AUTOMOBILE SAFETY AND FUEL ECONOMY: A CRITIQUE OF "THE EFFECT OF FUEL ECONOMY STANDARDS ON AUTOMOBILE SAFETY"

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Many opponents of federal Corporate Average Fuel Economy Standards (CAFE) argue that the standards increase highway fatalities.[1] In essence, they argue that fuel economy standards forced auto manufacturers to reduce vehicle weight, that traffic fatalities are higher in lighter cars, and therefore, that standards increase traffic fatalities.

Their argument is based largely on a recent paper by Robert Crandall and John Graham, which concludes that the CAFE standards will cause an additional 2,200 to 3,900 highway fatalities in 1989 model year cars over the next ten years. This paper's conclusion, however, is based on seriously flawed assumptions, out-of-date information on how automobile manufacturers improve automobile fuel economy, and misapplication of another study's results.

To estimate the increase in highway fatalities due to CAFE, Crandall and Graham constructed mathematical models that predict what average vehicle weight would have been in 1989 model year cars had CAFE standards not existed. These models assume that manufacturers seek to maximize the weight of their cars, but are constrained by expected future price increases in gasoline and steel. After estimating the weight reduction due to CAFE standards, they then used estimates of the relationship between vehicle weight and traffic fatalities to calculate the extra fatalities caused by the estimated weight reduction.

Errors in the Crandall/Graham Study

Study is Based on Out-Of-Date Technological Relationships

One of the most serious errors in the Crandall/Graham paper is the assumption that automobile technology is static -- that technology used to improve fuel economy in the 1970s is the same technology used to improve fuel economy in the 1980s. Crandall and Graham observed data on weight, gasoline prices, and steel prices between 1970 and 1977 to estimate the pre-CAFE, market-

* Robert W. Crandall and John D. Graham, "The Effect of Fuel Economy Standards on Automobile Safety," March 1988, Journal of Law and Economics, Vol. XXXII, pp. 97-118, April 1989.

determined technological relationship between average vehicle weight and expected future gas and steel prices.[2]

Shortly after this period, projected gasoline prices fell, and the authors speculated that were it not for CAFE standards, auto manufacturers would have increased the weight of their cars according to the 1970 to 1981 relationship between weight and gas and steel prices. The authors estimated that, on the basis of the 1970-1977 relationship, average vehicle weight would have been about 500 pounds higher in 1989 model year cars had CAFE standards not existed.

Using weight/price data from the 1970s to project how cars would be built in the 1980s assumes that automobile technology hasn't changed since the 1970s. But technology has changed rapidly in the automobile industry, and this is especially true with regard to fuel economy technology. In the 1970s, weight reduction was one of the simplest and cheapest ways to improve fuel economy. After 1980, manufacturers substantially improved fuel economy without having to resort to weight reduction. This very important technological change is ignored by Crandall and Graham.

To understand how important this technological shift was, refer to **Figure 1**. It is a graph of U.S. average passenger car fuel economy and weight during the years 1970 to 1988. As can be seen, average vehicle weight fell sharply and average fuel economy rose correspondingly from 1976 to 1980. However, after 1980 manufacturers began improving fuel economy without reducing the weight of cars. After 1980, average vehicle weight has remained almost constant while fuel economy rose over 20%. Crandall and Graham used weight/price relationships from the 1970 to 1981 period to project how manufacturers would have responded to changes in fuel economy demand if CAFE standards didn't exist, but clearly, the data from this period reflect out-of-date technology. If manufacturers didn't have to reduce the weight of cars in the 1980s to meet CAFE standards, why, in the absence of CAFE standards, would manufacturers respond to lower expected gas prices by adding weight back into cars in proportion to the weight they took out of cars in the 1970s?

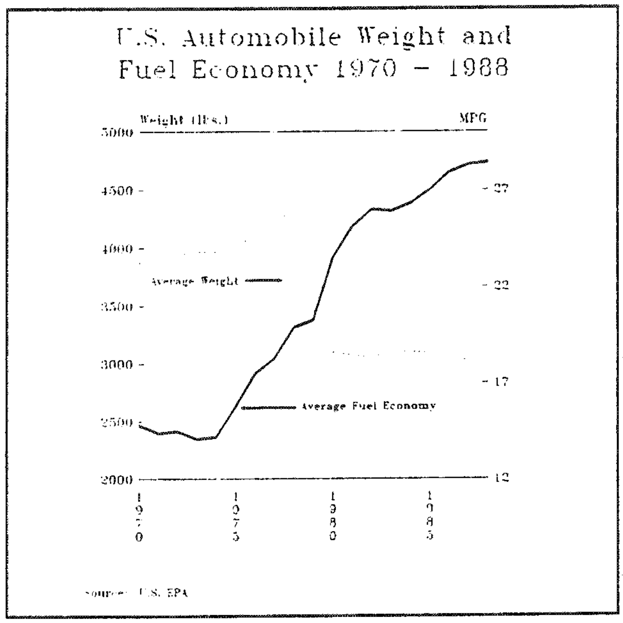

Figure 1

This problem is often encountered in econometric studies. It is very difficult to predict how sectors of the economy will respond to a hypothetical situation. When those predictions are based on the economic relationships and technology of another period, the predictions are on shaky grounds. When these economic relationships and technologies are clearly out-of-date, the predictions are meaningless.

An additional point about Crandall and Graham's use of automobile weight data bears discussion. The authors assume that CAFE standards had a strong effect on average vehicle weight. However, the record shows that vehicle weight was reduced in the early years of the CAFE program, when the standards were the least restrictive. Gasoline prices were relatively high during this period, so manufacturers had little difficulty exceeding the standards. But after 1982, when gasoline prices softened, manufacturers had difficulty meeting the standards. During this period, when CAFE standards were most restrictive, weight remained unchanged. If manufacturers chose not to reduce vehicle weight when, as a consequence of failing to meet the CAFE standards, they were threatened with hundreds of millions in fines, how can one argue that the CAFE standards strongly influence vehicle weight?

Manufacturers Don't Seek to Maximize Weight

Another serious problem with the Crandall/Graham study is the authors' assumption that vehicle manufacturers seek to maximize weight. This assumption is critical to the authors' conclusions because once the manufacturers reduced weight in response to rising gasoline and steel prices, the authors needed a way to explain why the CAFE-free market would have increased average vehicle weight once gasoline and steel prices softened.

This assumption conflicts strongly with the manufacturers' keen interest in improving vehicle acceleration. The heavier a car, the more slowly it accelerates. To make heavy cars accelerate as fast as light cars, manufacturers must use larger and more powerful engines, and stronger drivetrain parts to withstand additional power and torque, which of course is very expensive. Adding weight to a car therefore works against one of the major automobile design objectives.

An indication of how highly manufacturers rank the importance of improving vehicle acceleration can be found in a recent Arthur D. Little survey of the heads of engineering, research, and product planning in North America. The survey found that power/pickup was their number one priority in power-train design, followed by, in order of priority, quality, noise/vibration/quietness, driveability/performance feel, exterior styling, and fuel economy.[3]

Figure 2 shows the trends in average vehicle 0 to 60 mph acceleration between 1978 and 1988. Between model years 1982 and 1988, average vehicle acceleration performance improved 14%. Had vehicles in model year 1989 been 500 pounds heavier, as estimated by Crandall and Graham, the improvement in acceleration performance since 1982 would have been cut by about 90% -- unless, of course, manufacturers had spent a great deal of money putting larger and more powerful drivetrains into these cars.[4] Given the tradeoff between vehicle weight and acceleration, and the obvious importance manufacturers assign to acceleration performance, the assumption that manufacturers seek to maximize a vehicle's weight has little relation to reality.

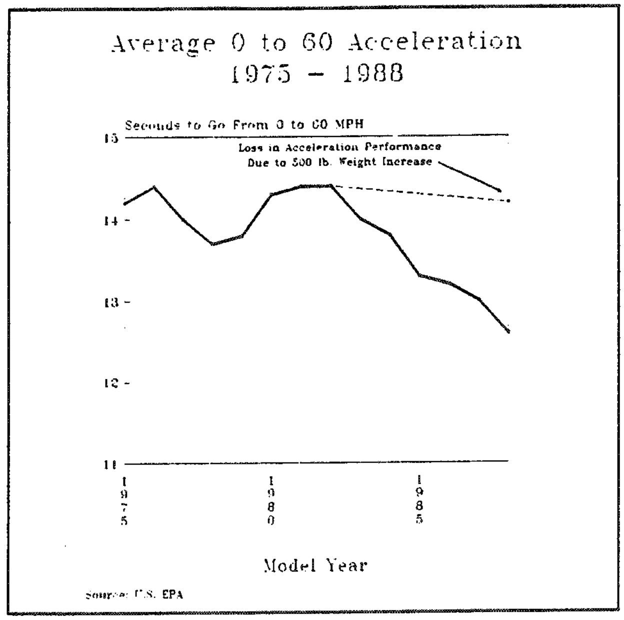

Figure 2

Crandall and Graham Misapplied Results of Safety Study

Once Crandall and Graham estimated how much more cars would have weighed had the CAFE program not existed, they used estimates of the relationship between vehicle weight and traffic fatalities to estimate how many additional deaths will be caused by the CAFE-induced weight reduction. The relationships between vehicle weight and traffic fatalities were taken from studies on the relationship between car size and auto safety done by Leonard Evans of the General Motors Research Laboratories Transportation Research Department.[5] Since car size and weight are strongly related, Evans used car weight to characterize car size in his studies. He found a strong negative correlation between car weight and traffic fatalities.

In order for Evans' relationships between car weight and fatalities to be useful in the Crandall/Graham study, Crandall and Graham had to assume that variations in car weight, not car size, caused Evans' observed differences in fatality rates, i.e., that weight is the causative factor. This assumption is critical to their argument that CAFE forced weight reductions, that weight reductions cause increased fatalities, and therefore, that CAFE standards cause increased fatalities. Had they not assumed that weight is the causative factor, they could not link traffic fatalities to fuel economy and CAFE standards.

In assuming that changes in car weight cause changes in fatalities, Crandall and Graham ignored an important caveat Evans placed in the introduction to his paper. Evans states,

> In all cases, we characterize car size by the physical variable mass as measured by the curb mass [weight] of the car. We then determine relation between probable driver death (or injury) and car mass. Such relations do not imply that car mass, as such, is the causative factor. Clearly, a wide variety of vehicular characteristics are strongly correlated with car mass (e.g., wheelbase, track, size in general, hood length, trunk size, engine displacement, etc.).

Clearly, Crandall and Graham used Evans' study results in a manner he explicitly warned against. Crandall and Graham have taken Evans' study results, and forced them to fit into a framework that ties highway fatalities to CAFE standards.

But one might ask, if weight and car size are strongly correlated, what is the difference? The record shows the difference. Although car weight dropped off significantly in the late 1970s and early 1980s, car size, as measured by interior volume, has remained almost constant since 1978, the year CAFE standards first took effect. See Figure 3. Thus, in looking at changes over time, there is a big difference between car size and weight.

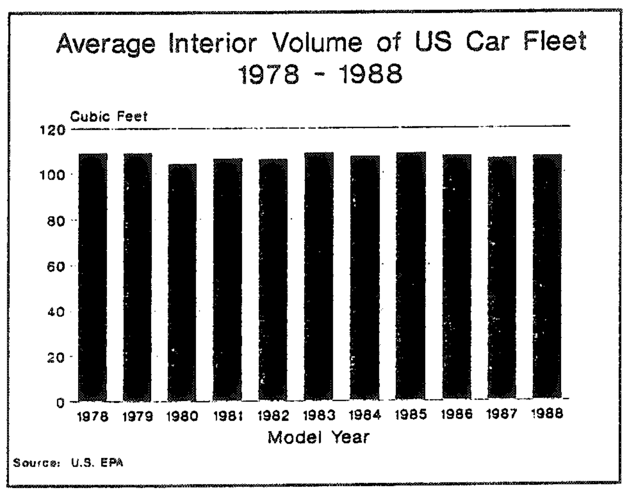

Figure 3

Evans' studies provide the basis for further research into why people in larger cars fare better in crashes. Is it because large cars have more "crush space" that can absorb energy in crashes, and thereby decelerate their occupants more slowly? Or do larger cars better prevent deformation of interior space during crashes? Whatever the cause, further research may provide clues to the answer. Ir the meantime, there is no basis for assuming weight is the cause.

Fuel-Efficient Cars Can Be Safe

A large number of options for improving automobile fuel economy exist, only one of which is reducing vehicle weight. Fuel economy increases achieved through changes such as transmission improvements, fuel injection, multi-valve engines, or turbocharging have little or nothing to do with auto safety. On the other hand, the primary determinants of auto safety are design features such as occupant restraint systems, air bags, and the ability of a car to absorb energy. Simply put, automobile safety is a matter of design, not fuel economy.

Government Crash Tests

Points in Figures 4 and 5 represents the weight and safety performance of a 1984 to 1988 model year car crash tested by the U.S. Department of Transportation's National Highway Traffic Safety Administration. These cars were crashed into a fixed barrier at 35 mph. The measure of safety performance is the head injury criterion, which reflects the potential for injury to the brain. A head injury criterion of 1000 or higher means a vehicle occupant would probably be killed or very seriously injured. The trend lines in the graph reflect the strength of the relationship between the HIC and vehicle test weight. Flat or low-sloped trend lines, as shown here, indicate there is no relationship between automobile weight and head injury criteria. In fact, there are some heavy vehicles that perform poorly (upper right portion of figures) and some light vehicles that perform very well (lower left portion of figures).

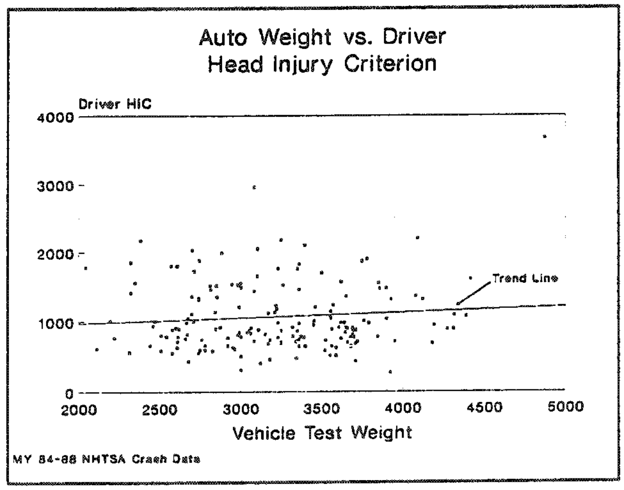

Figure 4

Crashing a car into a fixed barrier does not fully measure how weight affects a car's crash performance. Nonetheless, the figures illustrate that there are large differences in the crash worthiness of automobiles, independent of weight. A 1982 study by the Office of Technology Assessment pointed out that the differences in crash performance within weight classes were greater than the differences among weight classes. OTA concluded that "relatively minor" design changes could "overwhelm" the crash performance differences caused by size.[6]

EXAMPLES OF FUEL-EFFICIENT, SAFE CARS

As seen above, there are many existing light-weight cars that perform well in crash tests. But much safer and much more fuel-efficient cars are possible. The Volvo LCP 2000, a prototype high-efficiency car, was designed with both safety and fuel economy in mind. The car weighs 1500 pounds (less than half today's current average auto weight of 3100 pounds), achieves 63 mpg in the city and 81 on the highway, and can withstand frontal and side impacts of 35 mph, and a rear impact of 30 mph.[7] U.S. regulations require only that vehicles can withstand a frontal impact of 30 mph.

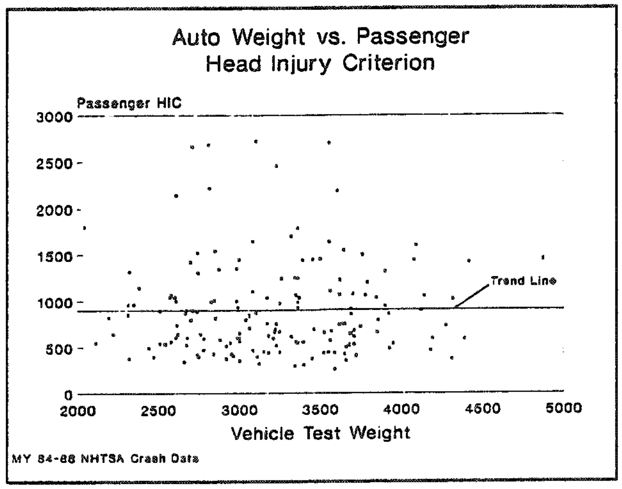

Figure 5

The U.S. Department of Transportation's Research Safety Vehicle Program, which existed from 1977-1980, developed an experimental car that was both safe and fuel efficient. The program concluded that a car using then-current technology (ten years old now) could carry five passengers; achieve 43 mpg; and withstand 80 mph frontal impacts, 50 mph side impacts, and 45 mph rear impacts.[8]

Conclusion

It is clearly incorrect to assume, as did Crandall and Graham, that weight reduction continues to be the primary means by which manufacturers improve fuel economy, and that the technological response to gasoline prices in the late 1980s would be the same as in the 1970s if CAFE standards didn't exist. Crandall and Graham's prediction that average automobile weight in model year 1989 would have been 500 pounds higher in the absence of CAFE standards is based on out-of-date technological relationships. It assumes that manufacturers would have been willing to either substantially reduce the acceleration performance of their cars, or invest a great deal of money in developing and installing more powerful drivetrains to improve the acceleration performance of much heavier cars. Furthermore, their estimate of additional traffic fatalities caused by CAFE standards is based upon misapplication of another study's results. A series of errors as significant as each of these renders the results of their paper unreliable.

More responsible studies on the issue have been completed. A recent study by the National Highway Traffic Safety

Administration establishes a relationship between vehicle weight and fatality rates in single vehicle nonrollover accidents.[9] Another study by the Insurance Highway Safety Institute finds a relationship between car size and fatalities. These studies have provided important, but inconclusive results. More research needs to be done to separate out the effects of driver behavior, types of crashes, and the propensity for different sizes of cars to be involved in a crash. More research also needs to be done on what design features cause large cars to have lower fatality rates, i.e., do large cars perform better because they are heavier, or because they have more energy-absorbing "crush space"?

If new research indicates that weight is the primary cause of lower fatalities rates in large vehicles, then future fuel economy improvements should be based on approaches other than weight reduction. If new research indicates that car size, such as interior volume or wheelbase, is the primary cause, then future fuel economy improvements should focus on measures that do not decrease car size. With either approach, current and future technologies provide a broad range of ways to substantially improve auto fuel economy while simultaneously improving auto safety. Simply put, automobile safety is a matter of design, not fuel economy.

Notes and References

1. See, for example, comments submitted to the National Highway Traffic Safety Administration by the Competitive Enterprise Institute, Docket No. FE-88-01, in the matter of Passenger Automobile Fuel Economy Standards for Model Year 1989; also see testimony submitted by Ford and General Motors to the U.S. Senate, Committee on Commerce, Science and Transportation, Consumer Subcommittee, hearing on Global Warming and CAFE Standards, May 2, 1989.

2. The CAFE standards became law in 1975 and first took effect in 1978.

3. *Automotive News*, May 15, 1989, p. E30.

4. EPA estimates the relationship between vehicle weight and acceleration performance to be:

$$T = F\ (HP/WT)^{-f}$$

where,
HP = horsepower
WT = inertia weight
and F and f are:

	Transmission Type	
	Auto	Manual
F	.892	.967
f	.805	.775

See, R.M. Heavenrich, J.D. Murrell, and J.P. Cheng, "Light Duty Automotive Trends Through 1986," Society of Automotive Engineers Technical Paper Series, #860366, 1986.

5. Evans, Leonard, "Car Size and Safety: Results from Analyzing U.S. Accident Data," Proceedings from the Tenth International Technical Conference on Experimental Safety Vehicles, Oxford, England, July 1-4, 1985.

6. Office of Technology Assessment, U.S. Congress, *Increased Automobile Fuel Efficiency and Synthetic Fuels*, September 1982.

7. Bleviss, Deborah L., *The New Oil Crisis and Fuel Economy Technologies: Preparing the Light Transportation Industry for the 1990s*, (Westport, CT: Quorum Books, 1988), p. 118.

8. U.S. Department of Transportation, *The Safe, Fuel-Efficient Car: A Report on its Producibility and Marketing*, October, 1980.

9. Partyka, S. and Boehly, W., "Passenger Car Weight and Injury Severity in Single Vehicle Nonrollover Crashes," National Highway Safety Administration, U.S. Department of Transportation, 1989.