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Relationship between US Societal Fatality Risk per Vehicle Miles of Travel and Mass, for Individual Vehicle Models over Time (Model Year)

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DISCLAIMER

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Executive Summary

This report presents a new approach to analyze the relationship between vehicle mass and risk: tracking fatality risk by vehicle model year and mass, for individual vehicle models. This approach is appealing as it greatly minimizes the influence of driver characteristics and behavior, and crash circumstances, on fatality risk. However, only the most popular vehicle models, with the largest number of fatalities, can be analyzed in this manner. While the analysis of all vehicle models of a given type suggests that there is a relationship between increased mass and fatality risk, analysis of the ten most popular four-door car models separately suggests that this relationship is weak: in many cases when the mass of a specific vehicle model is increased societal fatality risk is unchanged or even increases. These results suggest that increasing the mass of an individual vehicle model does not necessarily lead to decreased societal fatality risk.

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1. Introduction

Lawrence Berkeley National Laboratory (LBNL) has demonstrated that societal fatality risk per vehicle miles of travel (VMT) can vary substantially by vehicle model (Wenzel 2016). One possible cause of this wide range in fatality risk by model is the characteristics and behavior of the drivers who chose to purchase and drive certain vehicles. The National Highway Traffic Safety Administration (NHTSA) recognized this potential bias in its baseline regression models, and excluded certain vehicle types (muscle, police, and AWD cars) from its analysis to reduce the extent to which driver behavior may bias the regression results (Puckett and Kindelberger 2016). However, there may be additional subtle differences in the behaviors of drivers by vehicle model that may bias the regression estimates of the relationship between vehicle mass and fatality risk.

This report presents a new approach to analyze the relationship between vehicle mass and risk: tracking fatality risk by vehicle model year and mass, for individual vehicle models. This approach is appealing as it greatly minimizes the influence of driver characteristics and behavior, and crash circumstances, on fatality risk, by analyzing particular vehicle models over time, under the assumption that the types of drivers that choose specific vehicle models do not change substantially over time. However, only the most popular vehicle models, with the largest number of fatalities, can be analyzed in this manner.

2. Approach and Results

We track US societal fatality risk per vehicle miles of travel (VMT) and mass by model year for individual vehicle models, by plotting the risk and mass for a particular model by model year (model years 2001 through 2010). Figure 1 shows an idealized version of such a plot, assuming that a large reduction in risk accompanies a large increase in mass, in the even model years, and small reductions in risk occur in odd model years while mass is unchanged.

One benefit of this approach is that driver characteristics or crash circumstances of a particular vehicle model are not likely to change substantially from model year to model year. We can measure, and account for, the fraction of risky male or young drivers, or fragile old drivers, in vehicle models; however, we cannot account for more subtle differences in who owns particular models, and their driving behavior. By analyzing each model independently, we hope to minimize the effect of poor or risky drivers selecting certain vehicle models.

A drawback of this approach is that when a model is refreshed or redesigned, other design changes are likely to be made, such as addition of safety features or an increase in size, in addition to an increase in mass. In addition there is a general trend towards reduced risk over time (as indicated by the calendar year variables in NHTSA's regression analysis), and a general trend towards increased risk as vehicles age. The effect of vehicle age can be removed by only including vehicles of a given age, such as two years old. However, this dramatically reduces the sample size, and increases the uncertainty of the risks for a particular model in a given model year.

Figure 2 shows the trend in risk by model year, for the seven major vehicle types, for model years 2000 to 2007 in calendar years 2002 through 2008. For most vehicle types, average mass increases in each model year, accompanied by a reduction in risk; SUVs exhibit the most consistent trend, consistent with the theory that each increase in mass results in a reduction in risk.

Figure 1. Stylized trend in US societal fatality risk per VMT vs. mass over time (by model year)

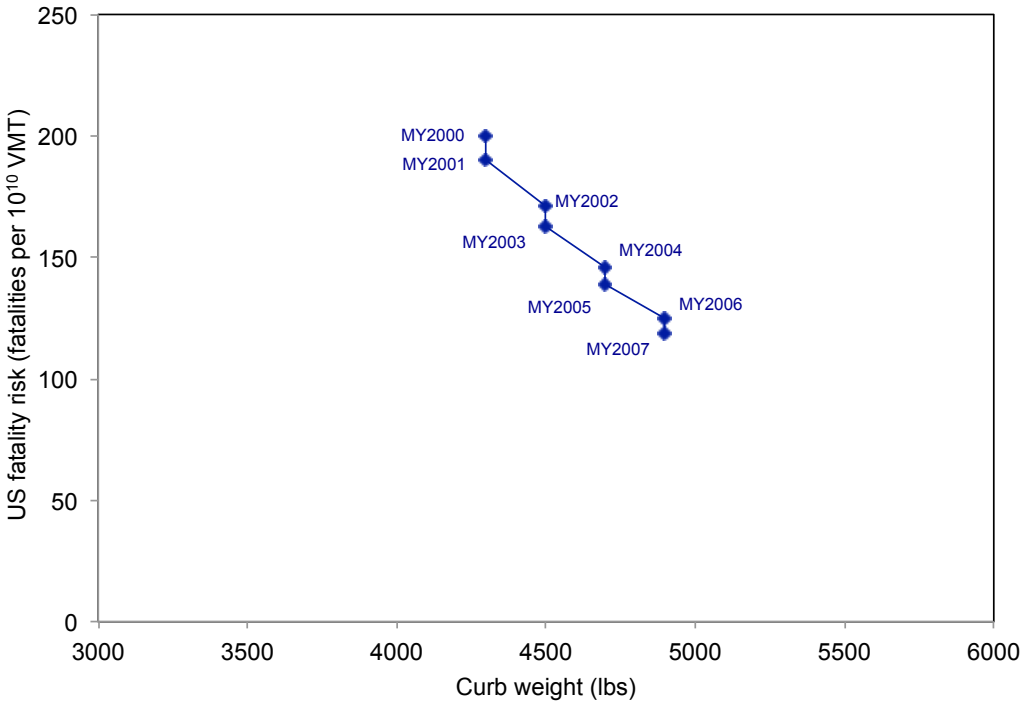


Figure 2. Trend in US societal fatality risk per VMT vs. mass over time (by model year), by vehicle type

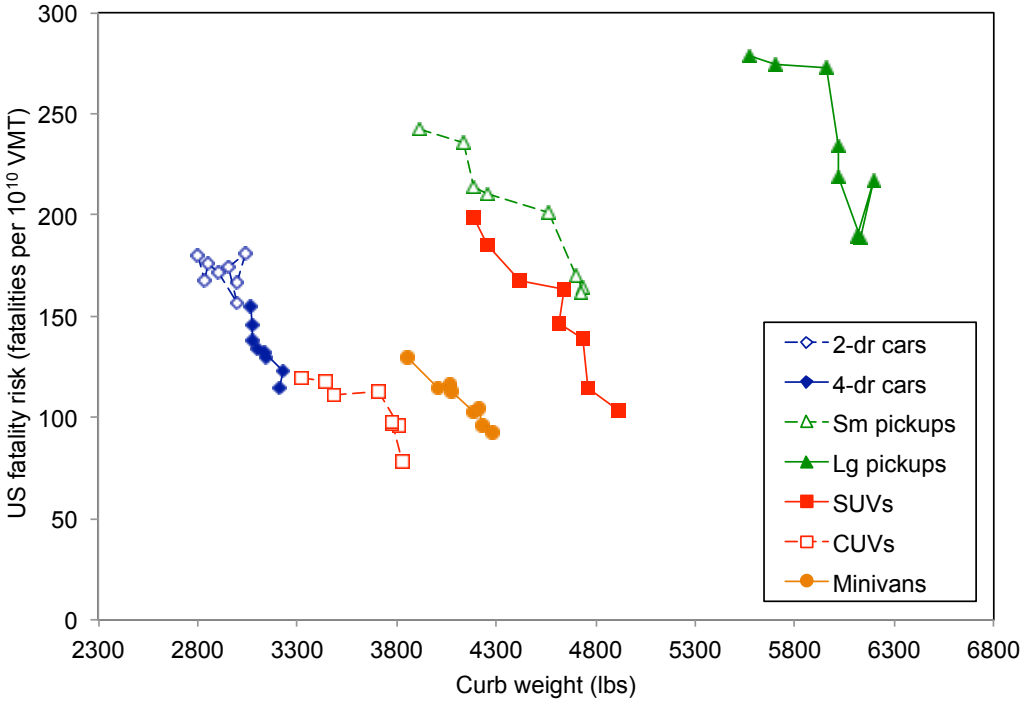


Table 1 shows the number of societal fatalities by model year, and Table 2 the societal fatality risk per 10 billion VMT, for the ten most-popular 4-door car models from model years 2000 to 2007 from calendar years 2002 to 2008. Societal fatalities include fatalities to occupants in each of the ten models, as well as any fatalities in vehicles with which the model crashed. No fatalities were recorded in MY06 or newer Dodge Neons and Chevrolet Cavaliers because these models were discontinued after MY05.

Table 1. Number of societal fatalities by vehicle model year, for ten most-popular 4-door sedans

	Societal fatalities, by model year							
Model	2000	2001	2002	2003	2004	2005	2006	2007
Dodge Neon	338	218	228	266	231	222	—	—
Ford Taurus	449	482	441	358	187	162	87	48
Ford Focus	312	316	291	288	108	201	88	105
Chev Cavalier	274	232	296	213	154	80	—	—
Chev Malibu	345	301	226	229	255	288	134	54
Nissan Altima	185	202	262	230	66	269	132	62
Honda Civic	252	240	224	198	158	119	89	45
Honda Accord	309	330	331	268	214	140	92	86
Toyota Corolla	208	239	164	301	212	233	171	77
Toyota Camry	390	327	400	299	208	228	66	150

Table 2. Societal fatality risk per 10 billion VMT by vehicle model year, for ten most-popular 4-door sedans

Model	Societal fatality risk per 10 billion VMT, by model year							
	2000	2001	2002	2003	2004	2005	2006	2007
Dodge Neon	212	219	197	237	261	263	—	—
Ford Taurus	141	139	139	122	116	112	99	101
Ford Focus	135	159	143	171	172	172	173	197
Chev Cavalier	245	209	208	198	152	198	—	—
Chev Malibu	180	172	164	153	153	157	167	133
Nissan Altima	143	155	131	118	89	124	115	121
Honda Civic	154	122	127	138	140	128	108	87
Honda Accord	105	123	113	106	113	95	88	94
Toyota Corolla	138	129	128	124	129	136	146	93
Toyota Camry	136	140	122	118	121	124	83	89

Figure 3 shows the trend in risk from (Table 2) and mass by model year for the ten models. In contrast to the trends by vehicle type shown in Figure 2, none of the models shows a consistent reduction in risk as mass increases. The Honda Civic and Accord show a reduction in risk with a mass increase in only three of the seven model years; Malibu and Corolla show a reduction in risk with mass increase in only two of the seven model years; and the remaining models show a risk reduction accompanied by a mass increase in only one model year. The Ford Taurus (blue circles) actually shows a consistent increase in risk as mass increases slightly with each successive model year; a possible cause of this risk increase may be the fraction of Taurus with ABS installed, which fell from over 70% in MY04 to 50% in MY05, 35% in MY06, and only 10% in MY07. The Ford Focus (blue triangles) also shows increases in risk in nearly all model years; this is particularly surprising as the fraction of Focus with side airbags installed increased from under 10% in MY05 to 35% in MY06 and 49% in MY07.

The Honda Civic provides another interesting example (green triangles). The Civic shows a large (240 lb) increase in mass between MY05 and MY06, accompanied by a 15% reduction in risk. Several changes were made to the MY06 Civic: ABS and side airbags became standard, and the Advanced Compatibility Engineering (ACE) body structure was introduced on all versions of the Civic in that model year. These changes likely accounted for much of the additional mass added to the Civic in MY06. The Civic's average footprint was also increased by nearly 2.6 square feet in MY06. However, note that the Civic's risk declined another 19% in MY07, despite very few design changes made in that year (a 35-lb increase in average mass but no change in average footprint); this may be partly caused by the general decline in risk for all vehicles in calendar year 2008 (Wenzel 2012). The trends shown in Figure 3 are similar if we consider fatalities in the case vehicle only, and do not consider fatalities in any crash partners, as shown in Figure 4.

Figure 5 compares the ten most-popular four-door car models in Figures 3 averaged together, with those for all four-door cars from Figure 2. Collectively, the ten most-popular models follow the expected trend, with mass increases in a given model year for the most part corresponding to a reduction in fatality risk.

Figure 6 updates Figure 2, by overlaying the data for model year 2003 to 2010 vehicles in calendar years 2005 to 2011 on top of the earlier data.

Figure 7 updates Figure 3 using data on model year 2003 to 2010 vehicles in calendar years 2005 to 2011. All Honda Accords received the ACE structure in MY08, which explains the large increase in mass and reduction in societal fatality risk in that year as indicated in the figure, comparable to the trend for MY06 Civics. Figure 7 also indicates that the Chevy Malibu also increased mass and reduced societal fatality risk in MY08. In addition to a 150-pound increase in mass, the footprint of the MY08 Malibu increased by two inches, and ABS, ESC, and side airbags became standard features. Note that the MY09 Malibu also experienced a large reduction in fatality risk, while its mass was essentially unchanged.

Figure 3. Trend in US societal fatality risk per VMT vs. mass over time (by model year), for 10 most-popular four-door car models

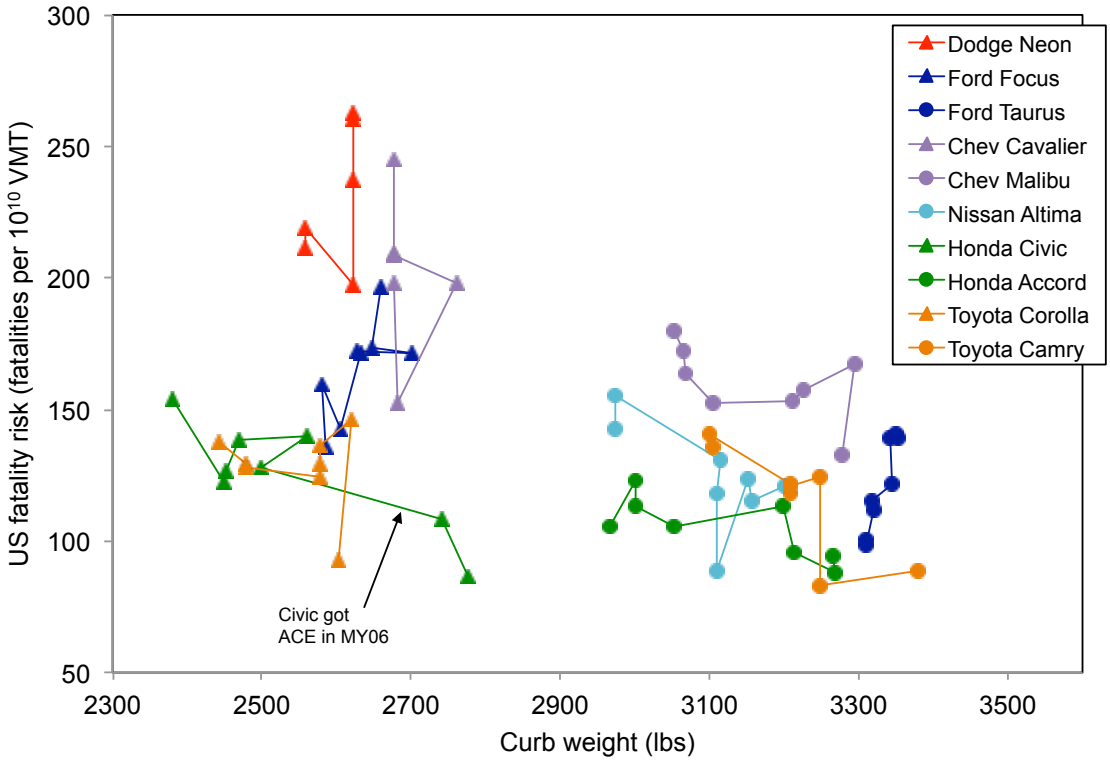


Figure 4. Trend in US fatality risk per VMT in case vehicle only vs. mass over time (by model year), for 10 most-popular four-door car models

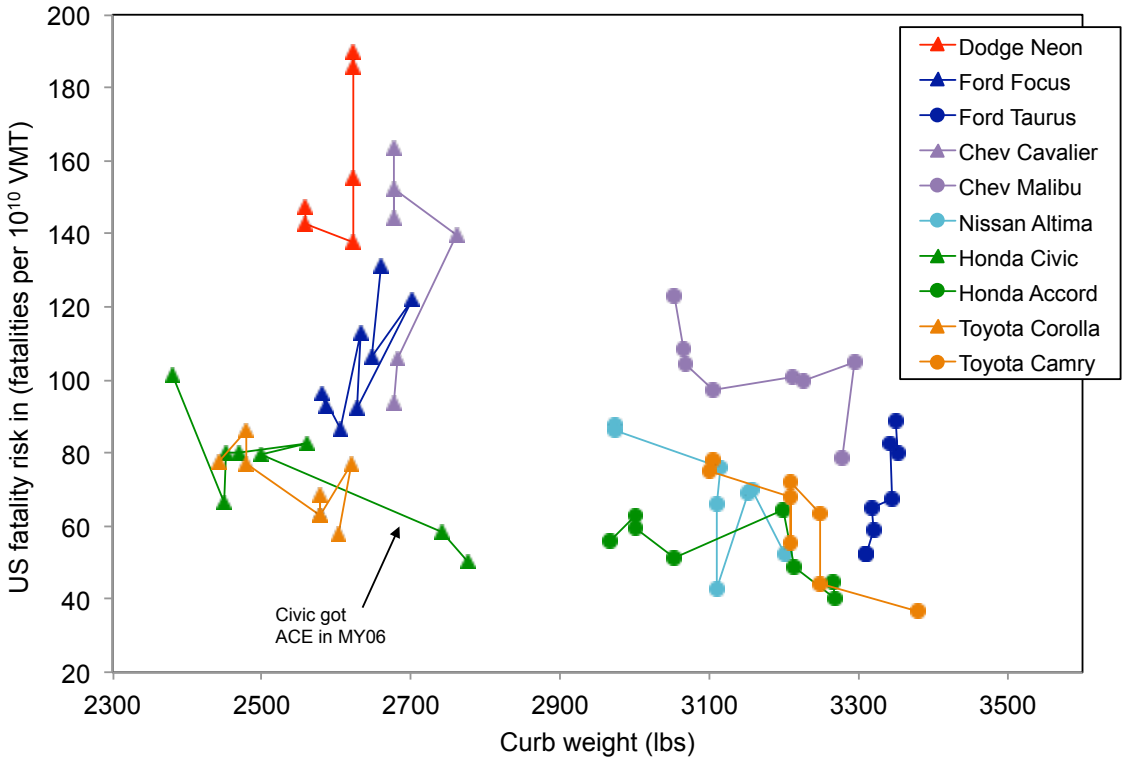


Figure 5. Trend in US fatality risk per VMT in case vehicle only vs. mass over time (by model year), for 10 most-popular four-door car models and all four-door cars

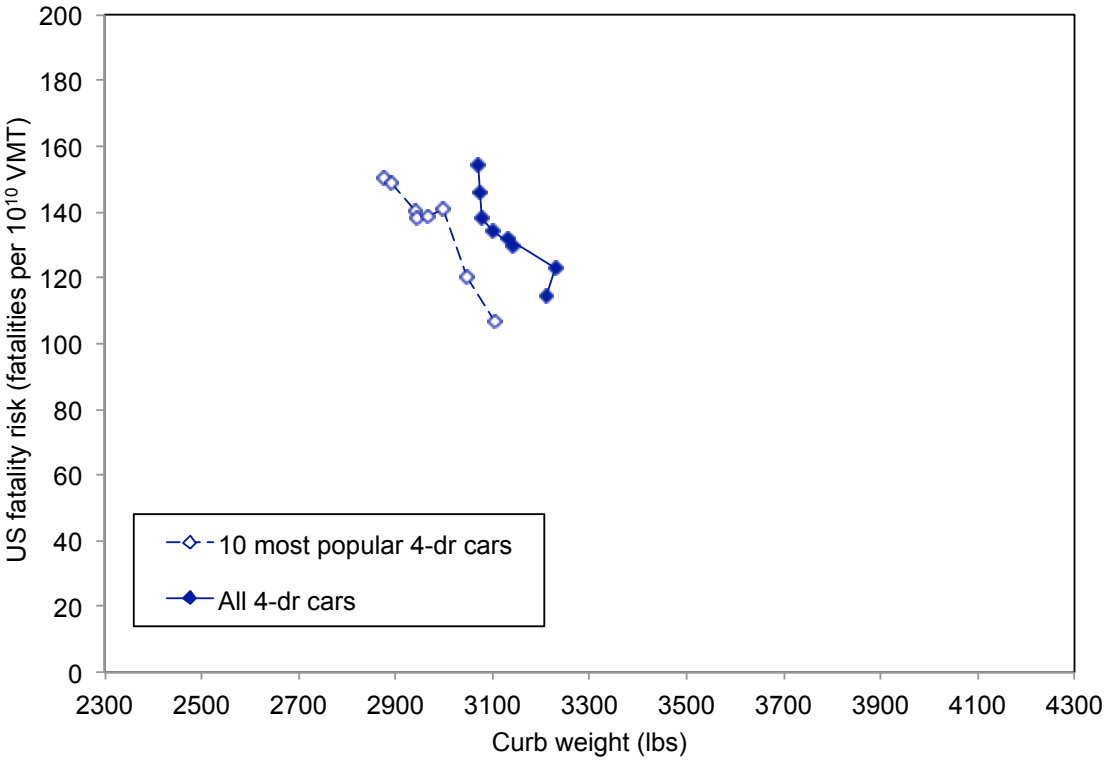


Figure 6. Updated trend in US societal fatality risk per VMT vs. mass over time (by model year), by vehicle type

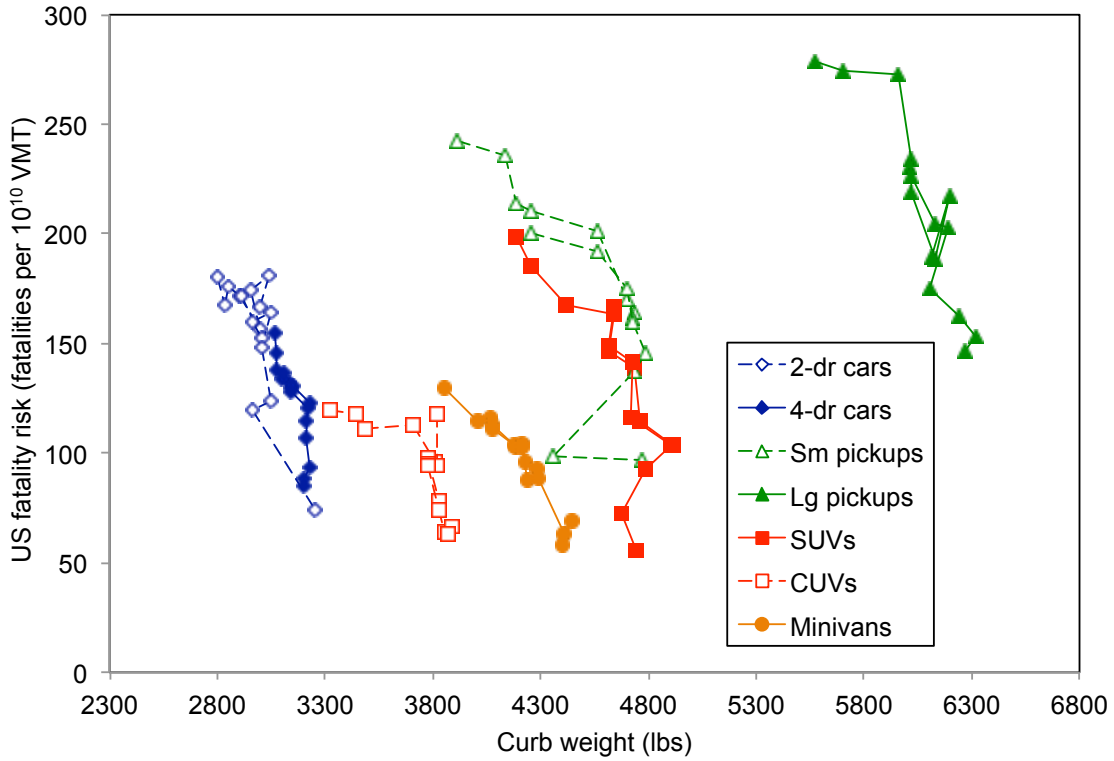
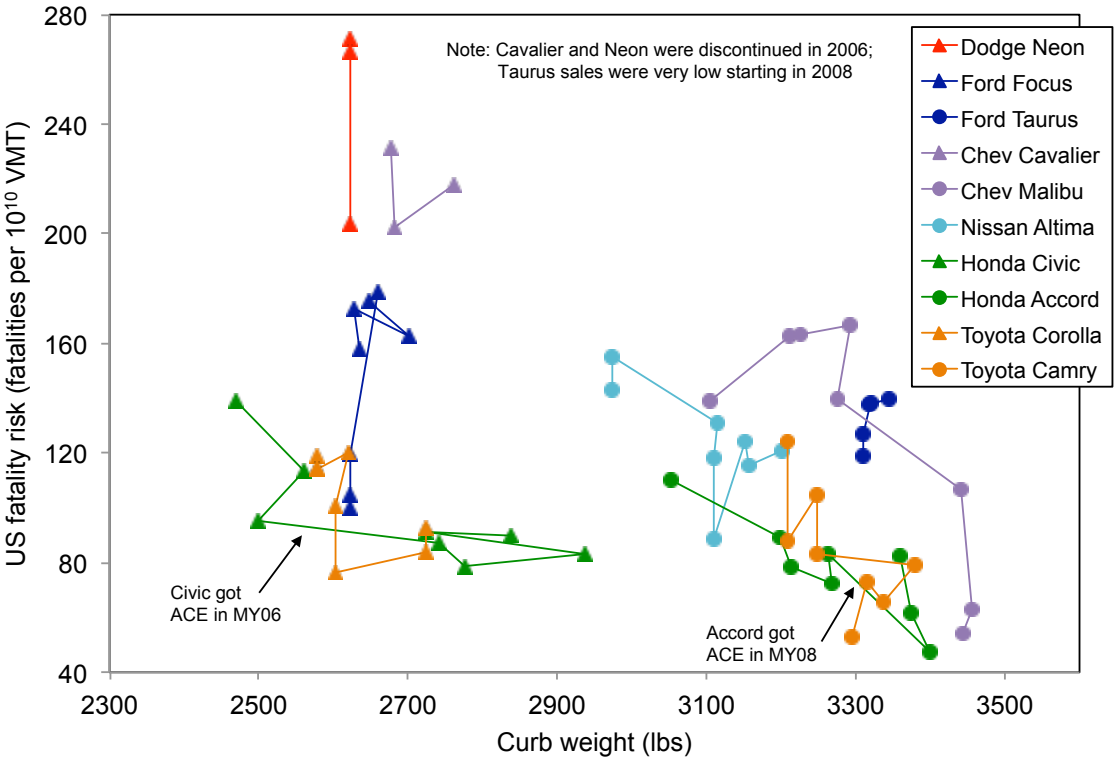


Figure 7. Updated trend in US societal fatality risk per VMT vs. mass over time (by model year), for 10 most-popular four-door car models



3. Conclusions

This report presents a new approach to analyze the relationship between vehicle mass and risk: tracking fatality risk by vehicle model year and mass, for individual vehicle models. This approach is appealing as it greatly minimizes the influence of driver characteristics and behavior, and crash circumstances, on fatality risk. However, only the most popular vehicle models, with the largest number of fatalities, can be analyzed in this manner. While the analysis of all vehicle models of a given type suggests that there is a relationship between increased mass and fatality risk, analysis of the ten most popular four-door car models suggests that this relationship is weak: in many cases when the mass of a specific vehicle model is increased societal fatality risk is unchanged or even increases. These results further support the notion that increasing the mass of an individual vehicle model does not necessarily lead to decreased societal fatality risk.

4. References

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