14.03/14.003 Microeconomic Theory & Public Policy Fall 2022

Lecture 19. Risk, Safety Regulation, and the Value of a Statistical Life

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The Value of a Statistical Life

- This is a topic that makes non-economists uncomfortable. How much should society spend, at the margin, to save a 'statistical life?'
- A statistical life is a **probabilistic concept**. When we save a statistical life, we reduce the number of deaths by one *in expectation.*
- The value of a statistical life (**VSL**) is clearly very different from what we would spend to save a specific individual who was in grave danger of death

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- The value of a statistical life (**VSL**) is clearly very different from what we would spend to save a specific individual who was in grave danger of death
- Where did this idea come from?
    - "The Cold-War Origins of the Value of Statistical Life" by H. Spencer Banzhaf, *Journal of Economic Perspectives*, 2014

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- ...Their optimization model... crunched the numbers for over 400,000 configurations of bombs and bombers using hundreds of equations. The massive computations for each configuration involved simulated games at each enemy encounter, each of which had first been modeled in RAND's new aerial combat research room.
- Their 1950 study recommended that the United States *fill the skies with numerous inexpensive and vulnerable propeller planes*, many of them decoys carrying no nuclear weapons, to overwhelm the Soviet air defenses. Though losses would be high, the bombing objectives would be met.

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- *How did the Air Force react?*

- Individuals and societies make implicit tradeoffs between safety and cost
- Comparing crash safety of Mexican vs. U.S. spec passenger cars
  - 2015 Nissan Tsuru vs. 2016 Nissan Versa

“Effects and Costs of Requiring Child Restraint Systems for Young Children Traveling on Commercial Airplanes”

Newman, Johnston and Grossman, *Archives of Pediatric and Adolescent Medicine*, 2003

The 1995 Child Safety Restraint Mandate: Context

- On July 2, 1994, a Douglas DC-9-31, N954VJ, operated by US Air collided with trees and a private residence near the Charlotte/ Douglas International Airport
- The captain, first officer, one flight attendant, and one passenger received minor injuries. Two flight attendants and 14 passengers sustained serious injuries. The remaining 37 passengers received fatal injuries
- A 9-month-old infant who had been held on her mother's lap sustained fatal injuries. The child's mother was unable to maintain a secure hold on the child during the impact sequence, and the child struck several seats

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- The National Transportation Safety Board (NTSB) concluded that *if the child had been properly restrained in a child restraint system, she might not have sustained fatal injuries*
- In 1995, NSTB issued **Safety Recommendation A-95-51**, **asking that small children be restrained in age-appropriate restraint systems**

Some relevant data from Newman et al., 2003

Annual enplanements by children under age 2	6.5 million
Estimated annual fatalities averted per year by CSR	0.4 deaths
Average cost of child airline ticket	~$200

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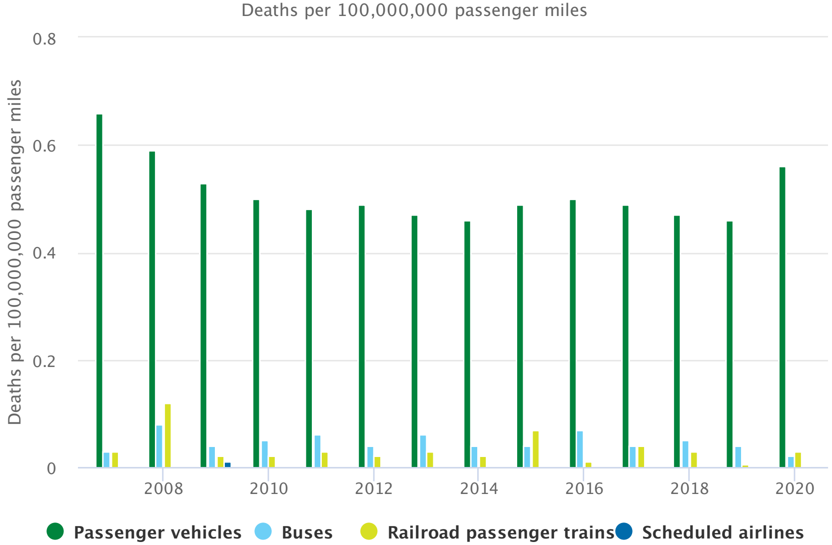
$$\frac{\text{Expenditure}}{\text{Deaths averted}} = \frac{6{,}500{,}000 \times \$200}{0.4}$$

$$= \$3.25 \text{ billion per death averted}$$

What else should we be considering?

Passenger death rates, United States, 2007–2020



Some (additional) relevant data from Newman et al. 2003

% of families likely to drive if required to buy infant seat	6% (390K)
Increase in car travel for switchers	300 miles
Average vehicle occupancy	2.4
Auto fatalities per 100 million miles	0.5
Air fatalities per billion enplanements	117

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$$\text{Air fatalities averted} = +0.4 + 6{,}500{,}000 \times 0.06 \times 2.4 \times \left(\frac{117}{1{,}000{,}000{,}000}\right)$$
$$= -0.51 \text{ deaths}$$

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$= -0.51$ deaths

Auto fatalities induced $= 6{,}500{,}000 \times 0.06 \times 2.4$

$\times \left(\frac{300 \times 0.5}{100{,}000{,}000}\right) = +\ 1.40$ deaths

The 1995 Child Safety Restraint Mandate: Outcome

- At a December 1999 roundtable on child passenger safety on aircraft, sponsored by the Safety Board, the Federal Aviation Administration (FAA) made a commitment to establish rulemaking that would provide **one level of safety for passengers of all ages**
- Although a new rule was scheduled to be issued by April 2000, none was issued
- In January 2004, the FAA indicated that because of continuing concerns about **diversion**, it would not be issuing regulations mandating the use of child restraints

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- In January 2004, the FAA indicated that because of continuing concerns about **diversion**, it would not be issuing regulations mandating the use of child restraints
- In 2005, the FAA supplied copies of two recently published papers that found that *highway deaths and injuries increased due to diversions from air travel to highway travel in the aftermath of September 11, 2001*
- The NTSB concluded that it could not convince the FAA to take the action recommended. On November 14, 2006, Safety Recommendation A-95-51 was classified **Closed Unacceptable Action**

“The argument in support of the FAA’s resistance to the NTSB recommended rule mandating child safety seats is unreasonable on its face, and ridiculous in its justification... It protects theoretical children driving in cars at the expense of real flesh-and-blood infants whose safety is unquestionably compromised when flown as a lap-baby”

Collision Course: The Truth about Airline Safety

by Ralph Nader & Wesley Clark, 1994

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NEWS IN BRIEF

142 Plane Crash Victims Were Statistically More Likely To Have Died In A Car Crash

WASHINGTON—Following last week's deadly crash of United Airlines flight 9753, which claimed the lives of 137 passengers and five crew members, the National Transportation Safety Board announced Wednesday that the victims were actually far likelier to have perished in an automobile accident.

“Using Mandated Speed Limits to Measure the Value of a Statistical Life”

Orley Ashenfelter and Michael Greenstone, *Journal of Political Economy*, 2004

The Value of a Statistical Life

- How do you get a **credible estimate** of the VSL? Not easy
- Asking people will not be very informative (they'll be horrified)
- But for policy analysis there is no way around such quantification
- We must make regularly societal decisions about how much risk we should tolerate and how much we should spend in tax revenue or how much we should curtail freedom of choice to abate risk

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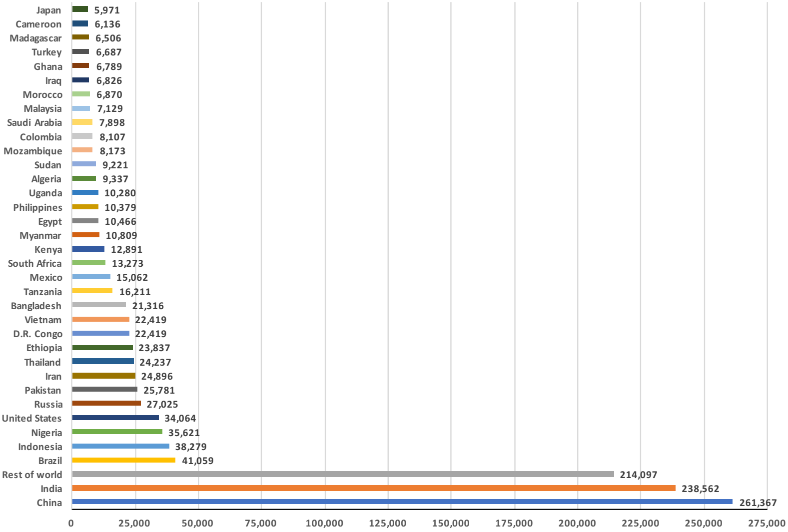
- We must make regularly societal decisions about how much risk we should tolerate and how much we should spend in tax revenue or how much we should curtail freedom of choice to abate risk
- **Idea:** the Weak Axiom of Revealed Preference says that we can observe the VSL from the trade-offs that people (or governments) make between cost and safety

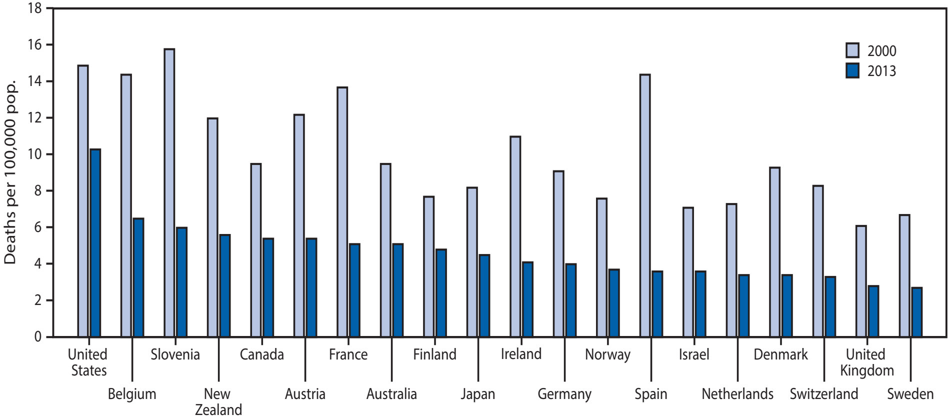
Worldwide Motor Vehicle Fatalities in 2015 (1.25 Million Fatalities Total)



World Health Organization, 2016

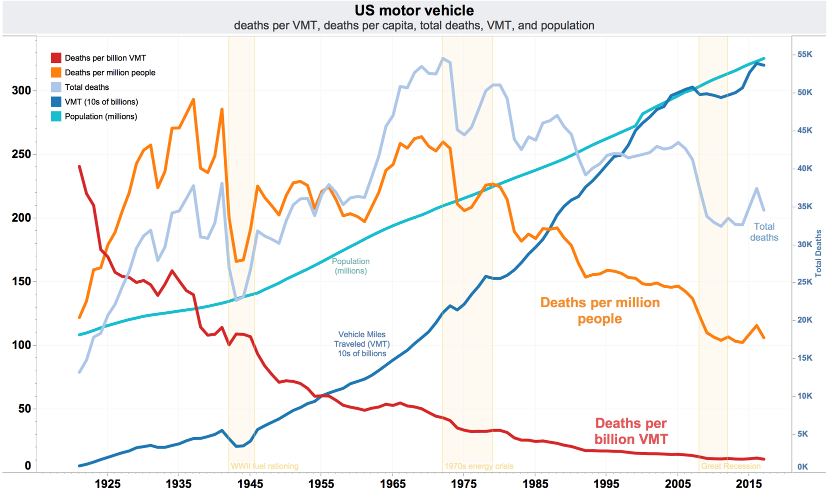
Motor Vehicle Fatalities per 100K Population in 20 High-Income Countries, 2000 and 2013

FIGURE. Motor vehicle crash deaths per 100,000 population — 20 high-income countries, 2000 and 2013



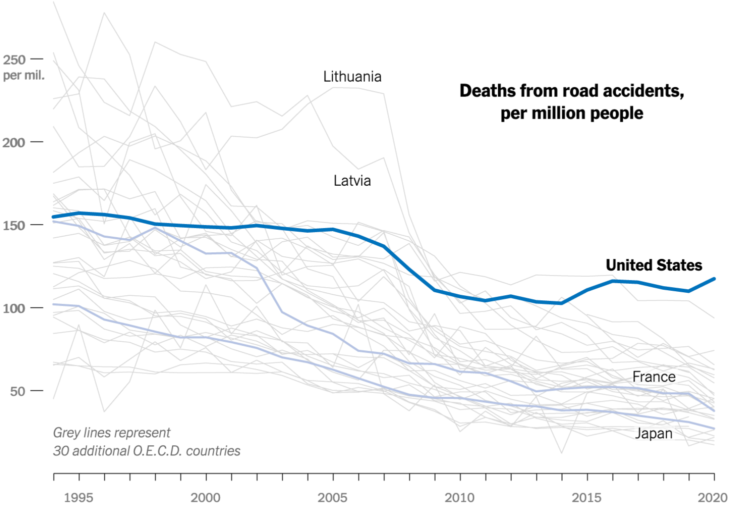
Sauber-Schatz et. al. 2016

U.S. Annual Motor Vehicle Travel and Motor Vehicle Deaths, 1923 – 2017



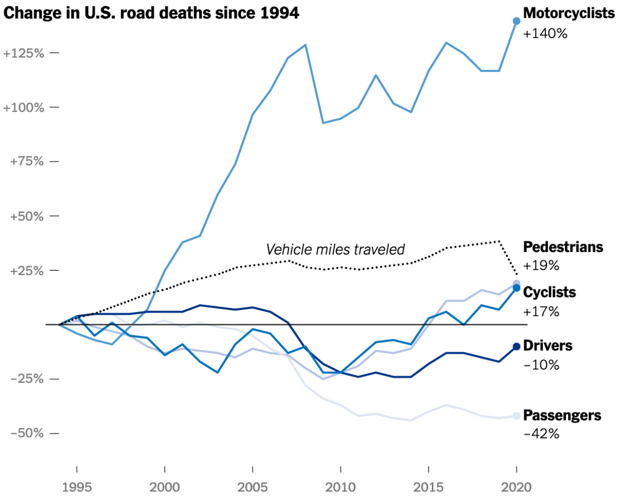
Source: Wikipedia 2018

High Road Accident Death Rate in U.S. Relative to 30 OECD Countries



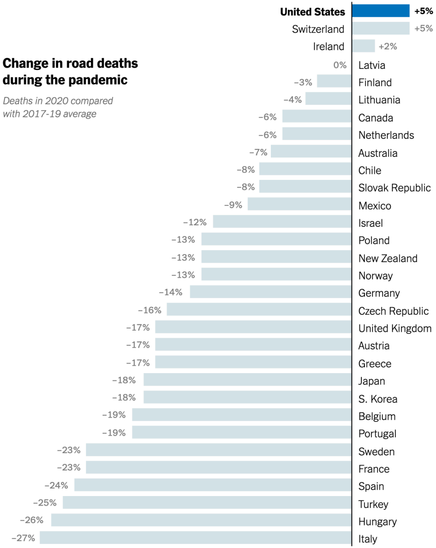
Source: Organization for Economic Cooperation and Development • The New York Times

U.S. Vehicle Fatalities Trending Up Since ∼ 2010



Note: Motorcycle registrations doubled in the U.S. between 2002 and 2020. • Sources: U.S. National Highway Traffic Safety Administration; Insurance Institute for Highway Safety • The New York Times

U.S. Drivers Went Rogue During the Pandemic



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The Value of a Statistical Life (VSL): Trading off safety vs. time savings

- Speed limits are one place where that choice is very apparent. The faster people drive, the less time they spend getting from place to place.
- Since time has value, going slower is costly in foregone opportunities.
- However, going faster increases the probability of death.

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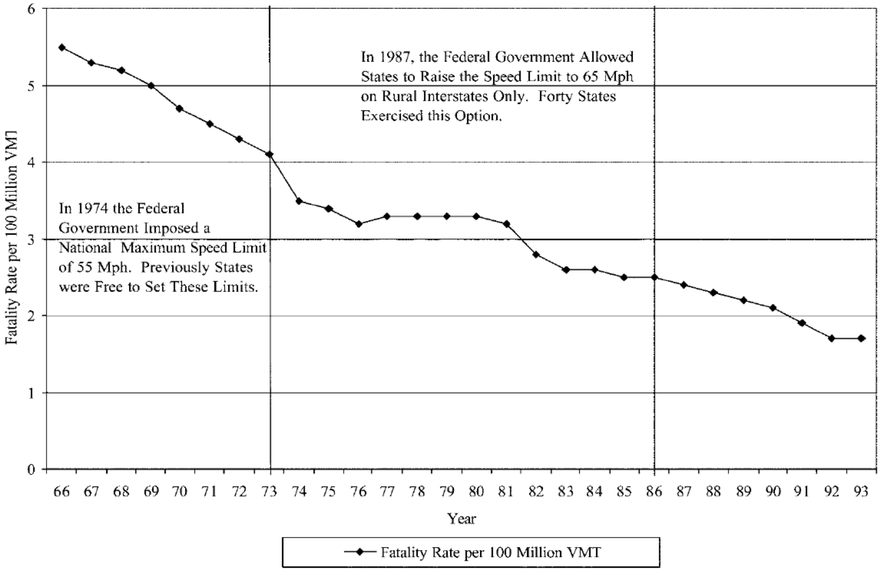
- Since time has value, going slower is costly in foregone opportunities.
- However, going faster increases the probability of death.
- **Question:** Why doesn't the decreased time spent at risk when traveling at higher speed wash out the additional risk borne from driving faster?
- Because the kinetic energy of a moving body is $E = \frac{1}{2} \times \text{Mass} \times \text{Velocity}^2$. So, the expected fatality of an accident increases quadratically with velocity whereas the time savings is linear in velocity.

The history of U.S. national speed limits

- Prior to 1973, speed limits in the U.S. were set by states. There was no national speed limit
- With the oil crisis in 1973, the federal government imposed a national speed limit of 55 MPH
- Although this was probably not the intention, highway fatalities fell 15 percent the following year (a reduction of nearly $10,000$ fatalities!)
- In 1987, with oil prices low, the federal government allowed states to raise their speed limits to 65 MPH if they wished to
- 37 states raised their speed limits in 1987 and 3 more did so in 1988

U.S. national speed limit was 55 MPH from 1974 to 1987



Research design of Ashenfelter and Greenstone (2004)

Research design

Four steps to research plan

1. Contrast the change in fatalities in adopting versus non-adopting states

Research design

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Question: Would it be sufficient to ask people individually how they would make the speed/accident trade-off?

Revealed preference choice of time savings versus risk

The Value of a Statistical Life

- **Question:** Why is it critical for the research design that *not all* states raised their speed limits?

The Value of a Statistical Life

- **Question:** Why is it critical for the research design that *not all* states raised their speed limits?
- The 'treatment' here is to *offer* state legislatures the option to relax speed limits in their states. If either no state *or* every state took up this offer, we wouldn't be able to bound the implied *VSL*.
- If no state took up, then we could only infer that the expected loss in life was not worth the time savings. But we could not estimate the change in either time savings or reduced safety
- If all states took up, we would infer that they are all constrained at 65 miles per hour. But we'd have no control group!

Fatalities in adopting v. non-adopting states *prior to* adoption

Sample Statistics for 1982–86 for States That Were Eligible to Raise the Speed Limit on Rural Interstates in 1987

	States Included in the Analysis	
	Adopted 65 mph (1)	Retained 55 mph (2)
	A. All States	
Number of states	21	7
1986 hourly wage (1997$)	$12.33	$13.97
1986 rural interstate traffic density	.0480	.0945
	E. Statewide Total	
VMT	374.2	446.4
Traffic fatalities	979.3	972.6
Fatality rate	2.617	2.179

Comparison of adopting v. non-adopting states *prior to* adoption

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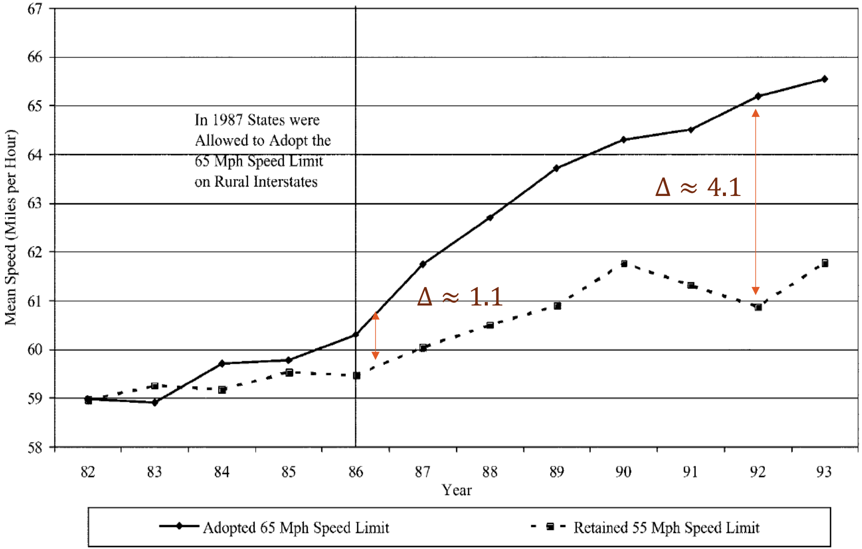
	A. All States	
Number of states	21	7
1986 hourly wage (1997$)	$12.33	$13.97
1986 rural interstate traffic density	.0480	.0945
	B. Rural Interstates	
Fatality rate	1.423	.957
Speed (mph)	59.6	59.3
Percentage of statewide VMT	9.3	5.8
Percentage of statewide traffic fatalities	5.0	2.5
	C. Urban Interstates	
Fatality rate	.887	.843
Speed (mph)	56.9	57.9
Percentage of statewide VMT	12.4	13.5
Percentage of statewide traffic fatalities	4.2	5.2

Average MPH traveled on rural interstates adopting v. non-adopting states



Proportionate (Log) Effect of the Adoption of the 65-mph Speed Limit on Hours Required to Travel the Observed Mileage, by Road Type

Diff-in-Diff Estimates: Travel Time

	Affected Road Type	Unaffected Road Types	
	Rural Interstates (1)	Urban Interstates (2)	Rural Arterials (3)
	A. Annual Effects		
1982–86, 1987	−.039*	−.014	−.047
	(.018)	(.018)	(.025)
1982–86, 1988	−.041**	−.002	−.006
	(.009)	(.011)	(.007)
1982–86, 1989	−.038*	.004	.007
	(.018)	(.014)	(.013)
1982–86, 1990	−.025	−.011	.002
	(.017)	(.016)	(.013)
1982–86, 1991	−.043**	−.012	.005
	(.017)	(.015)	(.010)
1982–86, 1992	−.057**	−.021	.003
	(.017)	(.019)	(.014)
1982–86, 1993	−.054**	−.024	.002
	(.015)	(.014)	(.016)
	B. Average Effect		
1982–93	−.041**	−.009	−.000
	(.007)	(.007)	(.007)

Fatality trends in states adopting 65 MPH speed limit versus retaining 55 MPH

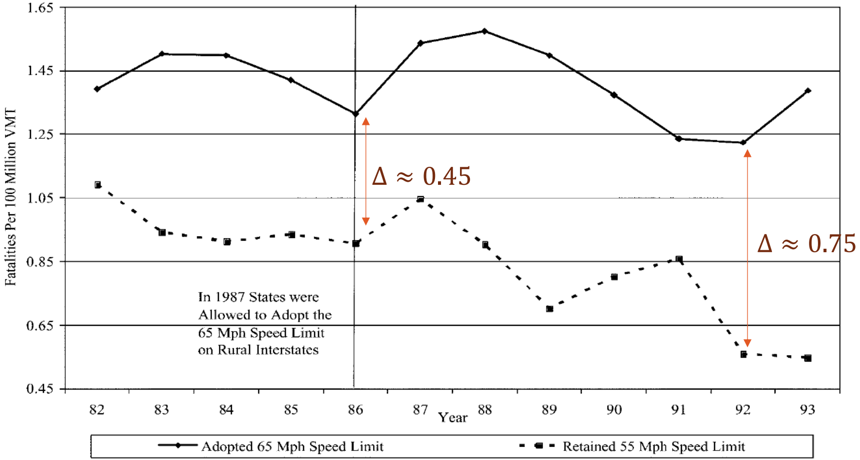


FIG. 3.—Trends in fatality rates on rural interstate roads, by adoption of 65-mph speed limit, 1982–93. The fatality rate is calculated as the weighted mean of the number of fatalities per 100 million VMT, where the weight is VMT.

Diff-in-Diff Estimates: Fatalities

Proportionate (Log) Effect of the Adoption of the 65-mph Speed Limit on Fatalities, Controlling for the Observed Mileage, by Road Type

	Affected Road Type	Unaffected Road Types	
	Rural Interstates (1)	Urban Interstates (2)	Rural Arterials (3)
A. Annual Effects			
1982–86, 1987	−.098	−.203	−.062
	(.195)	(.174)	(.119)
	[165]	[162]	[162]
1982–86, 1988	.351*	−.223*	−.073
	(.165)	(.111)	(.050)
	[167]	[163]	[162]
1982–86, 1989	.473	−.062	.021
	(.259)	(.142)	(.071)
	[167]	[162]	[162]
1982–86, 1990	.268	.073	.181*
	(.163)	(.161)	(.090)
	[166]	[163]	[162]
1982–86, 1991	.202	−.097	.238**
	(.123)	(.135)	(.073)
	[166]	[163]	[162]
1982–86, 1992	.399**	−.012	.140
	(.162)	(.190)	(.087)
	[164]	[162]	[162]
1982–86, 1993	.493**	−.059	.113
	(.179)	(.154)	(.077)
	[165]	[162]	[162]
B. Average Effect			
1982–93	.360**	−.056	.082*
	(.091)	(.073)	(.040)
	[326]	[327]	[324]

Difference-in-difference estimates: Fatalities on rural interstates (and urban interstates as placebo)

TABLE 2
DIFFERENCE IN DIFFERENCES (DD) ESTIMATES OF 65-MPH SPEED LIMIT ON FATALITY RATES AND SPEEDS

	DD of Levels (1)	DD of Levels Normalized by Preperiod Level in Adopting States (%) (2)	DD of Natural Logarithms (3)
	A. Rural Interstates (Affected Road Type)		
Fatality rate	.185	.130	.311
Speed	2.8	.047	.045
	B. Urban Interstates (Unaffected Road Type)		
Fatality rate	−.052	−.059	−.063
Speed	−.5	−.009	−.009

How do we translate these results into estimates of the VSL?

Estimates of monetary value of time saved per life lost

Estimates of the Monetary Value of the Time Saved per Marginal Fatality

Sample	(1)	(2)	(3)
	A. Functional Form I: Ln Transformation		
Rural interstates only	...	−.113** (.037) [$1.64 million]	...
Rural interstates and urban interstates	−.095* (.040) [$1.38 million]	−.076* (.034) [$1.11 million]	−.076** (.031) [$1.11 million]
Rural interstates and rural arterials	−.166** (.057) [$2.42 million]	−.146* (.066) [$2.12 million]	−.122* (.051) [$1.78 million]
All three	−.128** (.042) [$1.86 million]	−.103** (.041) [$1.50 million]	−.099** (.034) [$1.44 million]

Estimates of monetary value of time saved per life lost by adopting state

Arizona	$1.92	Mississippi	$.76
Arkansas	−$1.12	Nevada	$.49
California	$4.75	North Carolina	$1.09
Colorado	$2.31	Ohio	−$.47
Idaho	$2.05	Oregon	$5.41
Illinois	$3.19	South Carolina	$1.68
Indiana	$.70	South Dakota	$1.92
Iowa	$2.97	Tennessee	$.29
Kansas	$1.96	Wisconsin	$9.71
Kentucky	$1.24	Wyoming	$.50
Michigan	$.99		

Interpretation

- Unusual feature: Decision to 'take-up' the higher speed-limit is *chosen* by states—not randomly assigned (unlike a conventional IV)
- The choice aspect is crucial for interpreting the results through the lens of Revealed Preference
- Revealed Preference allows us to say that any state that *chose* to take up the higher speed limit *must* have valued the time savings at greater than or equal to the lives lost (otherwise, by Revealed Preference, it would not have made this choice)
- There is also an important discussion in the paper of whether political decision making about speed limits is efficient

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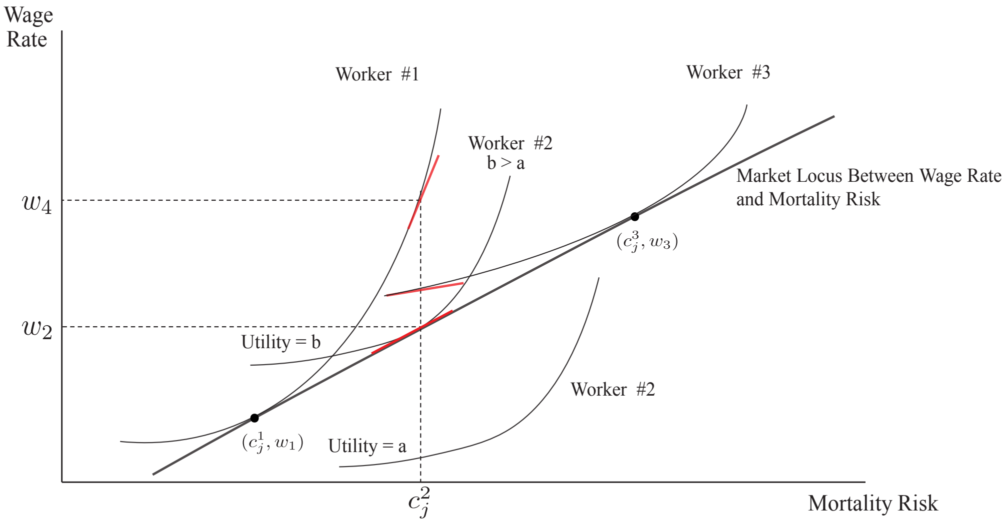
- There is also an important discussion in the paper of whether political decision making about speed limits is efficient
- It's *crucial* to the interpretation to know whether policymakers anticipated the risk/fatality consequences of raising speed limits

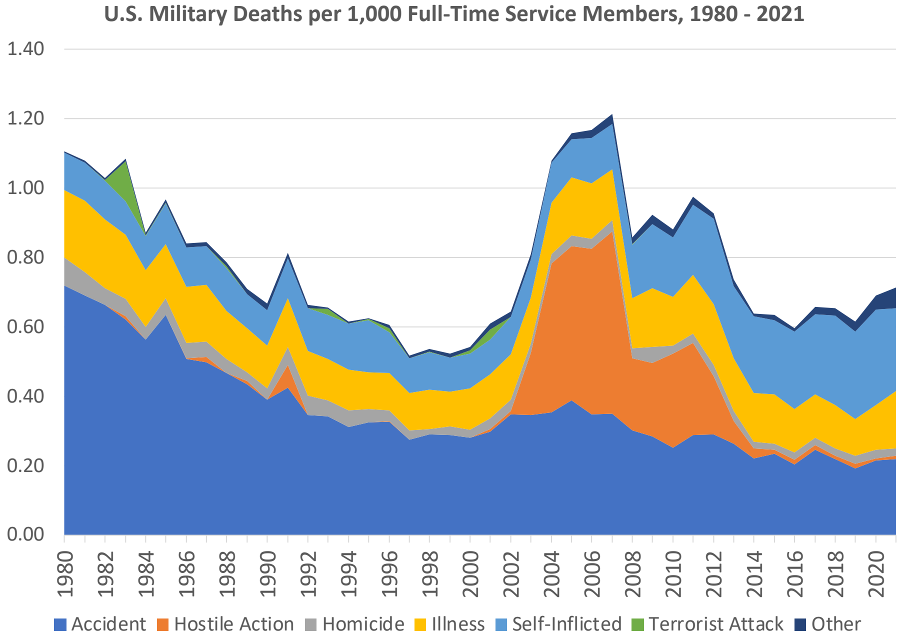
Question: How does the paper interpret the decision by policy makers?

“The Heterogeneous Value of a Statistical Life: Evidence from U.S. Army Reenlistment Decisions”

Kyle Greenberg, Michael Greenstone, Stephen P. Ryan, and Michael Yankovich, 2021

Hedonic Wage-Safety Theoretical Framework (Thaler-Rosen 1976)




U.S. Military Deaths per 1,000 Full-Time Service Members, 1980 - 2021
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Accident
Hostile Action
Homicide
Illness
Self-Inflicted
Terrorist Attack
Other

SEARCH

GET IN TOUCH

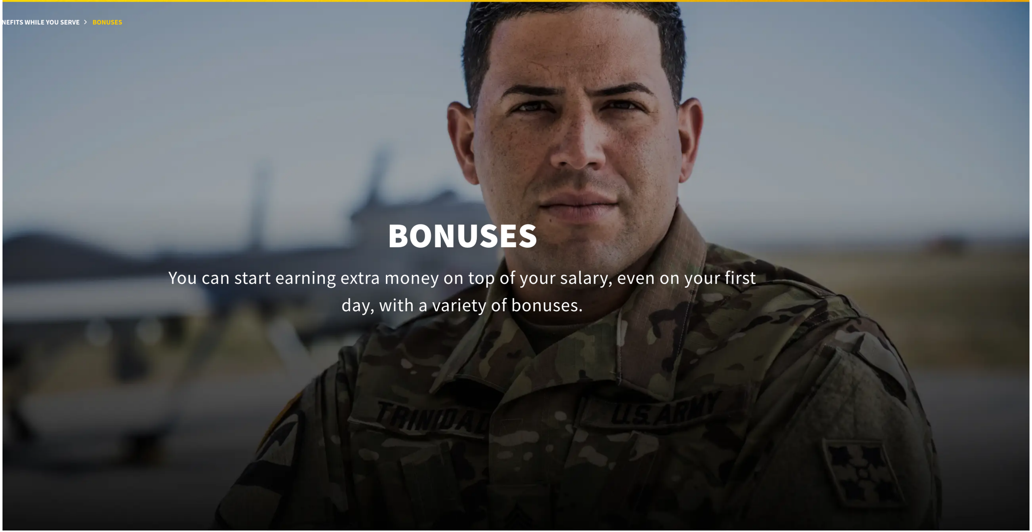
GET UP TO
$50,000
IN ENLISTMENT BONUSES

NEW
2-YEAR
ENLISTMENT OPTIONS

GET UP TO
$40,000
IN QUICK SHIP BONUSES

ENLISTMENT BONUSES

NEFITS WHILE YOU SERVE > BONUSES



BONUSES

You can start earning extra money on top of your salary, even on your first day, with a variety of bonuses.

Milper Message Number 07-141
SELECTIVE REENLISTMENT BONUS (SRB) PROGRAM

Issued 04 JUNE 2007. This MILPER message will expire NLT 31 DECEMBER 2007.

This message announces changes to the Regular Army Active Component SRB Program. The effective date for additions to SRB multipliers or maximum payments is 05 JUNE 2007. The effective date of decreases and terminations to the SRB Program is 05 JULY 2007.

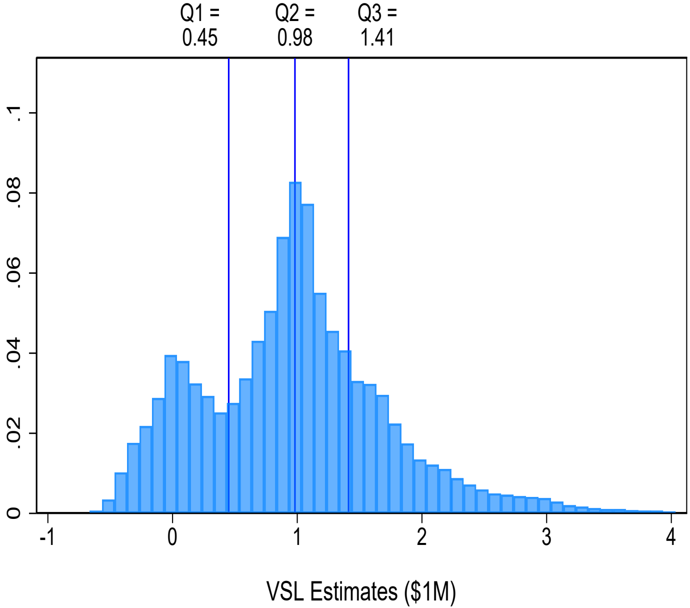
Zone A includes soldiers who have between 17 months and 6 years of service at time of reenlistment.

MOS/TITLE	SPC	SGT	SSG	CAP
11B Infantryman	1A	1.5A	1.5A	$15,000
13B Cannon Crew Member w/"P"	0	1A	0	$10,000
13F Fire Support Specialist	1.5A	2A	2A	$10,000
25U Signal Support Systems Spec.	1.5A	1.5A	0	$10,000
31B Military Police	1A	1.5A	1A	$10,000
68W Health Care Specialist	1A	1A	1A	$15,000
88M Motor Transport Operator	2A	1.5A	1A	$10,000
92Y Unit Supply Specialist	0.5A	0	0	$10,000
97E Interrogator	4A	4A	4A	$30,000

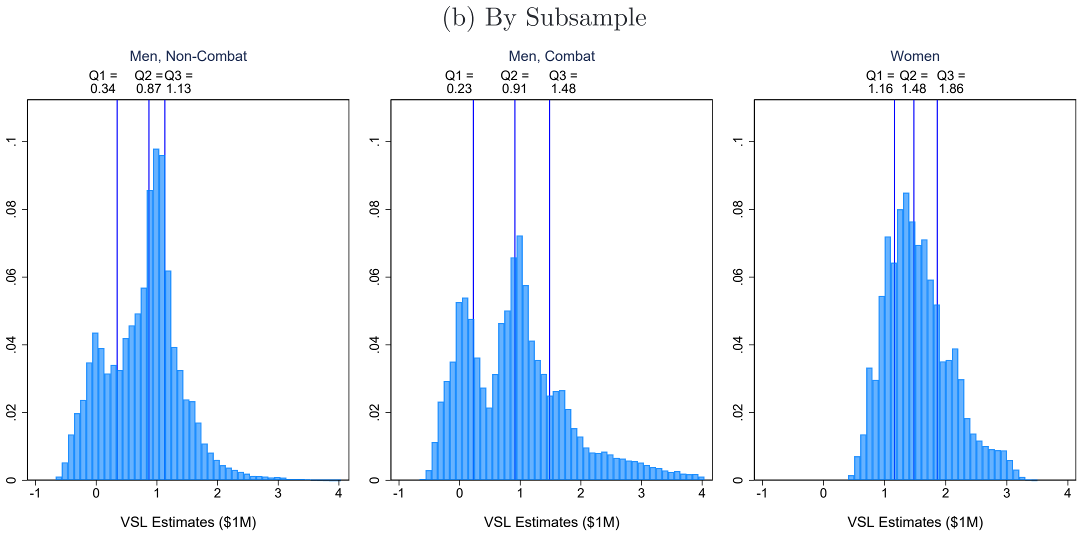
Table 1: Descriptive Statistics

	Full Sample (1)	Men, Non-Combat (2)	Men, Combat (3)	Women (4)
Panel A: Reenlistment Statistics				
Proportion Reenlisted	0.453	0.488	0.431	0.409
Bonus Offer ($ 2019)	7,198	6,890	8,164	5,727
Mortality Hazard (per 1000 soldiers)	5.43	3.25	8.92	2.96
Annual Deployment Probability	0.209	0.193	0.242	0.175

Main estimates: Implicit VSL of service members based on reenlistments



Implicit VSL of service members by gender and combat/non-combat



Implicit VSL for various demographic subgroups of soldiers