Lawrence Berkeley National Laboratory

Analyzing Casualty Risk using State Data on Police-Reported Crashes

Presentation at NHTSA's "Mass-Size-Safety Symposium"
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by

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Background

- Reducing mass is quick and inexpensive way to reduce CO_2…
- …but previous analyses indicate that lower mass increases risk
- NHTSA studies have estimated effect of weight reduction on risk
  - —fatality risk per vehicle registration-years and miles
  - —logistic regression analysis
    - controls for crash, vehicle and driver characteristics
    - coefficients on vehicle curbwt estimate how much fatality risk would have increased if weight reduced, all else being equal
  - —twelve different regression models
    - 6 types of crash (rollover, crash with obj, pedestrian, HDT, car, and LDT)
    - 2 vehicle types (cars, light trucks)
- Regression analysis is retrospective
  - —2003: MY91-99 in 1995 to 2000
  - —2011: MY00-07 in 2000 to 2008
  - —estimates the recent <u>historical</u> relationship between vehicle weight and/or size and risk
  - —can't <u>predict</u> this relationship with new technologies and/or vehicle redesign

LBNL's role in 2011 analysis

- Previous analyses of fatality risk
  - separated risk to drivers from risk to drivers of other vehicles
  - analyzed risk by vehicle type, make/model
- Hired by DOE, with guidance from EPA, to
  1. replicate NHTSA 2011 regression analysis of US fatality risk
     - advise NHTSA on data, variables, and methods
  2. conduct separate regression analysis of casualty (fatality + serious injury) risk in 13 states
     - will provide another perspective from NHTSA analysis
- Goal: how would changes in weight and size of contemporary vehicles have affected historical risk, all else being equal

Two methods to analyze relationship of vehicle weight/size on occupant safety

- NHTSA and DRI analyses (1998, 2003, 2005, 2010, 2011)
  - numerator: US fatalities, from FARS
  - denominator is induced exposure
    - not-at-fault vehicles in police-reported crashes in 13 states
    - crash data includes vehicle, driver, and crash variables
    - applies a weight to each vehicle in state crash data to scale up to national vehicle registrations
    - vehicle registration-years by state from RL Polk
    - vehicle miles driven by vehicle type from CarFax
  - US fatalities per million vehicle registration-years (miles)
- LBNL analysis (2010, 2011)
  - all data from police-reported crashes in 13 states
  - numerator: fatalities or casualties (fatalities + serious injuries)
  - denominator: all vehicles, or not-at-fault vehicles, in state crash data
    - use Polk data for risk per vehicle registration-years
  - state fatalities/casualties per crash-involved vehicle, or per million vehicle registration years (miles)

Similarities in NHTSA and LBNL approaches

- Both analyses will use multiple logistic regression to estimate effect of vehicle weight/size on risk
  - estimates likelihood that a specific crash resulted in fatality or casualty
  - can control for vehicle, driver (age, gender, etc.), and crash (urban/rural, night, wet, icy, speed limit, etc.) characteristics
- Both will use same database of vehicle characteristics
  - make/model, body type, curb weight, footprint, airbags, ABS, ESC, etc.
- Both will estimate effect of vehicle weight/size on risk per vehicle registration-years (miles), to be input into Volpe model

Differences between NHTSA and LBNL approaches

- Benefits of LBNL approach
  - all data from same source (13 state crash data)
    - removes any bias introduced by NHTSA procedure to scale state crash data to national vehicle registrations
  - estimates effect of weight/size on serious injuries and fatalities
  - risk per crash-involved vehicle and per registered vehicle separates effect on vehicle crash avoidance from vehicle crashworthiness (risk once a crash occurs)
- Drawbacks of LBNL approach
  - limited to 13 states that provide VIN
    - does the relationship between vehicle weight/size and risk vary by state?
    - are 13 states representative of national risk?
  - may not be enough fatalities in 13 states to get robust results for fatality risk

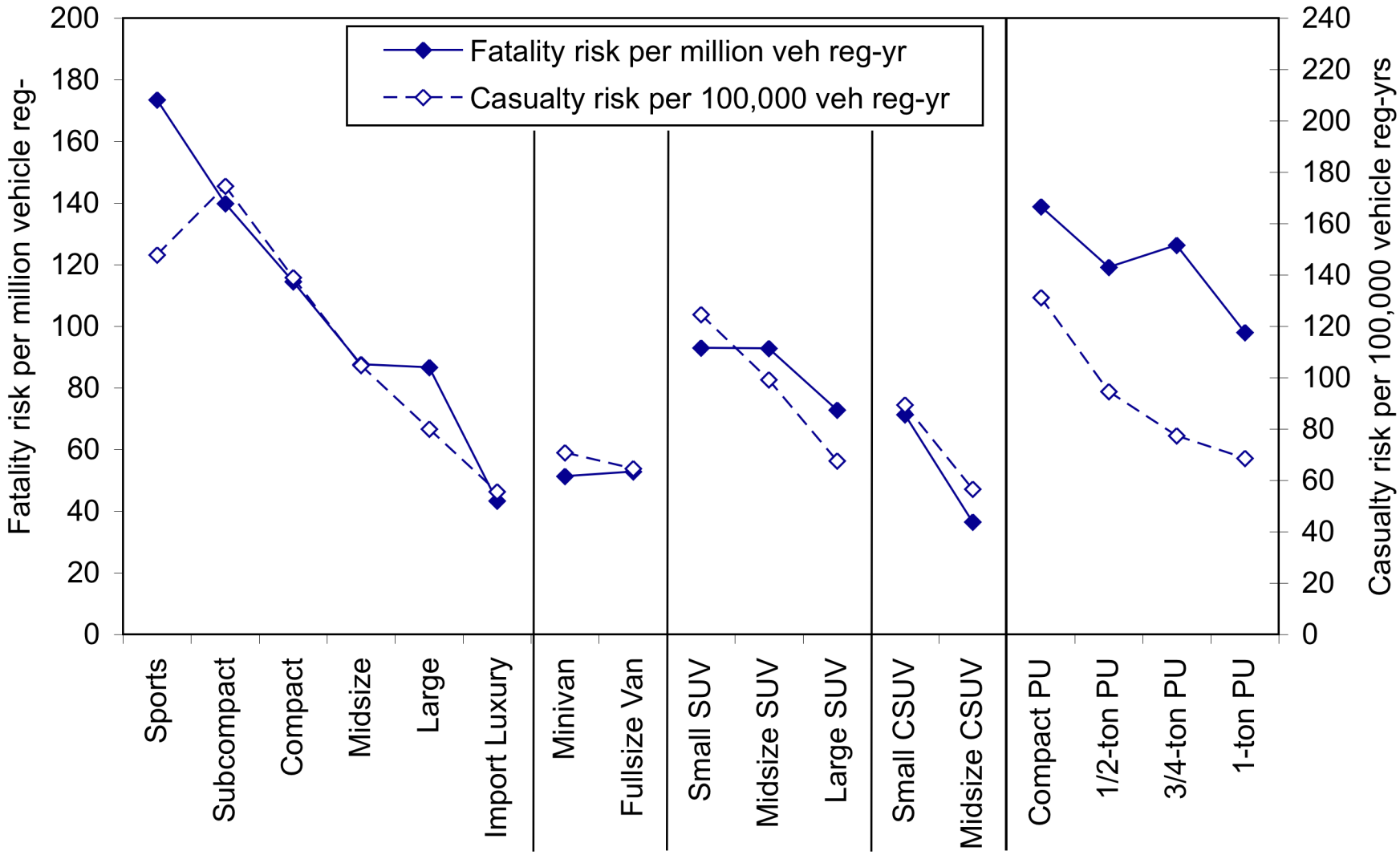
Analysis of different measures of risk, by vehicle make/model

- Gain insight into relative risk by vehicle type for different measures of risk
- LBNL compared the different types of risk, by vehicle make/model
  - model years 2000 to 2004
  - 2000-05 crash data from 5 states (FL, IL, MD, MO, PA)
  - 2005 Polk registration data for each state, by county
- Analyzed these issues
  - fatality vs. casualty risk
  - risk per vehicle registration-year vs. risk per crash
  - importance of miles driven
  - national vs. selected states
  - sample bias in state crash data
  - control variables for regression models

Fatality vs. casualty risk per-vehicle

- Per vehicle registration-year, fatality risk by vehicle type is very similar to casualty risk
  - sports cars and pickups have relatively higher fatality risk than casualty risk
- All risks shown here are risk to drivers only, in subject vehicle; risk to other road users not included

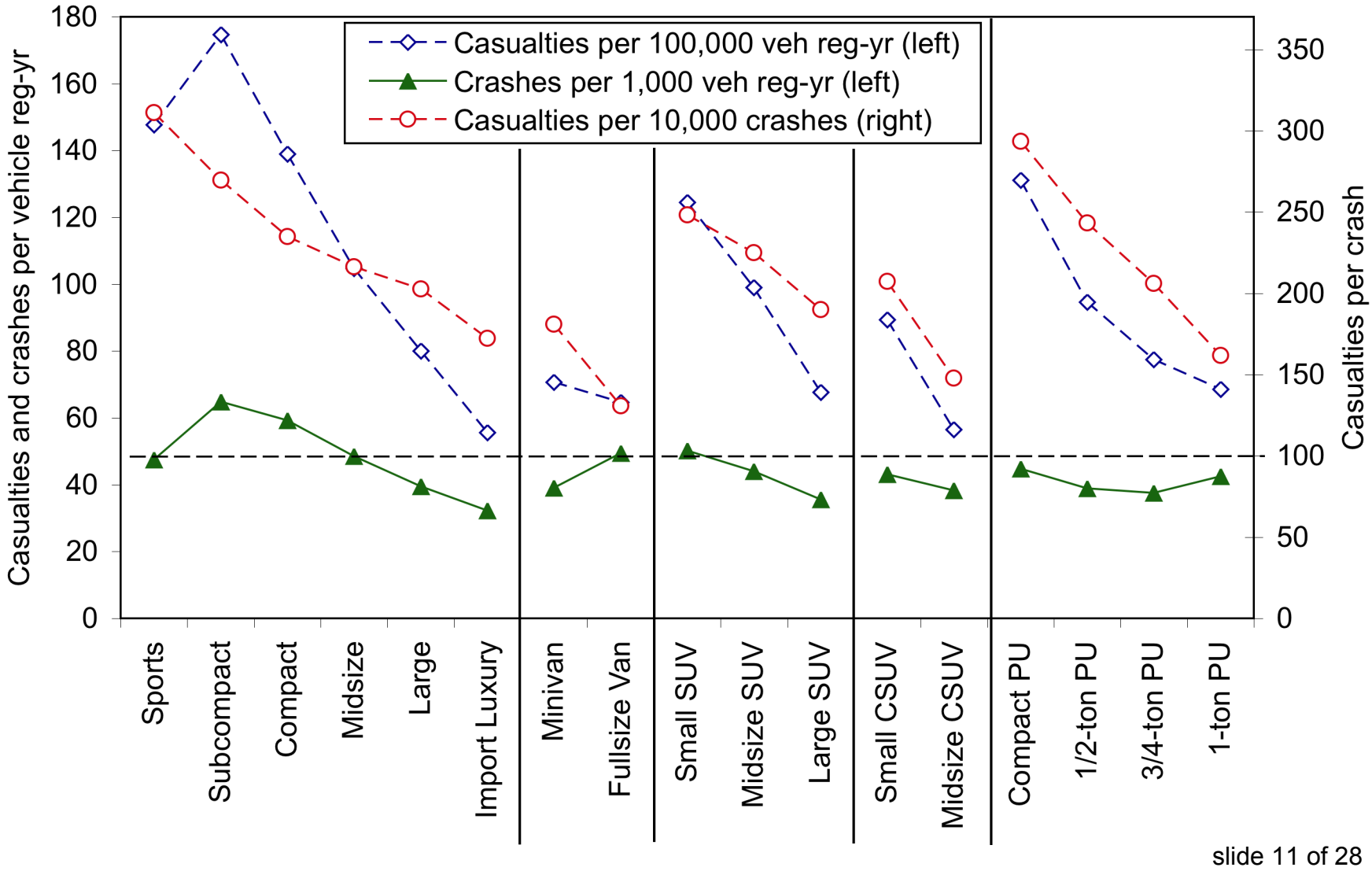
Fatality and casualty risks per vehicle, five states



Casualty risk per-vehicle vs. per-crash

- Casualty risk per vehicle registration-year is similar to casualty risk per crash, by vehicle type
  - —vehicle types with the same crash rates as midsize cars (sports cars, fullsize vans, and small SUVs) have the similar casualty risk per-vehicle and per-crash
  - —vehicle types with relatively high crash rates (subcompact and compact cars) have higher casualty risk per vehicle than per crash
  - —vehicle types with relatively low crash rates (large and import luxury cars, minivans, large SUVs, crossover SUVs, and pickups) have lower casualty risk per vehicle than per crash

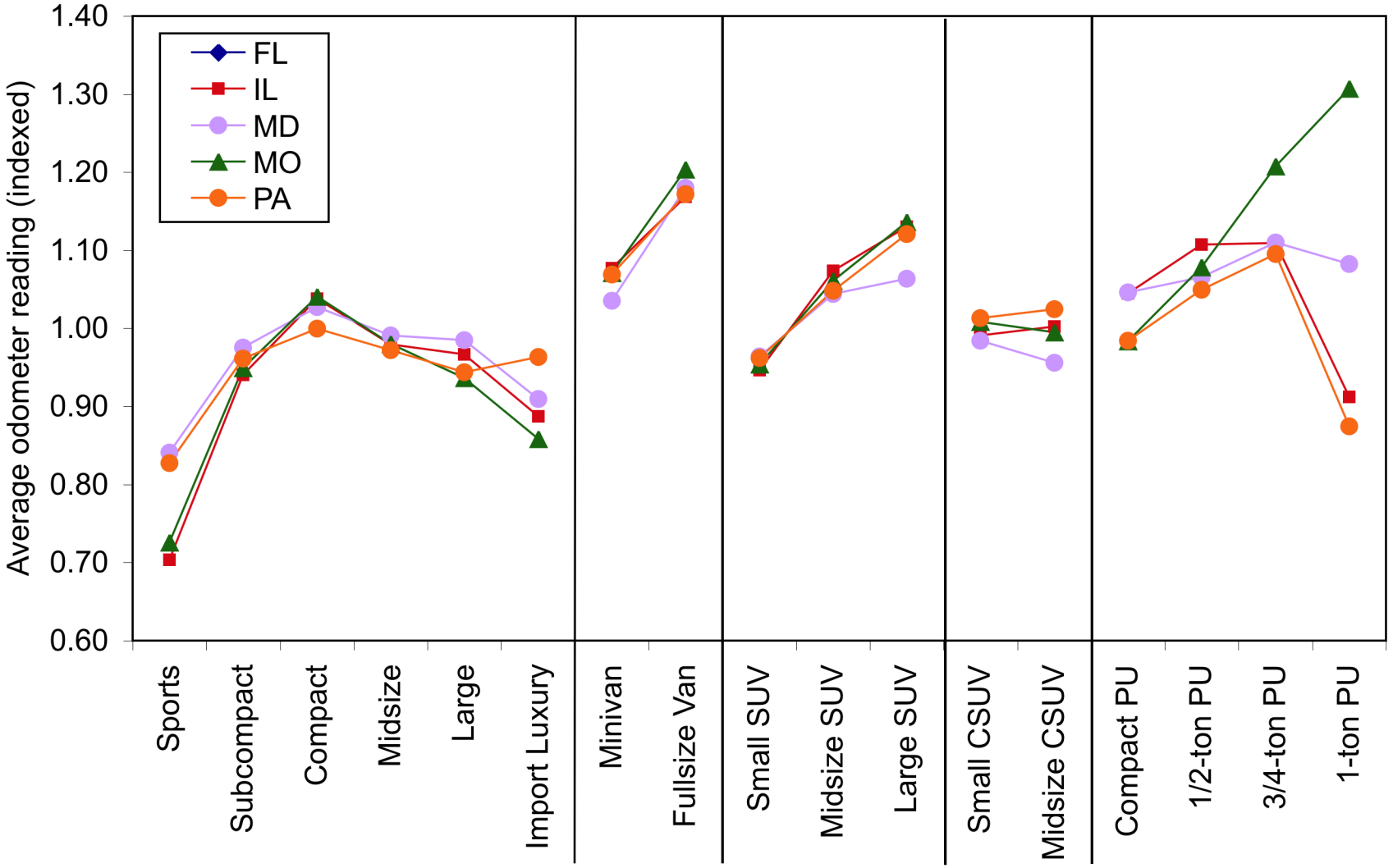
Casualty risks per vehicle and per crash, five states



Importance of miles driven in risk per vehicle

- To assess importance of miles driven, LBNL acquired vehicle odometer readings from 9 emissions inspection/maintenance (I/M) programs (IL, MD, MO, PA, as well as CA, CO, OH, TX, WI)
- Analyzed average odometer reading in 2002
  - relative miles driven by vehicle type are very similar across states (except large pickups in MO)
  - sports cars have lower VMT than other cars
  - minivans, fullsize vans, and large SUVs have higher VMT than cars

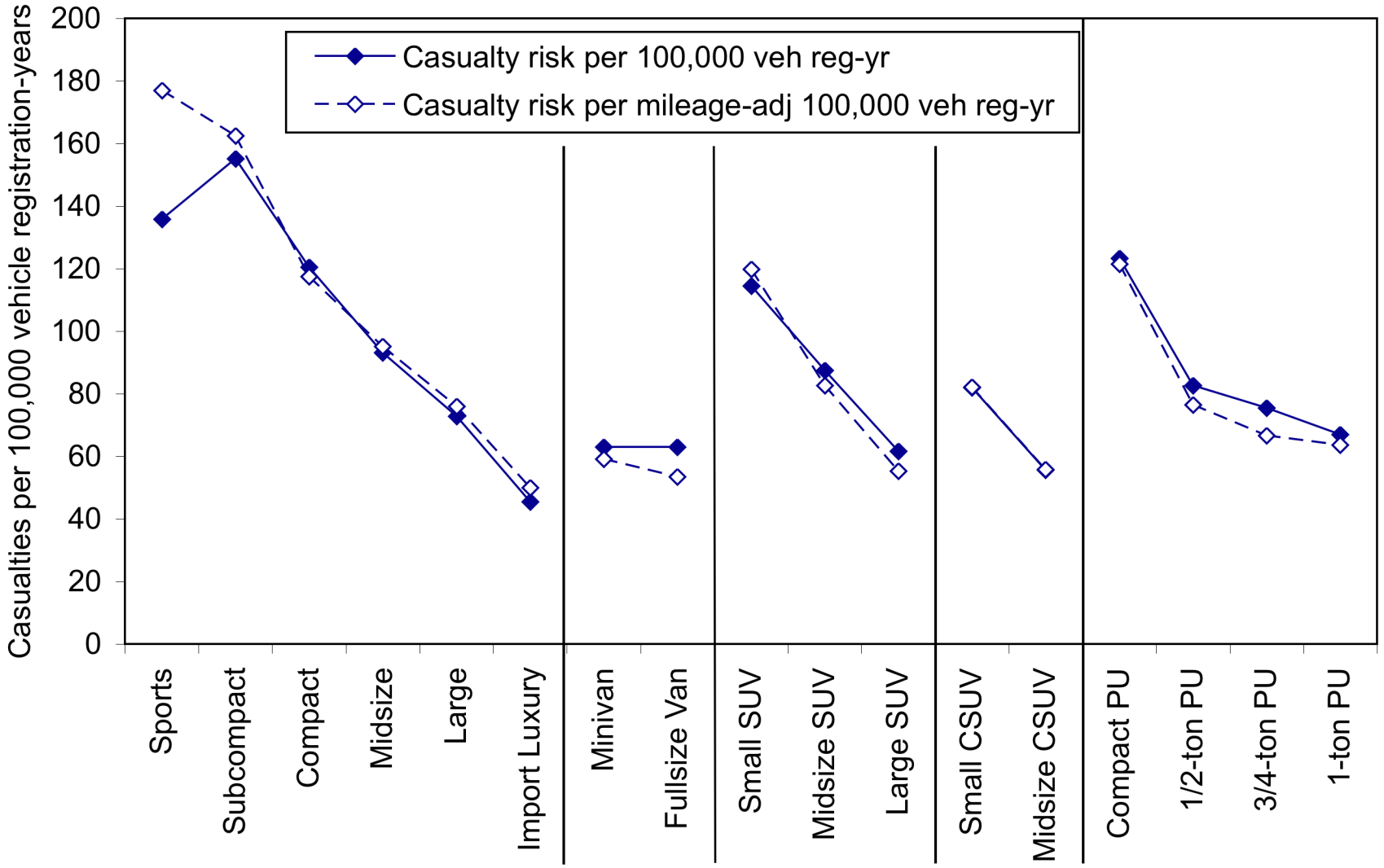
Relative miles driven by vehicle type very similar across states



Importance of miles driven in risk per vehicle

- Accounting for differences in miles driven by vehicle type has little impact on casualty risk per vehicle registration-year
  - —exception: sports cars have higher risk after accounting for their low VMT

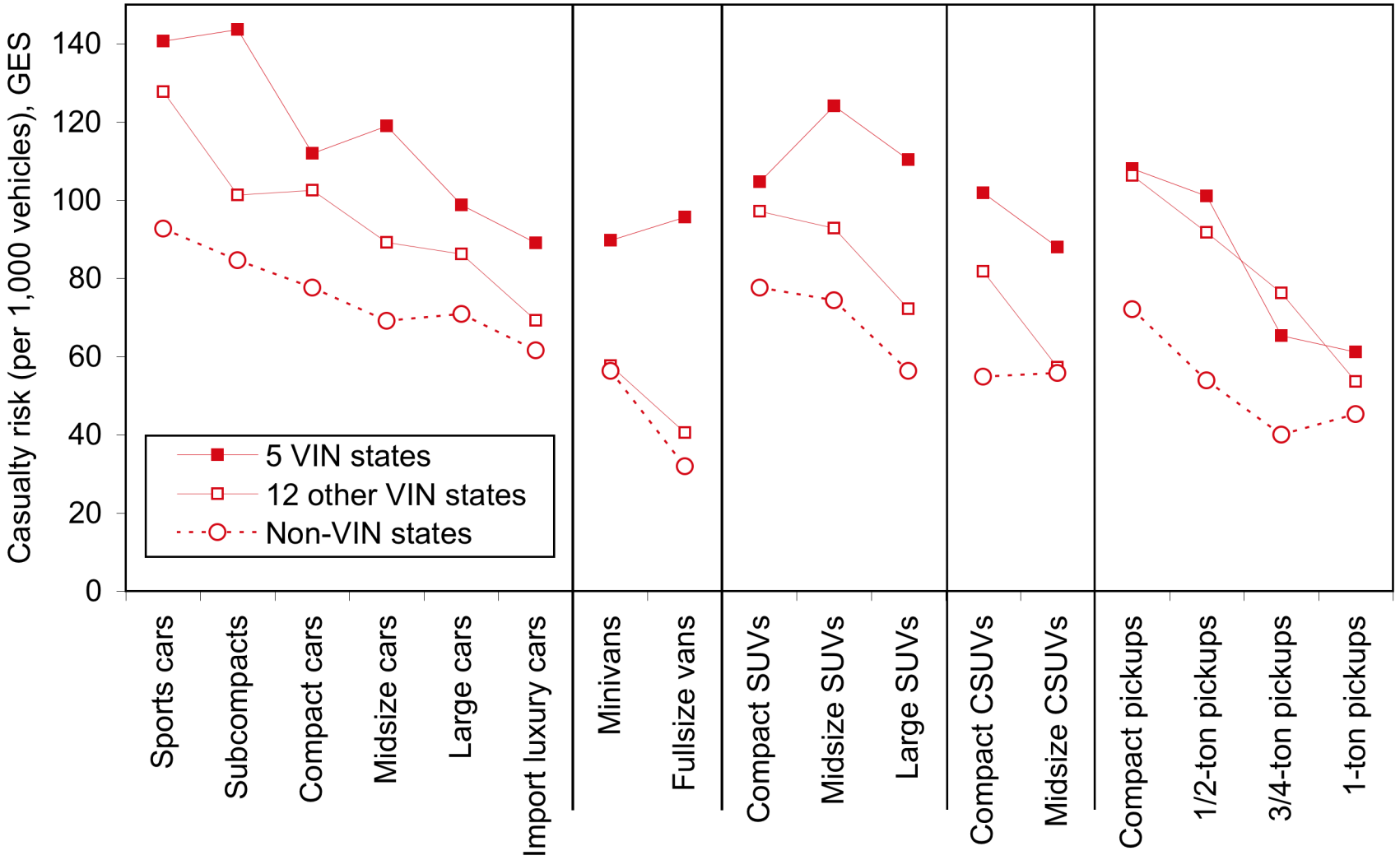
Accounting for vehicle mileage has little effect on casualty risk per vehicle



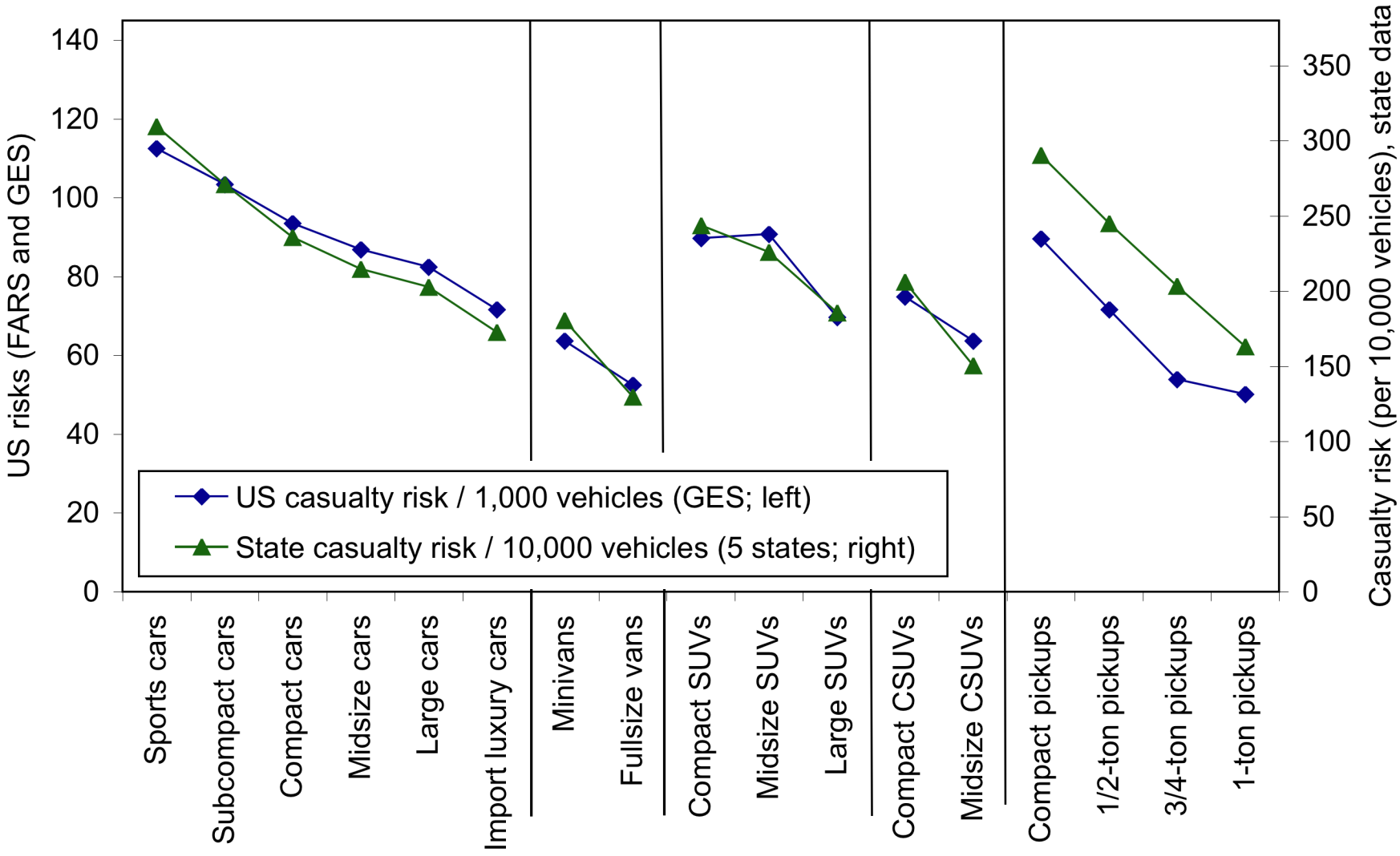
National risk vs. risk in selected states

- Only 17 states in NHTSA State Data System report VIN, which is needed to determine MY, make and model
- GES is a national sample of police-reported crashes
  - for all vehicle types, casualty risk per crash is higher in the 17 VIN states than in the non-VIN states
  - using only 17 VIN states may overstate national casualty risk, but likely not misrepresent relative national casualty risk by vehicle type
- Casualty risk using data from 5 states (in green) is almost identical to national GES casualty risk (in blue)
  - except for pickups, which have higher risk in data from 5 states than in national GES data

Casualty risk in VIN states slightly higher than nationally (GES)



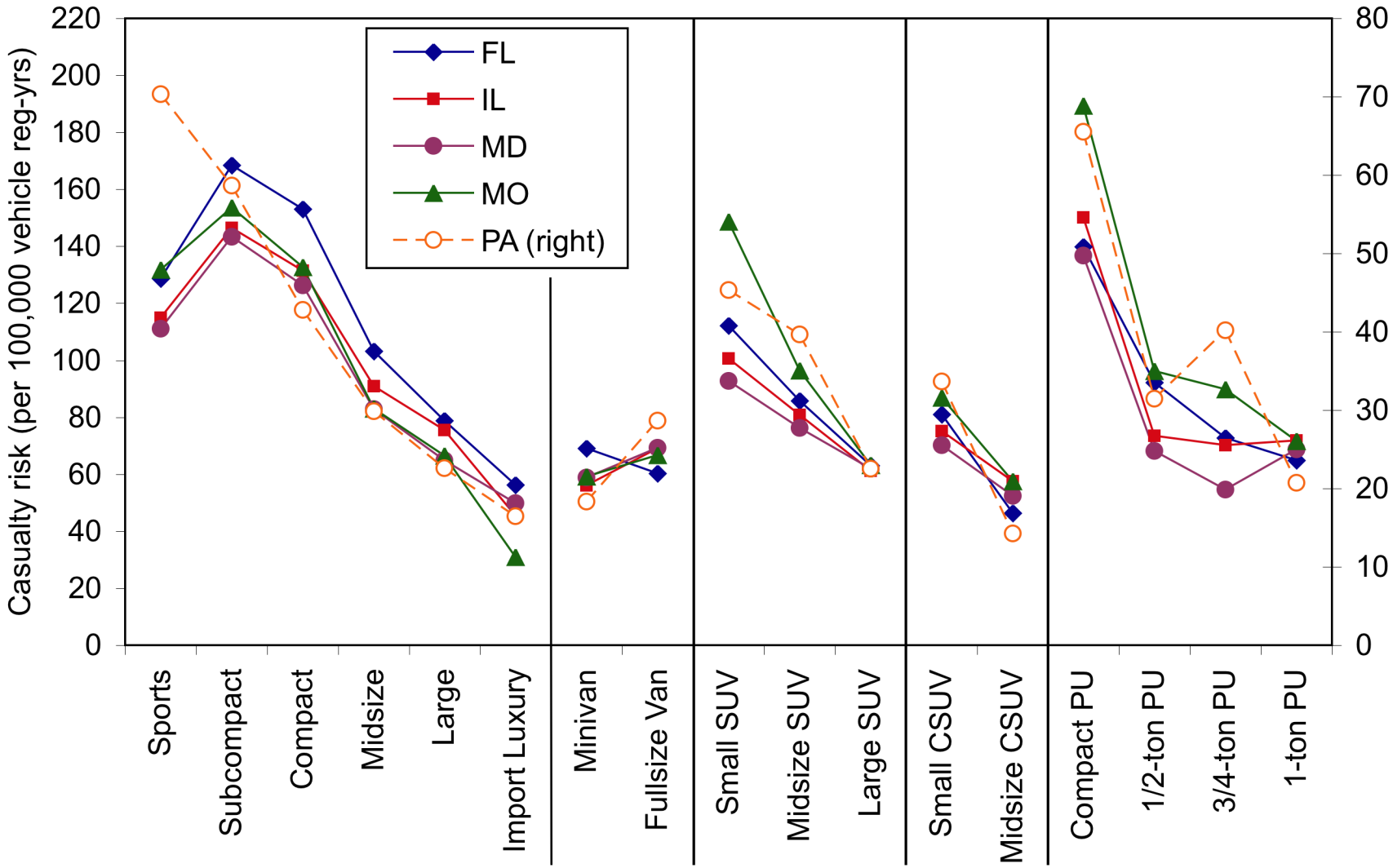
Casualty risk in 5 states similar to national GES casualty risk (except pickups)



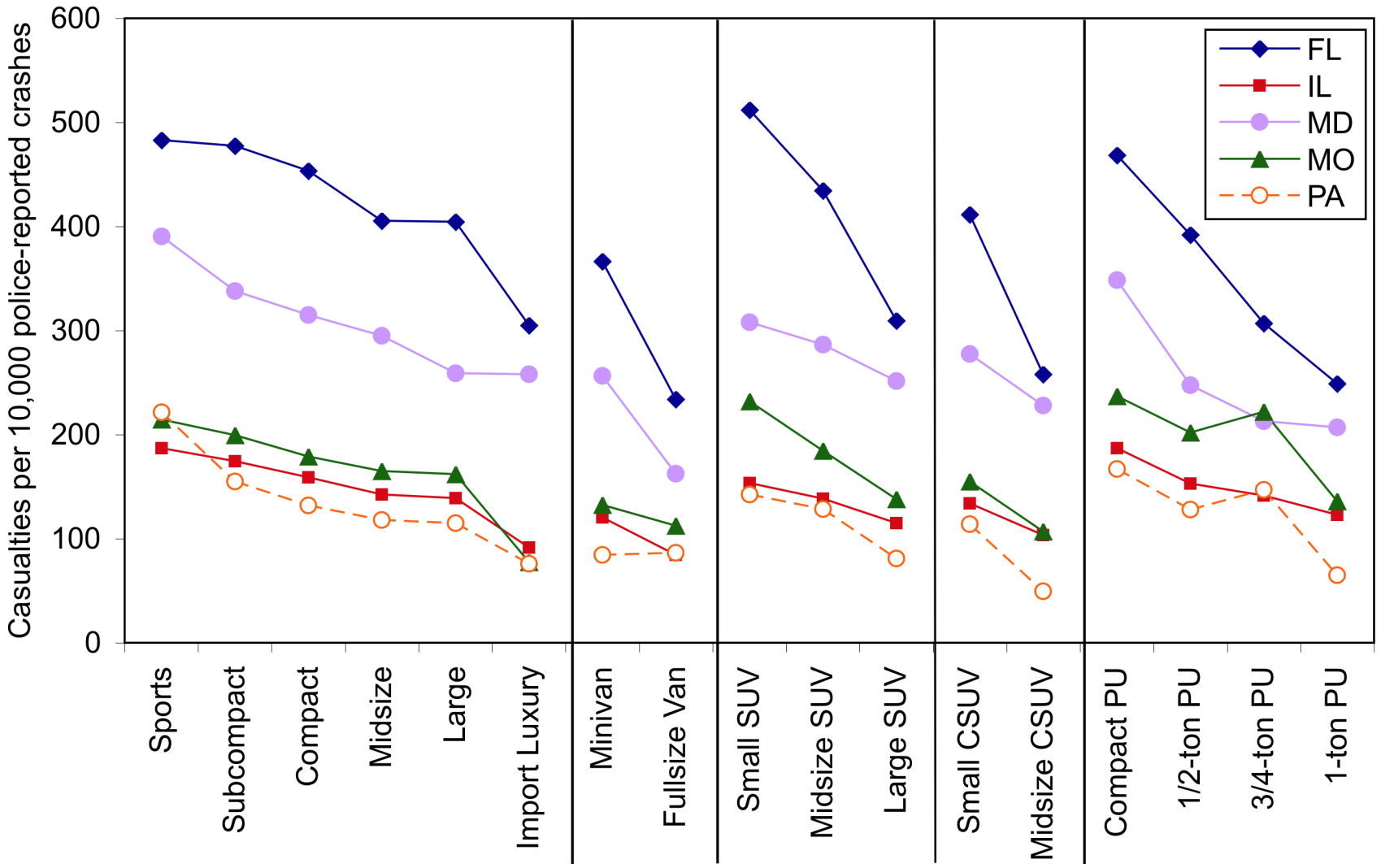
Sample bias in state crash data

- States have different requirements for reporting crashes, often based on a $ damage threshhold
  - as a result, non-injury crashes under-reported by some states
- Absolute casualty risk per vehicle registration-year, by vehicle type, are very similar in 4 states
  - PA has another category, “moderate injuries”, not included here
  - trends by vehicle type nearly identical
- However casualty risk per crash varies greatly
  - FL and MD much higher than other states, even in urban counties only
- Most of the difference is removed after normalizing risk per crash to that for midsize cars in each state
  - small differences remain, particularly for sports cars, small SUVs, and pickups

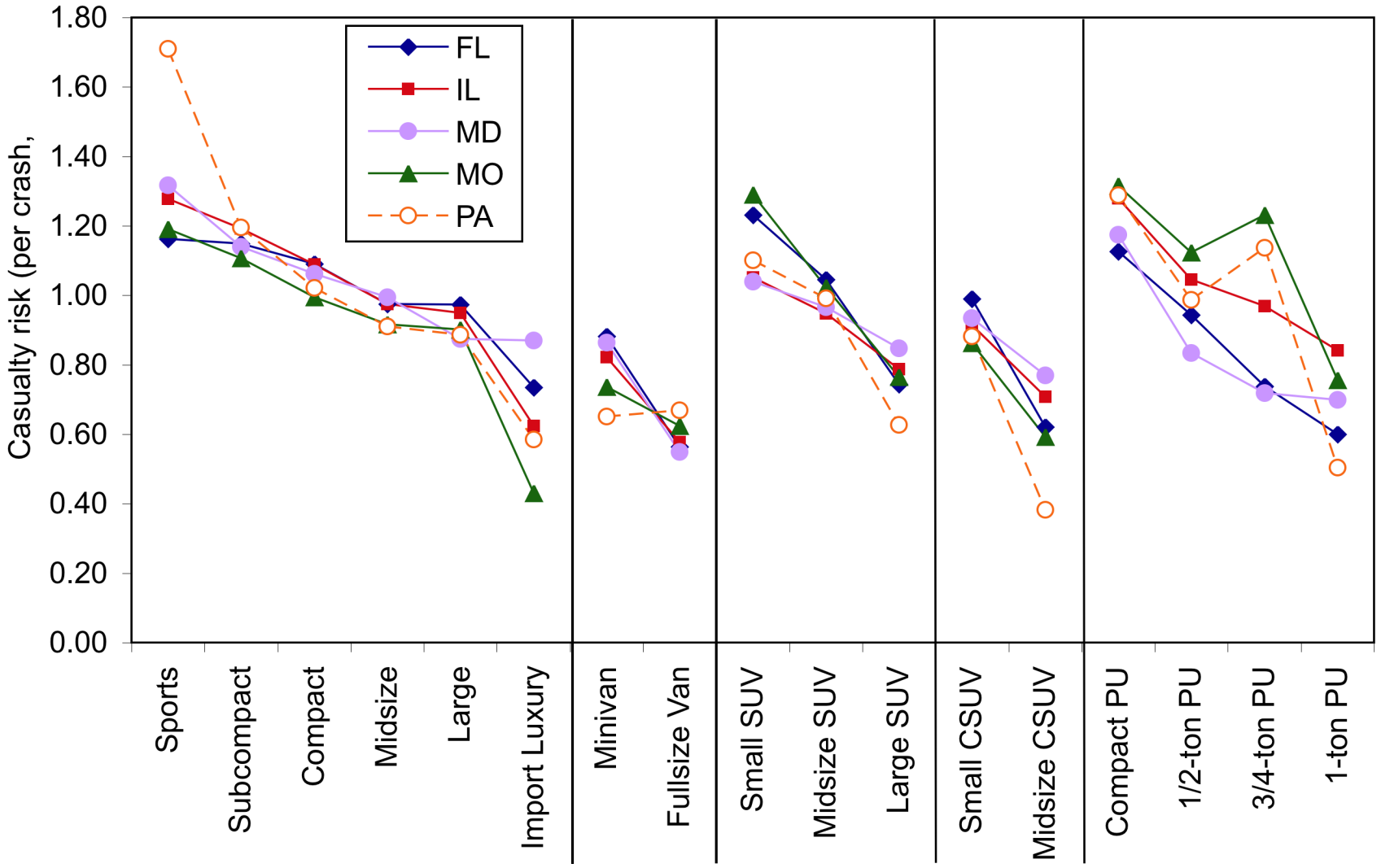
Casualty risk per vehicle is similar in 5 states (except PA)…



… however casualty risk per crash is much higher in FL and MD



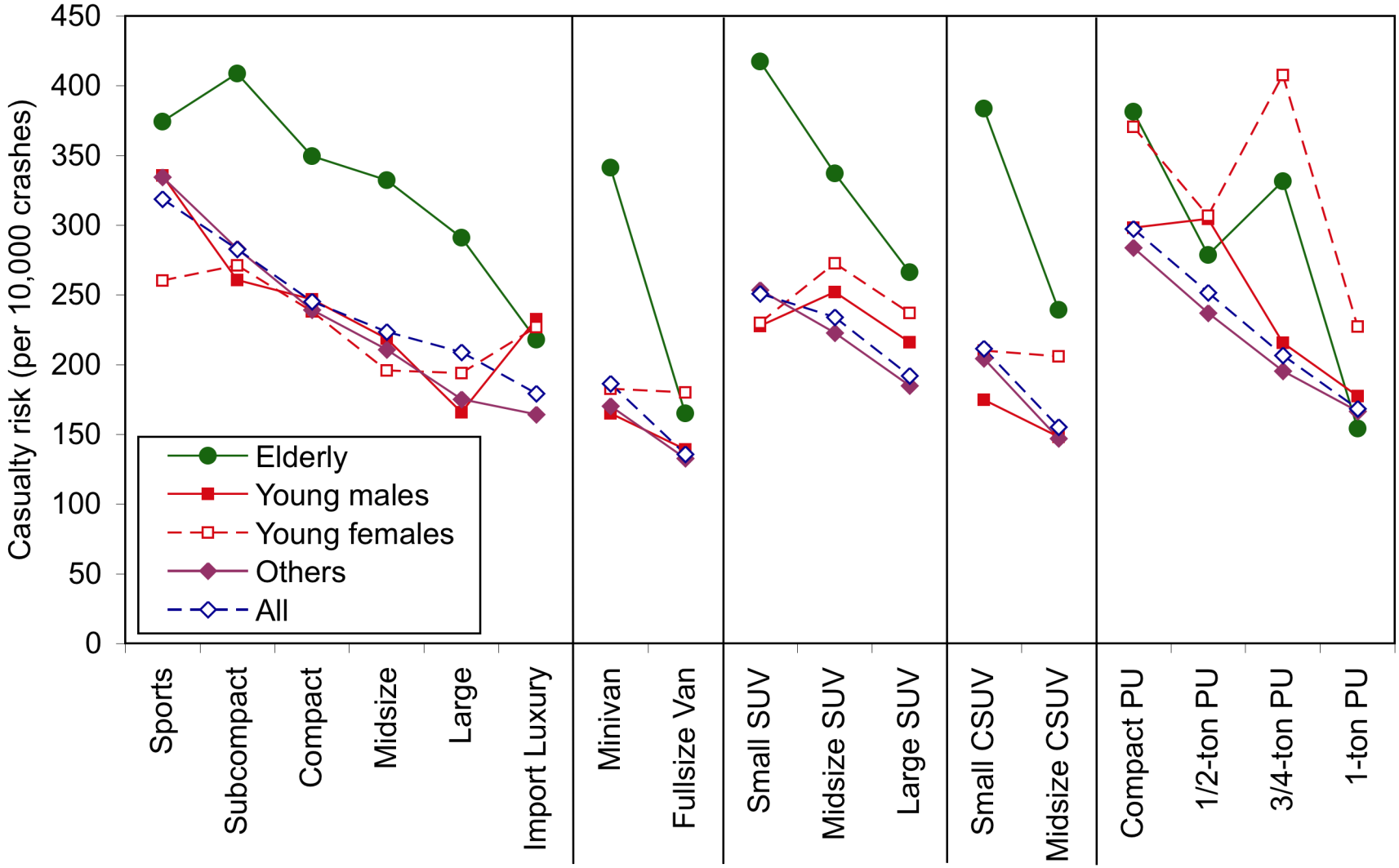
Casualty risk per crash indexed to risk for midsize cars in each state



Controlling for driver characteristics

- NHTSA 2003 controlled for drivers that exhibit high risk (i.e. young males)
- However, casualty risk per crash already accounts for vehicles and drivers that have higher crash rates
  - reduces relative risk for vehicles with higher crash rates (subcompact and compact cars)
- Given a crash, elderly (and in some cases women) have higher casualty risk because of their frailty, and not their behavior
- In regression models estimating casualty risk per crash:
  - not necessary to control for young male drivers
  - necessary to control for elderly and female drivers because of their frailty

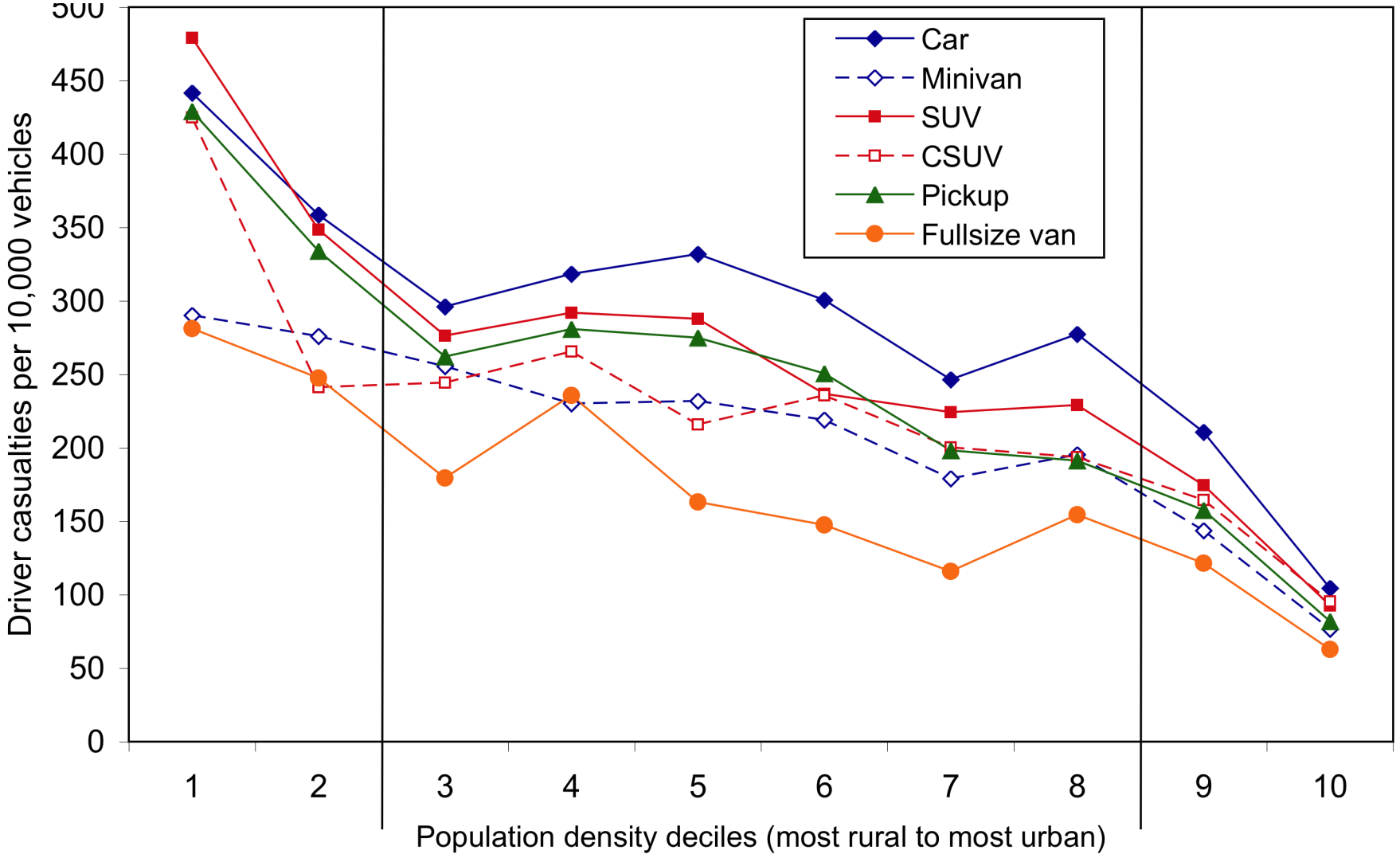
Casualty risk per crash similar for all drivers except the elderly (and in some cases young women)



Controlling for crash location

- Risk per crash is higher in rural counties than in urban counties
  - —for all vehicle types
  - —many pickups driven in rural areas increases their risk per crash
- Regression models estimating casualty risk per crash must control for the population density of the county in which the crash occurs

Casualty risks are highest in rural counties (with low population density)



Conclusions

- No single measure of risk; alternative measures (fatality vs. casualty, per vehicle vs. per crash) give more complete perspective
- NHTSA and LBNL approaches will use same data and methods as much as possible
- Casualty risks per vehicle are quite similar to fatality risks per vehicle; however casualty risks are substantially lower than fatality risks for sports cars and pickups
- Vehicle types with high crash rates (subcompact and compact cars) have higher casualty risk per vehicle than per crash; vehicle types with low crash rates (large and import luxury cars, minivans, large SUVs, crossover SUVs, and pickups) have lower casualty risk per vehicle than per crash

Conclusions (cont.)

- Accounting for miles driven by vehicle model has only a small effect on risk per vehicle, except for sports cars that are driven relatively few miles
- Based on analysis of national crash data (GES), casualty risk per crash is higher in the 17 SDS VIN states than in the non-VIN states, for all vehicle types; therefore using only SDS VIN states may overstate national casualty risk
- Casualty risk per crash in 5 states comparable to national GES risks for most vehicle types, but higher for pickups
- Control variables in regression models estimating casualty risk per crash
  - must control for sample bias in state crash data by including dummy variables for each state
  - must control for driver age/gender, but not necessarily young males
  - must control for location of crash (urban v. rural)