Testimony to the U.S. House of Representatives Science Committee

IMPROVING THE NATION'S ENERGY SECURITY: CAN CARS AND TRUCKS BE MADE MORE FUEL EFFICIENT?

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by

Dr. David L. Greene
Corporate Fellow
Engineering Science and Technology Division
Oak Ridge National Laboratory

1. WHAT ARE THE POLICY OPTIONS FOR ENCOURAGING THE ADOPTION OF FUEL EFFICIENT TECHNOLOGIES AND THEIR ADVANTAGES AND DISADVANTAGES?

There are many ways to structure policies to achieve significant increases in fuel economy effectively and efficiently. I will focus on five below. It is possible to create policies that are reasonably effective, efficient, and fair. Our own experience with our CAFE standards and difficulties we have had updating the CAFE law indicates that we should also prefer policies that provide a continuing incentive to improve fuel economy.

Following the oil crises of the 1970s, nearly every developed economy in the world adopted fuel economy standards in some form (IEA, 1984; 1991). Though the forms and means of implementing standards varied, and although fuel economy standards have been criticized on a variety of grounds, all these standards were effective in raising fuel economy levels. Fuel economy standards contributed to curbing the growth of world oil demand in the 1980s and, in combination with the market response to higher oil prices led to the OPEC cartel's loss of control over world oil markets in 1986. We *do* know how to reduce dependence on petroleum and we have done so effectively in the past. The combination of higher oil prices and policies aimed at increasing energy efficiency led to almost 15 years of low oil prices (Figure 1). Unfortunately, after these efforts were successful and oil prices crashed in 1986, we stopped trying. With OPEC nations holding more than two thirds of the world's proven oil reserves and more than half of the world's ultimate conventional oil resources, and with growing demand for oil for transportation in developed and developing economies, it was only a matter of time before they regained control of world oil markets.

Potentially effective fuel economy policies range from standards to market-based measures. Developed economies that have recently tightened their fuel economy or carbon emission standards for motor vehicles include Japan, the entire European Union (EU) and Australia. China has also recently adopted fuel economy standards with the aim of curbing their rapidly growing demand for oil (An and Sauer, 2004). Each country has a different form of standard, and each one is different from our own Corporate Average Fuel Economy (CAFE) Standards.

Japan and China have mandatory standards that vary (in different ways) across vehicle weight classes. The EU and Australia negotiated voluntary standards with automobile manufacturers collectively that are based on the sales-weighted average emissions of carbon dioxide per vehicle kilometer.

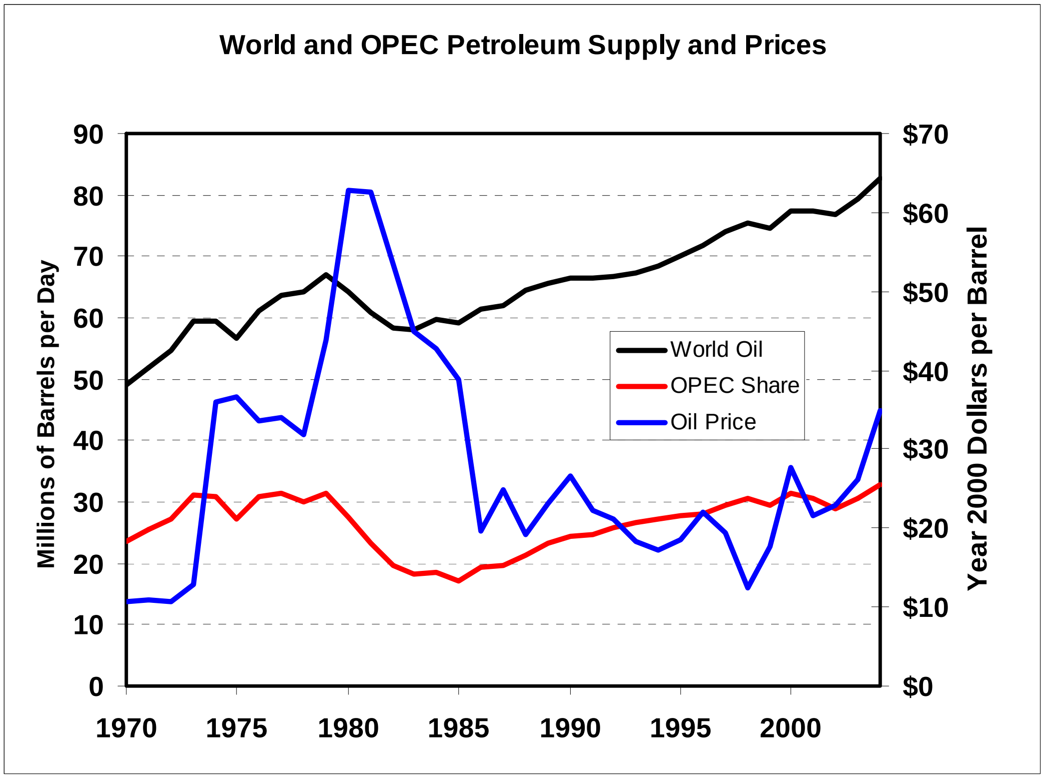

Figure 1. World Oil Demand, OPEC Market Share and Oil Prices

CAFE OR UNIFORM PERCENTAGE INCREASES (UPI)

Our CAFE standards were effective in raising passenger car and light truck fuel economy and curbing the growth of petroleum demand. They have been criticized on many grounds, but the one criticism that stands up to analysis is that they created a more severe burden for the "big three" domestic manufacturers than for much of their competition. Differential competitive impacts are inherent in the CAFE system whenever manufacturers specialize in different market segments because it requires each manufacturer to meet the same MPG target, regardless of its product mix. Manufacturers emphasizing larger light trucks and passenger cars will clearly have a more difficult task than those concentrating in smaller vehicle market segments. This problem was ameliorated but not eliminated in the CAFE law by defining separate targets for passenger cars and light trucks. Another provision to increase flexibility allows manufacturers to average their fuel economy numbers over a six year moving window (three years forward, three back). The economic efficiency of the CAFE law could be improved further by allowing manufacturers to trade fuel economy credits as recommended by the National Research Council (NRC, 2002) CAFE report. Still, these trades will result in income transfers among firms unless credits are initially allocated to firms in a way that compensates in advance for such transfers. That might be difficult to do because it effectively amounts to giving money to some firms and not others.

UPI have been proposed as an alternative to CAFE. This system requires each manufacturer to achieve not the same MPG level, but the same percentage increase in MPG. The UPI system essentially produces a mirror image of the differential competitive impacts of CAFE (Greene and Hopson, 2004; Plotkin et al., 2002), putting smaller vehicle manufacturers and manufacturers that have already adopted advanced fuel economy technologies at a disadvantage. A UPI system would also discourage manufacturers from adopting more fuel economy technology than was absolutely required, since exceeding the standard might later lead to having to meet a more difficult standard. In addition, while CAFE can discourage manufacturers from abandoning smaller vehicle production, UPI can discourage small vehicle manufacturers from moving into larger vehicle markets.

ATTRIBUTE-BASED STANDARDS

Attribute-based standards set fuel economy standards based on measurable vehicle attributes, such as weight or size. This can help reduce, but probably cannot eliminate (see, e.g., Plotkin et al. 2002, Ch. 6), the competitive impacts of CAFE or UPI style fuel economy standards. Japan has had successful weight-class fuel economy standards for decades, and China has just adopted a weight-based system. Weight-based standards take account of the product mix but do not recognize differences in manufacturers' current use of fuel economy technology. They do not recognize the possibility that different manufacturers may be serving customers with different preferences for fuel economy. For these reasons, some degree of differential competitive impacts will occur even under a weight-based system. Finally, weight-based standards, depending on how there are designed, may or may not provide an incentive for substituting advanced lightweight materials in vehicles as a way of increasing fuel economy.

Size-based standards are a promising but largely untested alternative to weight-based standards. Size-based standards could be based on dimensions such as wheelbase times track width, or interior volume. Such standards would have the advantage of preserving the option of reducing vehicle weight to increase fuel economy without sacrificing vehicle size. There is some recent evidence to indicate that moderate reductions in vehicle weight while maintaining basic vehicle dimensions would be beneficial to highway safety (Van Auken and Zellner, 2004). Because there is no experience with size-based fuel economy standards, the engineering and design implications of such standards should be carefully studied before they are formulated and implemented.

VOLUNTARY STANDARDS

Voluntary fuel economy standards were effective in Europe in the 1970s and 1980s, and the current EU-ACEA carbon dioxide emissions standard also appears to be headed for success in meeting its 2008 target. Canada also adopted voluntary standards, but they mirrored the U.S. CAFE standards which essentially guaranteed their success. According to economic theory, voluntary standards can be effective if there is a credible threat of mandatory standards. Voluntary standards can take any of the forms of mandatory standards.

The EU-ACEA voluntary standards are worthy of note because they apply to the entire industry, leaving the determination of individual firms' responsibilities to negotiations among the firms.

While this certainly has risks, it also creates the opportunity for firms to allocate responsibilities in an efficient and fair manner by setting each firm's target at the same level of marginal cost per gallon of fuel saved. Because compliance is achieved voluntarily, there is no need for transfers of income among firms. Thus, economic efficiency, fairness and minimal competitive impacts can all be achieved simultaneously. *No other system can claim all three advantages.*

FEEBATES

Feebates are an entirely market-based approach. Vehicles above a chosen "pivot" level of fuel consumption (best measured as the inverse of fuel economy, i.e., gallons per mile or liters per 100 kilometers) pay a fee, while those below receive a rebate (Davis et al. 1995). The most efficient approach is to set both fees and rebates at a fixed rate in terms of dollars per 0.01 gallons per mile (or equivalent). This provides the same economic incentive to save a gallon of gasoline for all vehicles (assuming equal miles of use).

The economic response to feebates is solely a function of the rate and not the pivot points because the rate determines the marginal value of increasing fuel efficiency. The pivot points determine the transfer of revenues. This allows the creation of revenue-neutral feebate systems that pay out as much as they take in. Feebate systems can be designed with one pivot point or with vehicle class-specific pivot points. Analysis of feebate systems has shown that the transfer of revenues among manufacturers can be reduced significantly by a two pivot point system that distinguishes between cars and light trucks (Greene et al., 2005). The benefits of greater numbers of pivot points is unclear, and increasing the number of pivot points increases the opportunity to "game" the system by moving vehicles from one class to another to attain a more easily achieved pivot point.

A key advantage of feebate systems is that they provide a continuing incentive to adopt fuel economy technologies as long as they remain in effect. Whereas once a CAFE target is met there is no further incentive to increase fuel economy, the feebate rate always offers an additional economic incentive to avoid a dollar of fee or gain a dollar of rebate. In view of the difficulty of raising CAFE standards over the past 20 years, this could be an extremely valuable feature in the U.S. political context.

The United States currently has in place half of a feebate system on half of the vehicles, in the form of the gas guzzler tax. The rate of the gas guzzler tax is very high, and as a result, it has nearly eliminated gas guzzling passenger cars. Guzzler taxes or rebates alone cannot be as effective as a comprehensive feebate system (Greene et al., 2005). A gas-guzzler tax on passenger cars and not light trucks undoubtedly decreases the numbers of larger heavier passenger cars without similarly affecting light trucks. Given the current CAFE law, the gas-guzzler tax also produces no benefit in terms of raising passenger car fuel economy.

GASOLINE TAXES

If the market for automotive fuel economy operated efficiently, increasing the tax on gasoline would be the most economically efficient way to increase fuel economy. Over the years, higher gasoline taxes have proven to be unpopular, but that is not an argument against their desirability from an economic efficiency standpoint. There are, however, good reasons to believe that the market for fuel economy is not efficient and, therefore, that standards have an important role to play.

First, even nations with gasoline prices two to three times higher than those in the United States have felt it necessary to have fuel economy standards. This includes the entire EU and Japan. If the market for fuel economy were efficient, gasoline prices in the range of $3 to $5 per gallon should be sufficient to raise vehicle fuel economy. Still, the EU and Japan found it necessary to have fuel economy standards.

Second, the net value to consumers of technology-based fuel economy improvements appears to be small over a wide range of fuel economy levels. In general, advanced fuel economy technology costs more that conventional technology. The benefit to consumers is therefore the present value of fuel saved minus the initial higher cost of the technology. The two graphs below show the estimated price increase and value of fuel savings for an average U.S. passenger car as fuel economy is increased from 28 to 45 miles per gallon. The data are taken from the 2002 NRC CAFE study. In Figure 2, the customer is assumed to count fuel savings over the full life of the vehicle, yet there is no more than a +/- $250 difference in net value (fuel savings minus price increase) over a range of 0 percent to 50 percent increase in fuel economy. Considering the uncertainty in what the customers' true fuel economy number will be, what the future price of fuel will be, and what the consumer is likely to actually pay for higher fuel economy, it is no wonder that fuel economy is not high on the consumers' list of things to consider when buying a car. From the manufacturers' perspective, however, a large increase in fuel economy is a long-term, high-cost, high-risk decision, requiring nearly complete vehicle redesign and substantial retooling—all for something customers are essentially indifferent about.

The second graph (Figure 3) displays the net value if consumers count only the first three years of fuel savings. In this case, there is no economic incentive for consumers to demand higher fuel economy or for manufacturers to supply it.

Third, recent evidence from surveys indicates that consumers are indeed undervaluing fuel economy. First, survey evidence, generally supported by automobile manufacturers, indicates that consumers expect an expenditure on fuel economy technology to be paid back in fuel savings within 2-4 years, far less than the full lifetime of a modern automobile. A recent study by the University of California at Davis (Turrentine and Kurani, 2005) conducted in-depth interviews with 60 households in California. Few even considered fuel economy in their purchase decisions. None explicitly calculated the potential value of fuel savings by any method. In short, there was no evidence whatsoever of textbook, economically rational behavior with respect to fuel economy.

Despite the apparent imperfection of the market for fuel economy, increasing the price of gasoline would be a sound and beneficial policy. It would signal consumers of the importance of reducing fuel use, making it somewhat easier for manufacturers to sell higher fuel economy vehicles. It would mitigate and could eliminate the rebound effect, the tendency for motorists to drive a little more when higher fuel economy reduces the fuel cost per mile of travel. Finally, a higher tax on gasoline would make up for revenues that would otherwise be lost to the highway trust fund in the future when higher levels of fuel economy reduce the demand for motor fuel.

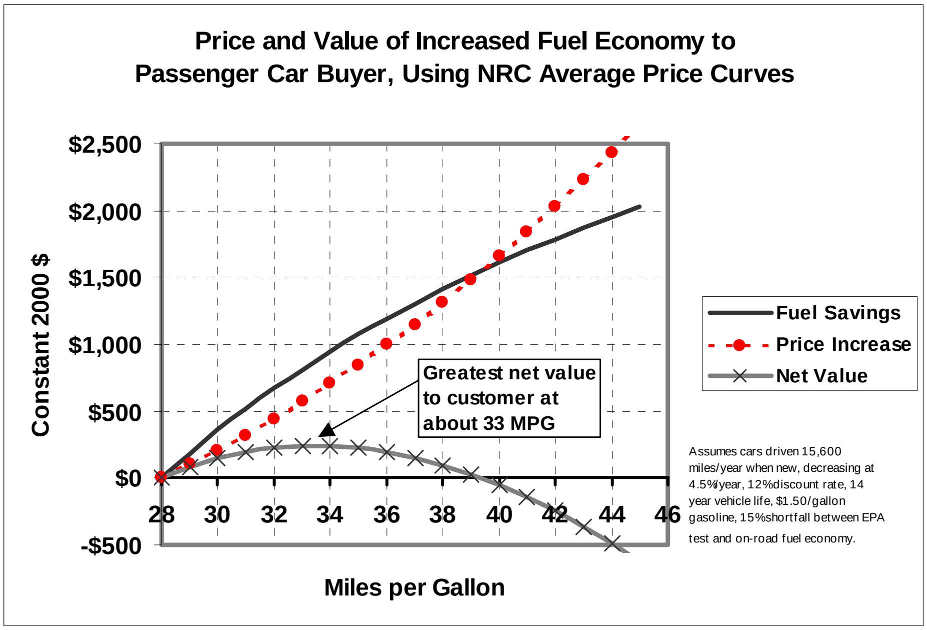

Figure 2. Net Value of Fuel Economy Technology to an Economically Rational Consumer

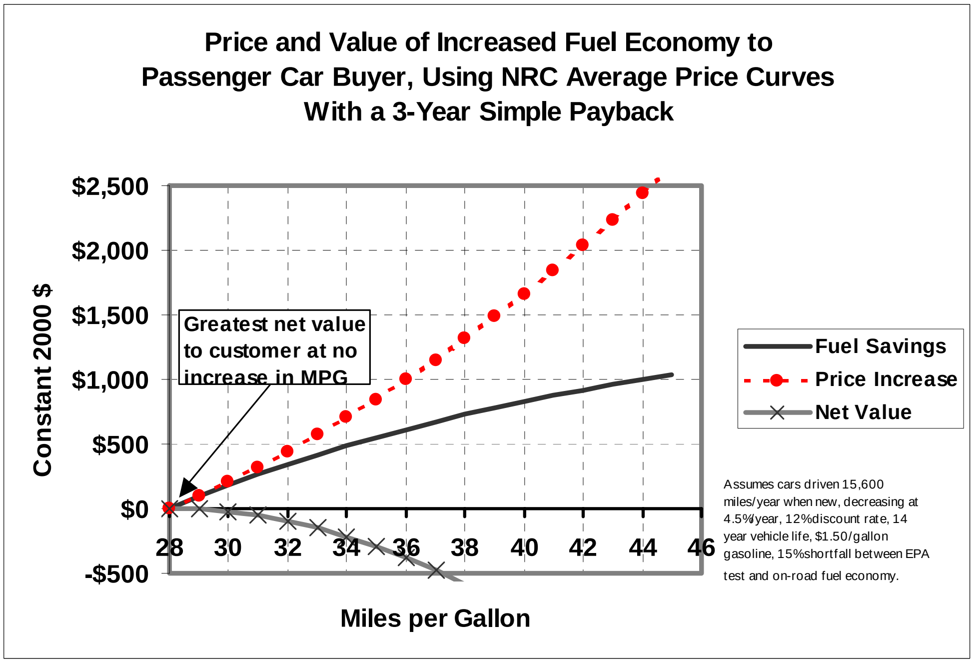

Figure 3. Net Value of Fuel Economy if only First Three Years of Fuel Savings Are Counted

2. CAN THE GOVERNMENT ENCOURAGE THE ADOPTION OF TECHNOLOGIES TO IMPROVE FUEL ECONOMY WITHOUT LEADING AUTOMAKERS TO MAKE VEHICLES LESS SAFE?

The government can encourage the adoption of technologies to improve fuel economy without leading automakers to make vehicles less safe. First, there are many technologies that can be used to improve fuel economy that should have no impact on vehicle safety. Technologies such as variable valve timing and lift control, displacement on demand, reduced aerodynamic drag, continuously variable transmissions, and engine friction reduction should be independent of vehicle safety. Several reports have developed lists of such technologies and estimate their likely impacts on vehicle costs and fuel economy. The 2002 NRC study of the CAFE standards provides an extensive analysis of how such technologies could be used to cost-effectively increase passenger car and light truck fuel economy. Given the availability of such technologies, manufacturers should be able to respond to the demands of a higher fuel economy standard without compromising safety.

The argument that fuel economy improvement inevitably leads to weight reduction which inevitably leads to increased fatalities and injuries is not correct. The role of weight reduction versus technology in achieving the fuel economy improvements of the past thirty years has been greatly exaggerated. Weight reduction was indeed an early strategy for increasing fuel economy. Vehicle weight reduction began before the CAFE standards went into effect, probably a response to the fuel shortages and higher prices caused by the first oil crisis of 1973-74. It continued after fuel economy standards went into effect in 1978 but ended in 1981. Fuel economy continued to improve through 1987 while weight increased. Since then, weight has increased while the average fuel economy of new light-duty vehicles has gradually declined, in large part due to the increasing market share of light trucks. According to data published by the Environmental Protection Agency, the average 2004 model year light-duty vehicle actually weighed six pounds more than the average light-duty vehicle sold in 1975. The average fuel economy of a new light-duty vehicle sold in 2004 was 58 percent higher than in 1975 (Figure 4). Clearly, none of this increase can be attributed to weight reduction since today's new light-duty vehicles are actually slightly heavier than their 1975 counterparts.

It has been argued, however, that further increases in fuel economy standards would inevitably lead to downsized or down-weighted vehicles and that smaller, lighter vehicles are inherently less safe. By and large, this objection has focused on weight reduction as the principal threat to safety. Reducing vehicle mass is certainly one way, though by no means the only way or even the most effective way, to increase fuel economy.[1] In a dissent to the 2002 NRC CAFE report, Marianne Keller and I pointed out that the evidence for a causal link from fuel economy to weight reduction to increase traffic fatalities and injuries was highly dubious. Since that report, our position has been strengthened by four scientific studies. With the support of Honda, Van Auken and Zellner (2002) attempted to replicate Kahane's (1997) path-breaking analysis of the relationship between vehicle weight and crash fatalities using more recent data from a somewhat different subset of states. They found that a reduction in the weight of passenger cars and light trucks of 100 pounds would not increase net highway fatalities. In an extension of this study in which they separately estimated the impacts of weight versus size (wheelbase and track width),

[1] In general, a 1 percent reduction in vehicle weight at constant performance can produce a 0.6 percent to 0.7 percent increase in fuel economy on the U.S. test cycle.

Van Auken and Zellner (2003) found that reducing weight while holding vehicle size constant would improve safety somewhat, while increasing weight at constant size would be harmful to safety. Kahane (2003) has since published a new study using a modified methodology that contradicts the findings of the first Van Auken and Zellner study and concludes that weight reduction accompanied by size reduction would be harmful to safety, but Kahane's new study still does not distinguish between the effects of size and weight.

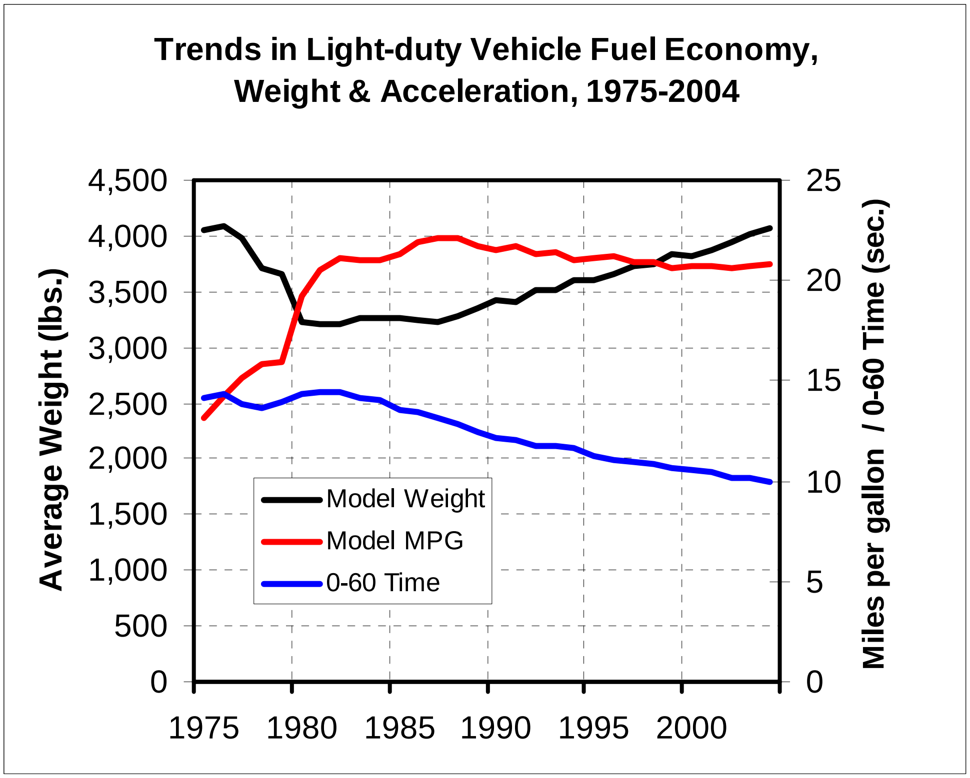

Figure 4. Trends in Light-duty Vehicle Fuel Economy, Weight & Acceleration, 1975-2004

In a paper forthcoming in *Accident Analysis and Prevention*, Wenzel and Ross (2005) demonstrate two key points. First, they show that, in a crash between vehicles, heavier vehicles may provide additional protection to their own occupants but this comes at the expense of the occupants of the vehicles with which they collide. This is important because it is consistent with the simple physics of elastic collisions which imply that increasing the weight of one vehicle in a crash is a zero sum game: the heavier vehicle gains safety at the expense of the lighter vehicle.[2] Wenzel and Ross (2005) also show that light trucks with chassis-on-frame construction tend to be exceedingly aggressive in collisions with other vehicles and that the harm they do to other vehicles outweighs the benefit of their additional weight to their occupants. These vehicles and roll-over-prone SUVs turned out, on net, to be harmful to overall traffic safety.[3]

[2] These same simple laws of physics imply that a proportional down-weighting of both vehicles would have no effect on the outcome of the crash. The predictions of Kahane's 1997 analysis were also consistent with these simple laws, as Keller and I demonstrated in our dissent to the NRC 2002 report.

[3] The fact that heavier vehicles benefit their occupants in a collision at the expense of occupants of the vehicles with which they collide creates what economists call an externality. The implication is that individuals will buy heavier vehicles than they would if they considered the impacts on others.

Perhaps the seminal study linking fuel economy, weight and safety was that of Crandall and Graham (1989). This study, however, was based on the very limited experience with significant fuel economy changes that was available at the time the analysis was carried out. It included data from 1947 to 1981, but the CAFE law was not passed until 1975, took effect in the 1978 model year, and affected only new vehicles and not the entire fleet. More recently, Noland (2004) examined the relationship between fuel economy, fatalities and injuries using a time series of data for states covering the period 1975 to 1998. Instead of regressing fatalities or injuries against vehicle weight, he regressed directly against fuel economy. This is significant because, as pointed out above, weight reduction is far from the only means of raising vehicle fuel economy. For example, reducing engine power is also beneficial to fuel economy.[4] By using fuel economy instead of weight as an independent variable, Noland was able to reflect all the possible paths by which fuel economy improvements might have influenced vehicle design and thereby safety. What Noland found was that the relationship between fuel economy and safety was not stable over time. It appeared that in the 1970s fuel economy was positively related to (increased) traffic fatalities, but that in later years there was no statistically significant relationship. Indeed, Noland found that, unless the years 1975 to 1977 were included in the analysis, no statistically significant relationship could be found.

At the 2005 Transportation Research Board Meetings, I presented the results of a statistical analysis of the relationship between national average passenger car and light truck fuel economy and total U.S. traffic fatalities for the period 1966 to 2002 (Ahmad and Greene, 2005) (see Figure 5). Testing a wide array of possible models and other contributing factors, our analysis demonstrated that the only statistically significant relationships between fuel economy and traffic fatalities indicated that increasing fuel economy was associated with lower traffic fatalities, not higher. For a number of reasons we cover in detail in the paper, we do not conclude that increasing fuel economy will reduce traffic fatalities. Rather we conclude that the aggregate national traffic fatality and fuel economy statistics provide no support for the hypothesis that increasing fuel economy led to increased traffic fatalities over the period 1966 to 2002. While these results contradict the earlier findings of Crandall and Graham (1982), we believe this is because of the longer record of experience available to us today.

Major improvements in light-duty vehicle fuel economy will require major vehicle design changes. Safety is always an issue when vehicle designs change. This strongly argues for insuring that manufacturers have sufficient time to carry out redesigns with the usual level of care and attention to detail. There need be no compromise in safety, provided that fuel economy targets are set at levels close to what can be achieved with approximately cost-effective technologies.

[4] A 1% reduction in horsepower, all else equal, would produce a 0.2% to 0.3% increase in fuel economy.

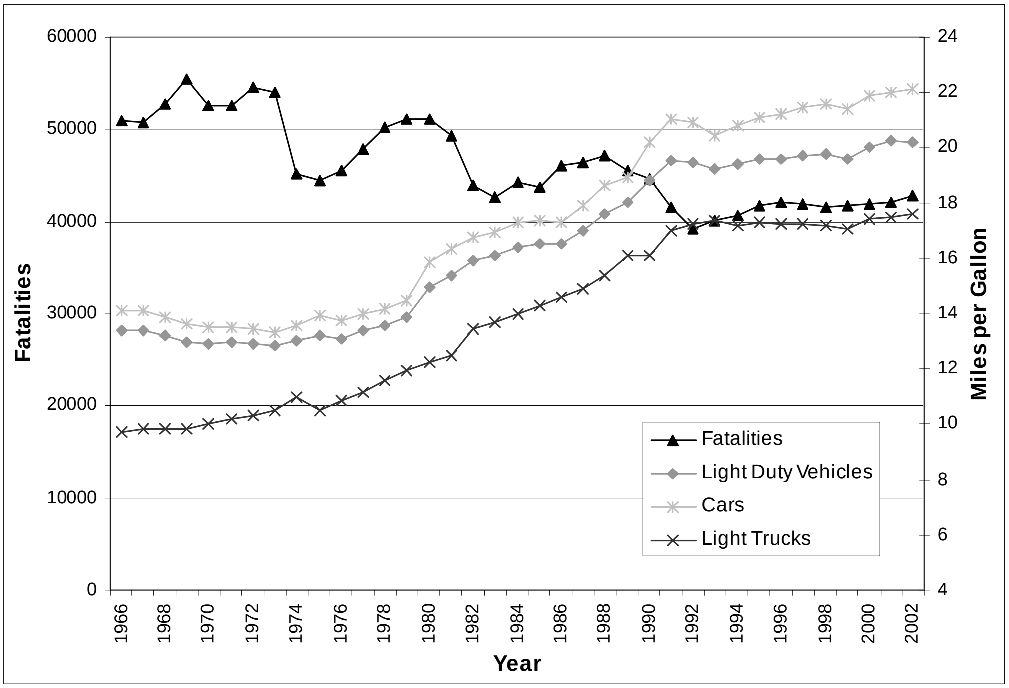

Figure 5. On-Road Passenger Car and Light Truck Fuel Economy and Traffic Fatalities in the United States, 1966-2002

3. CAN THE GOVERNMENT ENCOURAGE THE ADOPTION OF TECHNOLOGIES TO IMPROVE FUEL ECONOMY WITHOUT GIVING ANY INDIVIDUAL AUTOMAKER A SIGNIFICANT ADVANTAGE?

While it is possible for the government to encourage the adoption of technologies to improve fuel economy without giving any individual automaker a significant advantage, most of the policies described above will be more easily complied with by some manufacturers than others. However, there are ways to reduce competitive impacts and improve the fairness of fuel economy policies.

What makes a system fair from a competitive perspective? This question could be answered in many ways. I suggest the following definition. A fair policy is one that (1) requires each manufacturer to spend the same amount at the margin to reduce the fuel consumption of each car by one gallon per mile and (2) does not otherwise redistribute revenues among manufacturers.[5] A CAFE system with tradable credits could satisfy the first criterion, as would other market-based mechanisms such as a feebate system or gasoline tax, but they could satisfy the second only with a complex and probably controversial redistribution of revenue.[6]

[5] Assuming that every car travels the same number of miles, this would ensure that manufacturers and consumers were spending the same marginal cost for each gallon of gasoline saved.

[6] There is also good reason to doubt that the market in tradable credits would be an open and competitive one. In all likelihood, there would be two to three large buyers facing two to three large sellers, an oligopsony facing an oligopoly. Rubin et al., however, have shown that even in this situation most of the potential efficiency benefits of credit trading would probably be realized.

In my opinion, the EU-ACEA voluntary fuel economy agreement probably comes closest to meeting both criteria. It appears to me that manufacturers have allocated the responsibility for meeting the industry target to individual firms in such a way as to equalize the marginal costs per liters/100 kilometers, and there appear to be no inter-firm transfer payments. However, this is no more than my opinion since the firms have not disclosed the details of their agreement.

Four main factors give different firms different capabilities to increase fleet average fuel economy:

1. The technological capability of the firm
2. The firm's current adoption of fuel economy technology in its products
3. The preferences of the customers served by the firm
4. The firm's product mix

There are differences in the ability of firms to use specific fuel economy technologies, but in general, technology is a fungible commodity in the automotive market place. Firms can buy technology from suppliers and from other firms, generally, but not always at competitive prices. Since being technically capable is essential to being able to compete in today's marketplace, it is probably best not to attempt to address this issue in creating a fair fuel economy policy.
Some firms make greater use of technologies to increase fuel economy than others. This has special relevance if fuel economy metrics such as the uniform percentage increase are being considered. A UPI system would make achieving fuel economy goals more costly for those firms currently making the greatest use of technologies to increase fuel economy. Their marginal costs per gallon saved would therefore be higher than those of firms using less fuel economy technology. Firms may make greater use of fuel economy technologies as a matter of corporate policy or because they serve a segment of the market that places a higher value on fuel economy. In the latter case, a CAFE system would disadvantage manufacturers who served consumers less interested in fuel economy. There appears to be little publicly available research on this subject.

Finally, fuel economy policies can have different impacts on firms that specialize in large or small, high or low power vehicles. Although there has been substantial convergence over time in the product offerings of major manufacturers, differences still remain. Systems like CAFE, UPI, and feebates will have differential impacts on manufacturers. Setting individual targets for vehicle types (e.g., passenger cars vs. trucks) and size classes can mitigate these differential impacts, but at the cost of creating opportunities for "gaming" by shifting vehicles from one class to another to acquire a less stringent standard. A reasonable but not perfect balance can be achieved with these systems. Steps that can be taken to minimize differential competitive impacts are listed below.

1. Give adequate lead time
    a. Time to first possible redesign
    b. Time for orderly redesign and retooling
2. Allow for differences in the mix of vehicles sold
    a. Vehicle classes
    b. Attribute-based formulas
3. Build in flexibility
    a. Carry-forward, carry-back windows

    b. Credit trading with caps on credit prices
    c. Administrative review
4. Insure that goals are feasible with approximately cost-effective, fungible technologies
    a. Technical analysis
    b. Review other regulations for compatibility

As has been noted above, it is possible but not certain that a voluntary agreement that allows manufacturers to allocate fuel economy improvement responsibilities can achieve equal marginal costs of compliance and no revenue transfers among firms. With a feebate system or tradable credit CAFE system, it is also possible to allocate initial credits in such a way as to mitigate the differential financial impacts that would otherwise occur. Such allocations are likely to be controversial, however, since they will amount to substantial payments to some firms and not others.

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