidents

Measures of Risky Driving Behavior

Variable	Mean	Std. Dev.	Min	Max	Obs
# of phone uses	0.0108	0.4020	0	130	1,602,177
Distance (km)	36.6608	57.8538	0	1671.9800	1,602,177
Duration (h)	1.3204	1.5435	0.0003	29.7122	1,602,177
Speed (km/h)	25.3514	14.4986	0	199.8323	1,602,177
Drive at night	0.2431	0.4290	0	1	1,602,177
# of highway uses	0.2107	0.7737	0	27	1,602,177

Summary statistics – other covariates

First Glimpse: Change in Risky Behavior after NM

• At face value: NM precipitate a sizeable drop in risky behavior.

	Day t	Phone use	Distance	Duration	Speed	Drive at night	Highway
	0	0.0194	47.3733	1.7360	25.2869	0.2966	0.2841
	1	0.0079	36.3753	1.3226	25.2024	0.2450	0.1986
_	2	0.0075	34.3800	1.2397	25.2892	0.2332	0.1867
	3	0.0075	33.1763	1.1882	25.4404	0.2264	0.1842
	4	0.0061	32.3847	1.1594	25.4371	0.2226	0.1812
	5	0.0049	31.9934	1.1295	25.5978	0.2217	0.1765
	6	0.0046	31.4716	1.1151	25.5706	0.2166	0.1799
	7	0.0032	31.0410	1.0923	25.6637	0.2137	0.1756
	8	0.0016	30.4276	1.0736	25.7018	0.2130	0.1719
	9	0.0016	30.3020	1.0598	25.6910	0.2120	0.1664
_	10	0.0027	29.8254	1.0426	25.6889	0.2112	0.1645

Estimating the Effects of NM on Risky Behavior

• A dynamic panel model with fixed effects.

$$y_{it} = \gamma y_{it-1} + \frac{\beta}{NM_{it-1}} + X_{it}\phi + \alpha_i + \varepsilon_{it},$$

- y_{it}: one of our six measures of risky behavior.
 X_{it}: additional conditioning covariates
 α_i: driver fixed effects (can be correlated with NM_{it-1}).
- ε_{it} : assumed orthogonal to all RHS variables (for now)
- Take FD to get rid of α_i (Arellano and Bond, 1991)

$$\Delta y_{it} = \gamma \Delta y_{it-1} + \beta \Delta NM_{t-1} + \Delta X_{it}\phi + \Delta \varepsilon_{it}$$

Users experience shocks that jointly precipitate near-misses and risky behavior. We use $weather_{t-2}$ as instruments.

Regression Results

	Phone use	Distance	Duration	Speed	Drive at night	Highway		
			(a) H	ard brakes				
No agg in the trip	-0.0178***	-12.98***	-0.219***	0.660**	0.00271	-0.0911***		
	(0.00486)	(1.323)	(0.0372)	(0.289)	(0.00955)	(0.0130)		
No agg in the last 5 min	-0.0100***	-13.49***	-0.214***	0.845***	0.000414	-0.0771***		
	(0.00269)	(1.322)	(0.0372)	(0.251)	(0.00826)	(0.0111)		
Original	-0.0121***	-16.29***	-0.278***	1.064***	-0.000439	-0.0935***		
	(0.00320)	(1.549)	(0.0445)	(0.303)	(0.0100)	(0.0134)		
		(b)	Have both h	ard brakes a	nd turns			
No agg in the trip	-0.0207***	-25.56***	-0.344***	1.465***	0.00130	-0.143***		
	(0.00555)	(2.550)	(0.0689)	(0.460)	(0.0151)	(0.0205)		
No agg in the last 5 min	-0.0110***	-24.16***	-0.199***	1.428***	-0.00149	-0.103***		
	(0.00297)	(2.363)	(0.0606)	(0.342)	(0.0114)	(0.0154)		
Original	-0.0109***	-24.56***	-0.169***	1.444***	-0.00196	-0.101***		
	(0.00291)	(2.398)	(0.0605)	(0.336)	(0.0113)	(0.0152)		
Average values	0.0108	36.6608	1.3204	25.3514	0.2431	0.2107		
Observations	1,485,428	1,485,428	1,485,428	1,485,428	1,485,428	1,485,428		

How Long Do Effects of NM Last?



• 5-6 driving days in data \approx 2-3 calendar weeks. Strong "recency" effect.

- Experienced vs. less-experienced drivers
- NM's occurring on familiar vs. unfamiliar roads
- Routine (commuting) vs. non-routine trips

- Next, we build a simple structural model of drivers' choice of risky behaviors.
- Estimate **whether** and **how much** change in risk aversion can explain changes in behavior before and after NM's.

Model

Drivers have CARA utility

$$u(c;\rho) = -\exp(-\rho c),$$

- c is risky payoff, depends on whether there is an accident
 ρ is the risk-aversion parameter to be calibrated; having a near-miss triggers change in risk-aversion
- Payoffs:

$$c = \begin{cases} \prod_j y_j^{\zeta_j} & \text{without accident} \\ \prod_j y_j^{\zeta_j} - \kappa & \text{with accident} \end{cases}$$

- $\prod_j y_j^{\zeta_j}$: "subutility" from risky behaviors: phone uses, distance, highway
- Once an accident occurs, agents incur a cost, κ ≈ \$1065 (out of pock), \$213 (=20% deductible), \$107 (=10% deductible)

• Agent chooses risky behavior to maximize expected utility:

$$\mathbf{y}^{*}(X;\rho,\zeta) = \arg \max_{\mathbf{y}} \left[\underbrace{\Pr(A|\mathbf{y},X)}_{\text{prob of an accident}} u(\prod_{j=1}^{J} y_{j}^{\zeta_{j}} - \kappa;\rho) + \underbrace{(1 - \Pr(A|\mathbf{y},X))}_{\text{prob of no accident}} u(\prod_{j=1}^{J} y_{j}^{\zeta_{j}};\rho) \right].$$

Estimation Results

	(1)	(2)	(3)
	$\kappa =$ \$1065	$\kappa =$ \$213	$\kappa =$ \$106.5
Risk aversion before NM: ρ_0	0.0037	0.0214	0.0478
	(0.0004)	(0.5060)	(0.0083)
Percentage change of RA after NM 1: δ_1	0.1054	0.1197	0.1248
	(0.0123)	(0.2836)	(0.0476)
Percentage change of RA after NM 2: δ_2	0.2823	0.3494	0.4377
	(0.0287)	(0.1733)	(0.1258)
Parameter in payoff function: ζ_1	0.0020	0.0043	0.0002
	(0.0043)	(0.1503)	(0.0027)
Parameter in payoff function: ζ_2	0.4177	0.2458	0.2012
	(0.0467)	(0.0816)	(0.0514)
Parameter in payoff function: ζ_3	0.0079	0.0046	0.0038
	(0.0024)	(0.0114)	(0.0013)

Implied Accident Cost Reduction after Near-Misses

- NM ⇒ drivers become more risk averse ⇒ reduce risky behavior ⇒ reduction in the cost of insuring drivers.
- Estimate from the data
 - Average cost of an accident: 7342 CNY.
 - how long the level of risky behavior reverts back to the original level: about 2 weeks.
 - Near-miss (def 2) occurred on 10.33% of the driving days.
 - Users drive 215 days in a year (from survey).
 - Average annual auto insurance premium ≈ 5710.03 Yuan (est from quotes).

	Before NM	After NM 1	After NM 2
Pr(accident)	0.1296%	0.1242%	0.1194%
Reduction in Pr(accident)		0.0054%	0.0102%
Reduction in Accident Cost (Yuan)		2.7754	5.2424
Reduction in Accident Cost (Annualized; Yuan)		189.22	116.43
Reduction in Accident Cost (% of Avg Premium)		3.31%	2.04%

Summary of Findings

- Following near-misses, drivers drive more conservatively:
 - A reduction in driving distance of 12.98 km
 - Big drop in cellphone and highway uses.
- The effects last roughly 2–3 weeks.
- Such changes in behavior are consistent with an increase in risk aversion of 10.54–43.77%.
- Implied accident cost reduction: amounts to 2.04–3.31% of avg car insurance premium (116.43–189.22 CNY/person).

Policy Implications

- The finding of time-varying risk aversion has implications for insurance pricing
 - Experience rating raise premiums after at-fault claims is the dominant pricing scheme;
 - Logic underlying this reverses if drivers become more risk-averse after accidents.
- Our paper focuses on measuring *high-frequency* variation in driving behavior, whereas changes in insurance premiums occur at much lower frequency.
 - Our results may have direct implications for the design of "real-time" dynamic pricing policies.

Login and Trip Summary Pages







Trip Start and End Pages





80分

85分

注意力

环保指数



Summary Statistics: Other Covariates

Variable	Mean	Std. Dev.	Min	Max	Obs	
	(a) Driving scores					
Control score	81.0513	5.5614	1	100	1,602,177	
Cautious score	81.7256	2.7264	45	100	1,602,177	
Focused score	82.2600	9.4508	17	100	1,602,177	
Driving score	81.2518	4.1803	28	100	1,602,177	
		(b) Traff	ic cond	litions		
Weekend	0.2681	0.4430	0	1	1,602,177	
Rush hour (7-9am, 5-7pm)	1.2943	1.1743	0	31	1,602,177	
# of traffic jams	0.5365	1.0110	0	31	1,602,177	
		(c) Weath	er info	rmation	l	
High temperature (°C)	22.0915	9.8028	-30	45	1,602,177	
Low temperature (°C)	13.9506	10.0043	-36	32	1,602,177	
Sunny	0.2165	0.4118	0	1	1,602,177	
Rain/snow	0.2992	0.4579	0	1	1,602,177	
Cloudy/windy/foggy	0.4655	0.4988	0	1	1,602,177	



Are Drivers Learning from Near-Misses? (test 1)

- Changes in risk-aversion? Alternative explanation: drivers learn and improve their driving after NM.
- Compare experienced vs. inexperienced users:
 - Learning is likely less of a concern among experienced drivers.
 - Use drivers who requested insurance quotes through the app: information on car registration date.
 - Experienced drivers: vehicle registered before 2015.
- Findings:
 - Indeed: near-misses have a larger impact on inexperienced users – effects on driving distance and duration are much larger.
 - But even for experienced drivers, multiple RB's decrease after near-miss.

Are Drivers Learning from Near-Misses? (test 2)

- A second assessment of the learning story: changes in risky behavior after near-misses on **familiar roads** are unlikely to result from learning.
- Familiar trips:
 - If similar routes have been taken by the user in the past based on the geographic coordinates of the starting and ending locations of each trip.
- Findings:
 - For three out of six measures (distance, duration, and highway uses), risky behavior significantly decreases after the user experienced near-misses on familiar roads.

Validity of Using Weather as Instruments

- Problem: Serial correlation in weather
 - weather_{t-2} may not be orthogonal to ε_{t-1} .
 - Drivers may adjust their plans in period t 1 (in ε_{t-1}) in response to weather_{t-2}
 - Especially pertinent for measures duration, distance, drive at night – which can be plausibly adjusted in difficult weather conditions.
- Consider "routine" drivers, who have little leeway in adjusting their driving plans.
 - Weekday commuters, driving at regular times/routes.
 - (also more likely to be a driver, rather than a passenger)
- Findings:
 - Four out of six measures still significantly negative; directions and magnitudes are comparable to the benchmark.