WHY CAFE WORKED

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November 6, 1997

Prepared by the
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managed by
LOCKHEED MARTIN ENERGY RESEARCH CORP.
for the
U. S. DEPARTMENT OF ENERGY
under contract DE-AC05-96OR22464

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ABSTRACT

The 1975 Energy Policy and Conservation Act established mandatory fuel economy standards for passenger cars and light trucks sold in the U.S. Since that time the Corporate Average Fuel Economy (CAFE) standards have often been criticized as costly, inefficient, and even unsafe, despite the general absence of direct empirical evidence to support such claims. This paper explains why properly designed and executed fuel economy regulations may be preferable to other policies for reducing petroleum dependence and carbon emissions, and reviews empirical evidence on the impacts of the CAFE standards. It appears that the standards substantially achieved their objective without producing significant negative side-effects because they were set at levels that could be achieved by cost-effective or nearly cost-effective technological innovations.

ACKNOWLEDGMENTS

The author thanks Barry McNutt, John DeCicco, James Kahn and Lester Lave for helpful criticism of an earlier draft of this paper, and Debbie Bain for her careful preparation of the manuscript. Any errors are the fault of the author alone. This paper is dedicated to Michael Greene.

1. INTRODUCTION

The frequently controversial Federal Automotive Fuel Economy Standards, a.k.a. Corporate Average Fuel Economy (CAFE) standards established by the U.S. Energy Policy and Conservation Act of 1975 (PL94-163), have in fact been a notable success.[1] Not only have they been largely responsible for the nearly doubling of U.S. passenger car fuel economy and more than 50 percent increase in light truck MPG from 1975 to 1984, but they have also been effective in achieving their primary objective: restraining the automobile's appetite for oil. At the 1975 on-road light-duty vehicle MPG of 13.1, the 2.2 trillion vehicle miles traveled in 1995 would have required 55 billion more gallons of fuel and cost motorists an additional $70 billion (1995$).[2] All of this was done at a price American consumers were apparently willing to pay. Public opinion polls have consistently shown approval ratings in the vicinity of 75 percent for maintaining or raising the CAFE standards. Although numerous hypothetical and theoretical objections to CAFE have been raised, tangible evidence of significant negative effects is lacking. The combination of efficiency and political acceptability enjoyed by technical efficiency standards virtually guarantee that they will be a part of any serious effort to achieve sustainable transportation.

This paper attempts to explain why the CAFE standards have been such a successful energy policy. It begins by pointing out that economic theory does not relegate technology standards to inevitable "second best" status as some imply (e.g., Blakemore and Ormiston, 1996, p.7). As a public policy aimed at correcting an externality, regulations can be the key part of a "first-best" public policy response. To be sure, practical problems will arise in implementing either an effluent tax or a regulatory standard (Vickery, 1992). Next, it is argued that in the oligopotistic automotive market a combination of satisficing behavior on the part of consumers and risk-aversion on the part of producers makes it very likely that fuel economy standards will be more effective than a motor fuel tax. This does not mean that gasoline or vehicle use taxes are not important or useful policy tools. Indeed, they are essential if policies are to be economically efficient. It means that taxes will be most effective and efficient if used in conjunction with fuel economy standards.

Objections to fuel economy regulations are then enumerated, and the historical evidence with reference to the CAFE standards is reviewed. These range from claims that CAFE forced consumers to buy smaller less desirable cars (Shin, 1990; Crandall, et al., 1986), to claims that CAFE differentially harmed domestic auto manufacturers (Nivola and Crandall, 1995), to claims that CAFE

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[1]For studies arguing CAFE success, see, for example, Glazer (1994), Kirby (1995), and Goldberg (1996). Arguments against can be found in Crandall et al. (1986), Nivola and Crandall (1995), Leone and Parkinson (1990), and Shin (1990).

[2]Sources are the Federal Highway Administration, *Highway Statistics 1995*, table VM-1, Washington, DC; Davis (1997), tables 3.9 and 3.21; the Energy Information Administration, *Monthly Energy Review*, May, 1997, table 9.4. This calculation ignores the fact that at 13.1 instead of 19.7 MPG, the fuel cost per mile of travel would be greater and motorists would drive less. Taking this into account, and assuming an elasticity of -0.2, the fuel savings would be reduced to 45 billion gallons and $55 billion.

forced manufacturers to produce lighter vehicles that resulted in increased traffic injuries and fatalities (Crandall and Graham, 1989), to the claim that a variety of take-back effects from increased driving to slower scrappage rates essentially negated the potential benefits of increased MPG (Leone and Parkinson, 1990; Kleit, 1990). The experience of the past 25 years suggests that concerns over these potential threats were greatly exaggerated.

2. REGULATION AND ECONOMIC EFFICIENCY

When an activity such as vehicle travel produces an external cost, it is well known that even perfectly competitive markets will fail to allocate resources so as to maximize social welfare (e.g. Baumol and Oates, 1988). The most widely recognized solution to such a problem is to levy a tax on the activity equal to the marginal social damage created by the externality it produces (Pigou, 1918). However, in many instances, the link between activity and external damage is not immutable. This is certainly the case with motor vehicle emissions. The U.S. Department of Transportation (U.S. DOT) estimates that the average vehicle on the road in 1994 emitted one-half to one-fourth as much pollution as the average vehicle in use in 1970, depending on the pollutant (U.S. DOT/BTS, 1996, p. 141-142). The difference is the use of advanced pollution control technology, such as three-way catalytic converters, multi-point fuel injection, and electronically controlled combustion, in newer vehicles. Clearly, technology can change the relationship between the level of activity and the environmental damage caused by it. Moreover, technology has proven to be by far the most important factor. Had there been no changes in emissions rates per vehicle mile since 1970, highway vehicles would have produced 4.5 times as much hydrocarbons, 3.2 times the CO and twice as much nitrogen oxides as they actually did in 1964 (U.S. DOT/BTS, 1996, p. 143). It is difficult to imagine how such reductions could have been achieved by reducing vehicle travel. Still, economic efficiency requires both that decisions taken regarding the amount of travel reflect the external costs of that travel, and that decisions taken regarding the use of technology in vehicle design do likewise. In economic jargon, there are two marginal conditions to be satisfied (see, Freeman, 1997).

The fact that technology, too, must be optimized to reduce emissions has profound implications for environmental policy. First, if there is a tax to be imposed, it must fall directly on the external damage. Taxing only the activity, vehicle travel, will fail to produce the appropriate changes in technology. Second, there is no inherent reason why a well-chosen technology standard, in combination with a tax on the activity, could not achieve precisely the same result as an optimal externality tax imposed directly on the externality itself. This is demonstrated for the case of carbon emissions in the appendix.

But even more important is the fact that correcting market failures associated with transportation is a very complex undertaking. At present, it remains impractical to measure and directly tax external damages done by criteria pollutant emissions (Vickery, 1992). Not only is there the problem of accurately measuring each vehicle’s emissions and collecting the tax, but emissions will vary importantly according to how a vehicle is operated and maintained, and damages will vary according to weather conditions, location, and many other factors. Taking almost all of these complications into account, Innes (1996) has demonstrated that regulatory standards such as CAFE can be a part of an efficient policy strategy.

The problem is further complicated by the fact that air pollution is not the only market failure associated with transportation. As Crawford and Smith (1995, pp. 33-34) put it:

> "Formulating appropriate policies toward the taxation of road transport is, however, far from straight-forward, due to the varied range of social costs (externalities) associated with road use (congestion, accidents, road and environmental damage), and the complex interactions between road transport, other modes of transport and issues of spatial development . . . this complexity is amplified by the existence of significant "second best" aspects of the use of existing fiscal instruments . . ."

In the case of the CAFE standards, the market failure they were most directly aimed at, oil market disruptions and the market power of the OPEC cartel, is not properly characterized as an externality (Greene et al., 1997; Greene, 1997).[3] For this reason, the success of the CAFE standards may ultimately depend as much on the degree to which they stimulated technological change as their effectiveness in reducing oil consumption.

The point is that there are neither theoretical nor pragmatic reasons for prejudging regulatory standards like CAFE to be *a priori* inferior to other policy instruments for correcting market failures associated with energy use in automotive transportation. An issue that does bear directly on the relative merits of efficiency standards versus taxes, is the efficiency of the market for automotive fuel economy. If there are good reasons to believe that this market may not respond effectively to fuel taxes, a regulatory approach might be preferable.

3. THE MARKET FOR FUEL ECONOMY: HOW EFFICIENT IS IT?

In the absence of evidence to the contrary, it is customary for economists to assume that any given market operates as a competitive market, efficiently allocating resources and producing goods and services that maximize social welfare. Why, CAFE critics ask, should the market for fuel economy be otherwise (e.g., Nivola and Crandall, 1995, Ch. 2; Blakemore and Ormiston, 1996, p.7)? First, there are clear market failures. Consumption of petroleum products in motor vehicles produces nontrivial external damages to the environment that have been well documented (see, e.g., U.S. DOT/BTS, 1996). Also, the petroleum market itself is partially cartelized which, though not an externality, is still a significant market failure in the form of imperfect competition (see, e.g., Greene et al., 1997). Second, there are good reasons to believe that the market for fuel economy itself is "sluggish," that is, it may tend to produce a satisfactory rather than an optimal solution (see, e.g. Stern, 1984). The reasons for this, which are explicated below, include imperfect information and

[3]A part of the cost of oil market failure, the monopsony cost, is analogous to an external cost (Broadman, 1986).

satisficing behavior on the part of consumers, together with risk aversion and to some extent oligopolistic behavior on the part of producers. Were it not for the significant market failures associated with petroleum consumption, this sluggishness could probably be safely ignored.

If the buyer of a new car could save $200 per year on fuel by purchasing a 10 MPG more efficient vehicle, wouldn't this provide an adequate incentive to consumers to search one out and producers to produce such a vehicle? Surely, the market will respond to an incentive worth $1,500, or so in present value. While this argument seems appealing, it ignores the fact that to get that $200 per year in savings, consumers must pay more for the vehicle in the first place. It is the net value of the fuel economy investment that matters to consumers, not the gross fuel savings. Studies of the costs of fuel economy improvement show that the net value of higher fuel economy to consumers is relatively flat over a fairly wide range of fuel economy increases. Using data from the National Research Council's (NRC, 1992) study of automotive fuel economy, Greene (1996) has shown that estimates of the potential for fuel economy improvement based on industry data indicate less than a $100 variation in net present value over an approximately 5 MPG range above current MPG levels. Calculations based on U.S. Department of Energy (U.S. DOE) data indicate just slightly more than a $100 difference in net value over a 10 MPG range above the present MPG level (Figures 1 and 2). In other words, whether new car MPG is 30, 35 or 40, would be a matter of ±$100 or so net present value to the average consumer. One hundred dollars is just a bit more than one-half of one percent of the average price of a new car. In other words, the incentive to the consumer is not large, it is on the order of the cost of a set of floor mats, or the difference between the standard wheel covers and a slightly flashier set.

Anyone who has purchased an automobile knows that choosing a car can be a complex multidimensional decision. Among the important items to consider are price, size, reliability, safety, style, performance, handling, comfort, fuel economy, and more, including a wide array of amenities from sound systems to air conditioning to power seats. There is also frequently a negotiating process in which failure to be fully informed and pay close attention can cost hundreds or even thousands of dollars. Will a consumer really take the time and effort to optimize on each and every feature, especially on a feature whose net worth is less than $100? I submit that on items of lesser importance, rational consumers will balance the potential benefits against the cost in time and effort of making a precisely optimal decision. In other words, they will decide roughly on a satisfactory range and, if the item falls within that range for that characteristic, they will deem it acceptable. Precious time and effort to research facts and trade-off attributes will be saved for the most important characteristics.

It is often claimed (e.g., Nivola and Crandall, 1995, p. 27) that information about fuel economy is very precise, because every car carries a prominently displayed fuel economy label (a byproduct of

Figure 1. Net Present Value of MPG Increases for a Subcompact Car, Using Industry Data

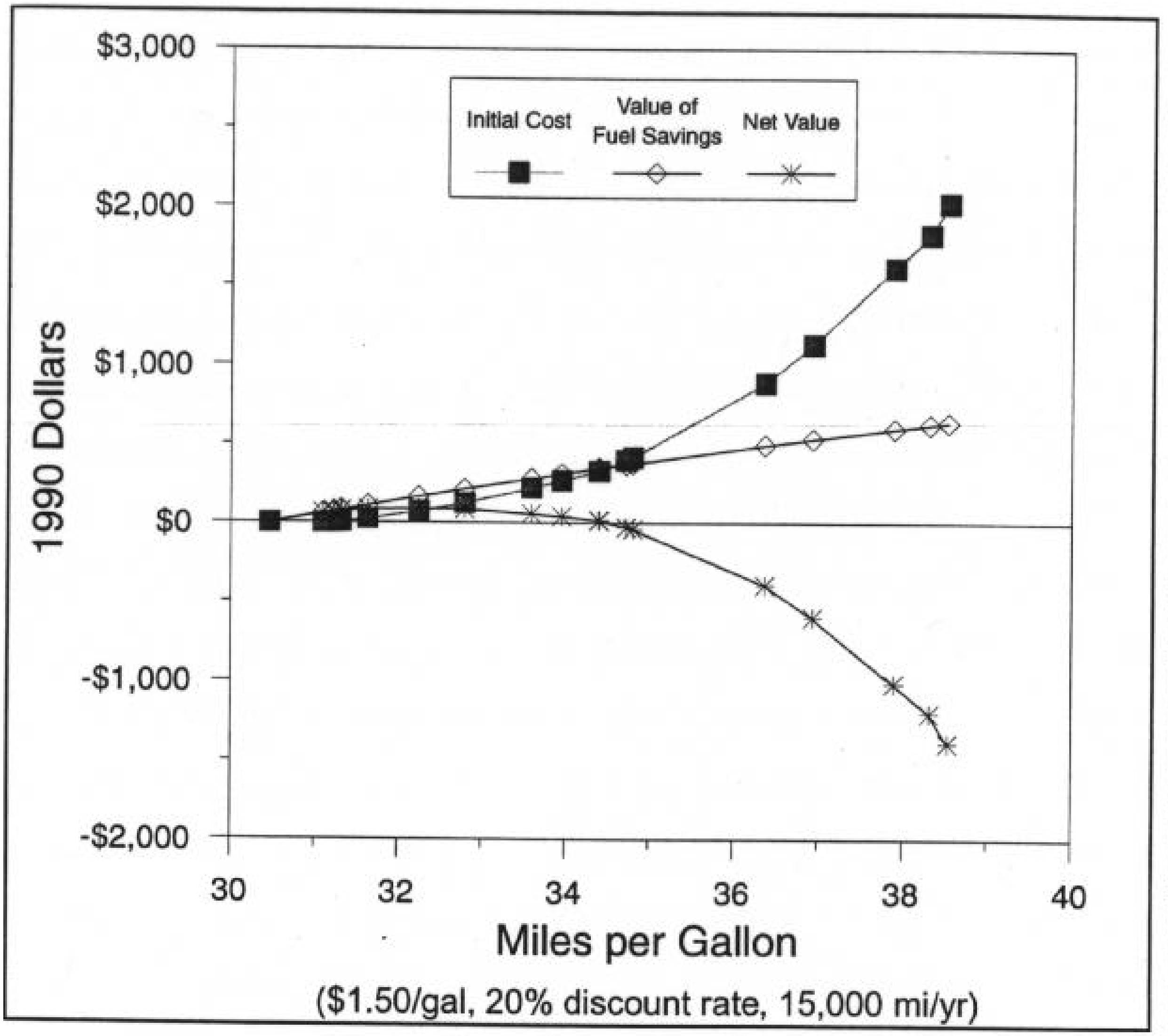
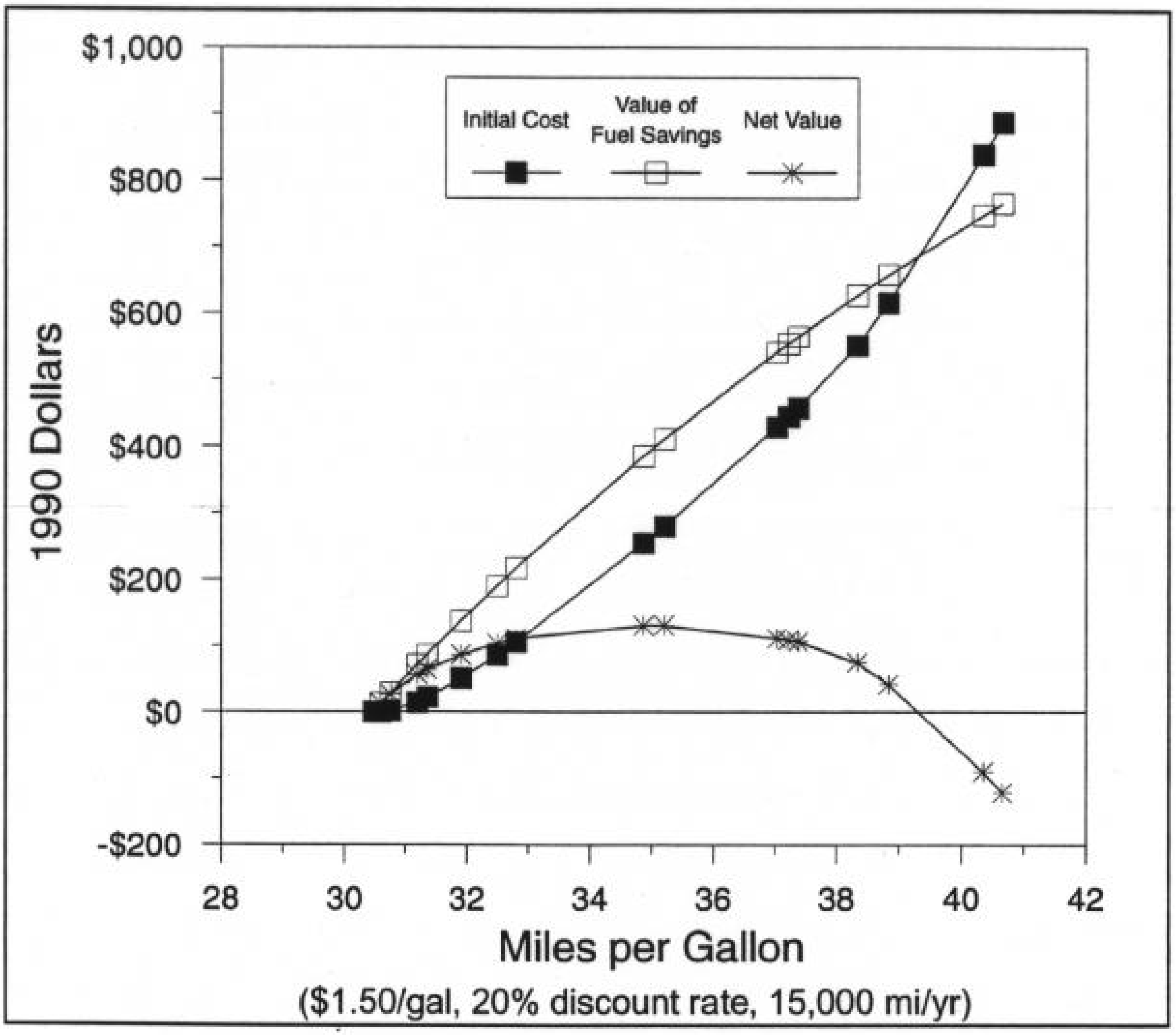


Figure 2. Net Present Value of MPG Increases for a Subcompact Car, Using U.S. DOE Data



the fuel economy regulatory program, by the way). But how precise is the information on the label? The numbers have already been adjusted for the average shortfall between EPA test and actual on-road experience (about 15 percent), but this will vary by ±10 percentage points, or more, according to driving style and environmental conditions. Also, the label provides two fuel economy numbers, one for city and one for highway driving. Although the difference varies from car to car, the highway number is 30 percent to 50 percent higher than the city number. For the 1996 Ford Taurus, for example, the highway MPG is 45 percent higher (29 v. 20 MPG). It is up to the motorist to determine what his or her representative driving pattern is and to compute the weighted harmonic mean. For the motorist with a typical 55 percent city, 45 percent highway pattern, this would be 23.25 MPG. (The motorist who did not know that a harmonic mean was necessary and also failed to take a weighted average would have estimated 24.5, an error of 5.4 percent.) Now one must estimate future fuel prices, future annual driving rates and, having decided upon the appropriate discount rate, then compute the net present value of the fuel economy improvement.

But wait, we're not done yet. That increase in fuel economy is going to cost something. The buyer must now estimate the cost of the fuel economy improvement, how long the vehicle is to be held, what the depreciation over that period is likely to be and then discount that to be able to estimate the present cost of the investment in fuel economy (this also involves assessing how accurately the used car market will evaluate the remaining value of the fuel savings when the car is resold or traded in). But where is the label that says what the fuel economy improvement cost? There isn't one. This the consumer must estimate from a multidimensional trade-off analysis of the fuel economies, prices, and other characteristics of various cars available in the market, no mean feat even for a Ph.D. econometrician.

The bottom line is that consumers cannot optimize their fuel economy decisions because they lack all the necessary information and it is not cost-effective to obtain it. When this situation is combined with the relatively minor difference in net value between the optimal fuel economy level and one 5 or 10 MPG away, the result is a weak market signal to manufacturers to change fuel economy. And what about the risk to manufacturers of making a wrong decision? Significant changes in fuel economy require major changes in vehicle design. The 10 MPG increase shown in Figure 2 above requires a completely new drivetrain, a complete body redesign to improve aerodynamics and achieve weight reductions via materials substitution, plus a host of miscellaneous improvements to accessories such as air conditioners, power steering, and alternators (NRC, 1992, appendix E). Such innovative redesign involves considerable risk that consumers may not like the style changes or that new components may not prove as reliable as the old ones. Moreover, if a manufacturer is to achieve a fleet average gain of 10 MPG, all makes and models would have to be similarly redesigned. This would amount to "betting the farm" on something about which consumers are almost indifferent.

But if fuel economy improvements are risky to manufacturers, how do standards help? What is the magic of standards that reduces the risk? The magic of standards derives from the difference between the intensive competition among manufacturers for sales, and the extensive competition between the automobile industry as a whole and all other products vying for the consumer's dollar. Whereas the demand for a particular make and model of car may be highly price sensitive (econometric studies such as Bordley, 1994, and Berry et al., 1995, indicate price elasticities in the vicinity of -5 for choice of make and model), the aggregate demand for all new cars is much less sensitive to price, or any other vehicle attribute (the price elasticity of demand for new cars is generally agreed to be about -1, e.g., see Kleit, 1990). Thus, a pricing or design mistake that could spell disaster for a single carline or a single manufacturer would be a much smaller problem for an entire industry.

This does not imply that fuel economy standards can be set recklessly, without regard to cost-effectiveness to the consumer and without allowing adequate time for testing, retooling and the normal turnover of manufacturing capital. Even small mistakes are big mistakes when they affect the entire automotive industry. Nor does it imply that the differential impacts of standards on different manufacturers can be ignored. What it does mean is that society as a whole can rationally be less risk-averse than a single manufacturer when deciding on a future fuel economy program.

Indeed, considerable care was taken in establishing the CAFE targets to be sure that cost-effective, marketable technologies would be available to meet the standards. Initial comprehensive studies (e.g., Coon et al., 1974; Energy Resources Council, 1976; U.S. DOT, 1977a; U.S. DOT and EPA, 1975) were complemented by hearings and public rulemakings (U.S. DOT/NHTSA, 1977b; 1978) to verify that the fuel economy goals established met the law's tests of technological feasibility and economic practicability, taking into consideration the nation's need to conserve oil and the effects of other regulatory standards. The fact that manufacturers were able to meet CAFE requirements largely by adopting technological improvements is the key reason why other, theoretically possible market distortions did not materialize. The role of technology is perhaps best illustrated by Greene and Fan's (1995) calculation that the typical 4,000 lb., 15 MPG passenger car of 1975 built with today's technology would get 25 MPG.

Finally, while there is certainly competition in the automobile market, it is somewhere between perfect competition and oligopoly. The biggest manufacturers can observe what competitors are doing and choose to lead, follow, or stand pat, up to a point. In other words, a given manufacturer's decision to embark on a fuel economy improvement program may depend a great deal on what the other major manufacturers are doing.

The implication of all of the above is that it is reasonable and rational to expect a sluggish market for automotive fuel economy. The net present value to consumers is relatively flat over a wide range of potential fuel economy levels. In addition, it is not reasonable to expect consumers to be precise optimizers in trading-off fuel economy and other vehicle attributes. This relatively weak incentive to producers is matched by a potentially enormous risk to a manufacturer if a plan for major improvements in fuel economy turns out to be a miscalculation.

4. THE REBOUND EFFECT: DOES FUEL ECONOMY IMPROVEMENT ACTUALLY SAVE FUEL?

4.1 VEHICLE TRAVEL AND FUEL COST PER MILE, THE MAIN EFFECT

A key criticism of the regulatory approach is that increasing fuel economy without imposing the appropriate tax will reduce the fuel cost per mile of vehicle travel, thereby stimulating increased travel. Increased travel, of course, implies increased fuel consumption which would work against the chief intent of fuel economy improvement: to reduce fuel consumption and the resulting greenhouse gas emissions. The existence of a "rebound effect" in no way denies the existence of an efficient regulatory standard (Khazzoom, 1980).[4] The importance of the rebound effect is that its size is a critical determinant of the relative importance of technical efficiency versus a usage tax in achieving the economically efficient reduction in emissions.

There is no reason to doubt that the rebound effect exists. The key question is, how big is it? If it is very small, say 10 percent or so, its impact will be negligible. If very large, say 90 percent, then it would virtually negate the intended societal benefits of fuel economy regulation. The size of the rebound effect depends on the elasticity ($\beta_{M,gP}$) of vehicle travel, (M), with respect to the cost of fuel per vehicle mile, (gP), where g is fuel intensity in gallons per mile and P is the price of fuel in dollars per gallon. The effect of a change in fuel intensity, g, on fuel consumption, F, is given in equation (1).

$$\frac{dF}{dg} = M + g\,\frac{dM}{d(Pg)}\,\frac{d(Pg)}{dg} = M + gP\,\frac{dM}{d(Pg)} \qquad \textbf{(1)}$$

If both sides of equation (1) are multiplied by (g/F), then by rearranging terms and noting that F = gM, the relationship between the elasticity of fuel consumption with respect to fuel intensity, ($\beta_{F,g}$) and the fuel cost per mile elasticity of travel, ($\beta_{M,gP}$) is obtained.

$$\beta_{F,g} = 1 + \beta_{M,gP} \qquad \textbf{(2)}$$

Since the fuel cost per mile elasticity of travel is <0, the efficiency elasticity of fuel use will decrease the more fuel-cost-elastic travel is. The fuel cost per mile elasticity of travel is a function of the own price elasticity of fuel demand and the fuel price elasticity of fuel intensity as shown in equation (3).

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[4]This effect is taken into account in the theoretical derivation of an optimal regulatory standard and usage tax presented in the appendix.

$$\beta_{M,gP} = \frac{(\beta_{F,P} - \beta_{g,P})}{(1 + \beta_{g,P})} \tag{3}$$

Estimates of gasoline demand made before the mid 1980's suggested that U.S. gasoline demand was inelastic in the short-run but close to unit elastic in the long-run (see, Dahl, 1986; and Dahl and Sterner, 1991, for comprehensive reviews). A much smaller number of early studies indicated that the fuel price elasticity of fuel economy was on the order of +0.5. These values when entered in equation (N+2) would imply fuel cost per mile elasticity also in the vicinity of -1, or somewhat less. The difficulty shared by all of the early studies was a relatively small historical variation in both fuel prices and fuel economy. The second oil price shock of 1979-1982, the oil price collapse of 1986, the smaller oil price rise of 1991, together with the substantial increase in light-duty vehicle fuel economy over the 1980-1995 period created a much richer database with which to infer price responses (Figure 3).

More recent estimates based on the full experience with fuel price and fuel economy changes has produced very different but nearly unanimous results. Using aggregate national data, first Mayo and Mathis (1988), then Gately (1990; 1992), Greene (1992), Jones (1993) and then Nivola and Crandall (1995) all found fuel cost per mile elasticities of travel of less than -0.25, even in the long run. Most estimates fell in the vicinity of -0.10 to -0.2. Haughton and Sarkar (1996) confirmed these results using a time series of state-level data. Only Walls et al. (1993) have recently produced estimates based on a single year of survey data that indicate fuel cost per mile elasticities in the vicinity of -0.4. But that analysis omits age of vehicle as an explanatory variable for vehicle miles. Vehicle usage is well known to be negatively correlated with vehicle age, as is fuel economy for models years 1975 through 1983. Models estimated using survey data that include age as a right-hand side variable, carried out by Golob et al. (1996) and Goldberg[5] (1996) have produced cost per mile elasticities close to zero.

The conclusion that the elasticity of VMT with respect to fuel cost is small, is quite robust when recent data are used. Even Nivola and Crandall (1995) who assert in chapter 3 of their book that the fuel price elasticity of VMT is -0.5, report in Appendix A of their book that their own econometric analysis produced a fuel price elasticity of -0.1, entirely consistent with the results of other recent studies.[6] In addition, they found that the elasticity of fuel economy (MPG) was only 0.04 and not statistically significantly different from zero. In other words, Nivola and Crandall's (1995, p. 126) econometric results are consistent with the hypothesis that there is no rebound effect whatsoever.

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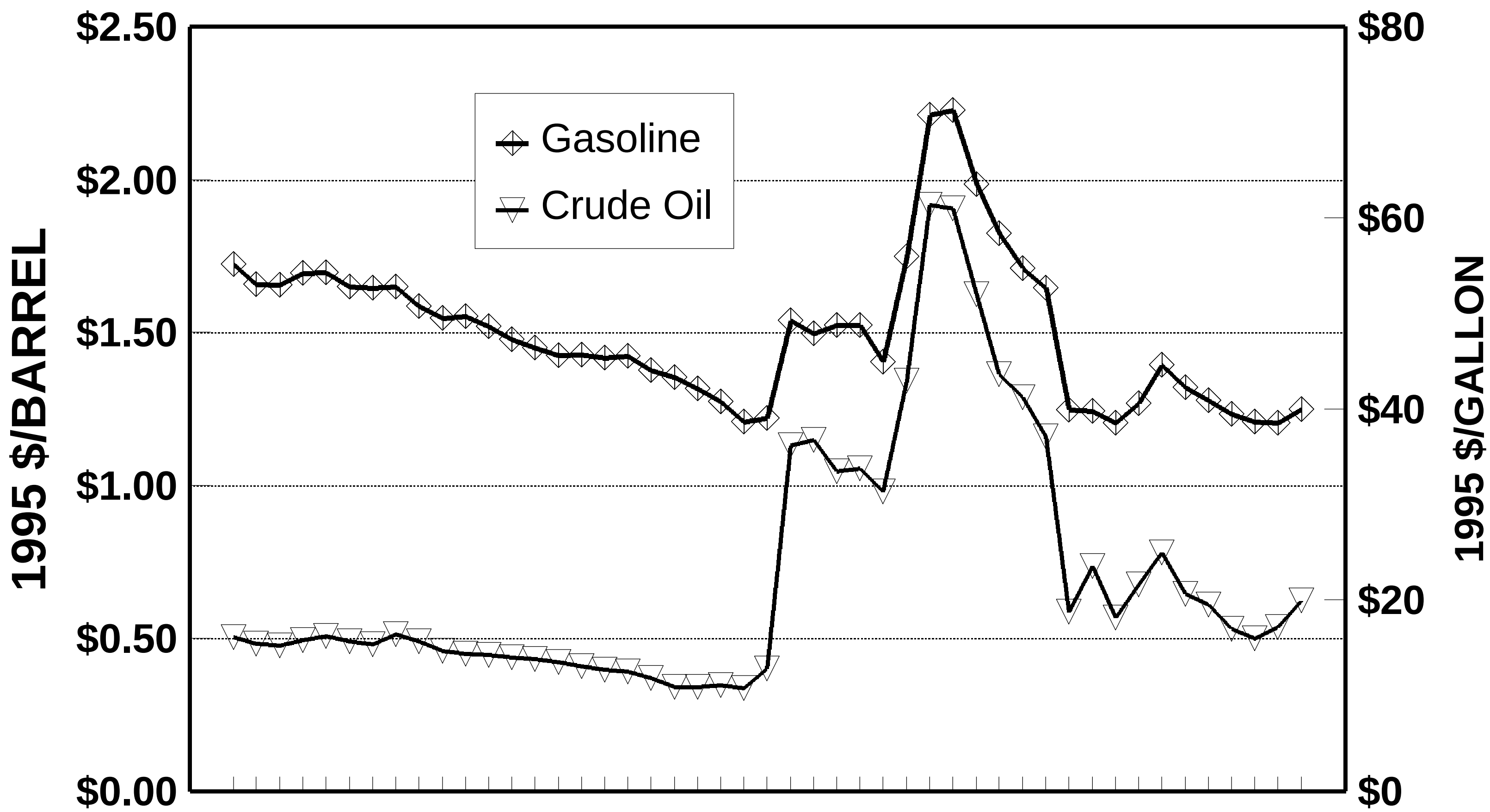
[5]Goldberg (1996) does not actually include age as a variable but instead uses an instrumental variable approach to reduce the effect of omitted, correlated variables. She obtained a fuel cost elasticity estimate of -0.11.

[6]Their data were for the U.S. as a whole and covered the period 1962 to 1992.

Figure 3. Crude Oil and Gasoline Prices, 1950-1996



U.S. DOE/EIA, AER 1996, Tables 5.16, 5.19, and 5.21.

The idea that the rebound effect may be smaller than the fuel-cost-per-mile elasticity of vehicle travel is further supported by recent analysis of asymmetry in the price elasticity of demand for petroleum and petroleum prices. Dargay and Gately (1994) have shown that petroleum and petroleum product demands appear to respond more to price increases than price decreases. Their econometric analysis indicates an elasticity of about -0.21 for rising prices but only -0.04 for falling prices for oil demand in the U.S. transportation sector. Since increasing fuel economy amounts to a decrease in the fuel cost of travel, this suggests that the rebound effect may well be smaller than the average fuel cost elasticity of vehicle travel.

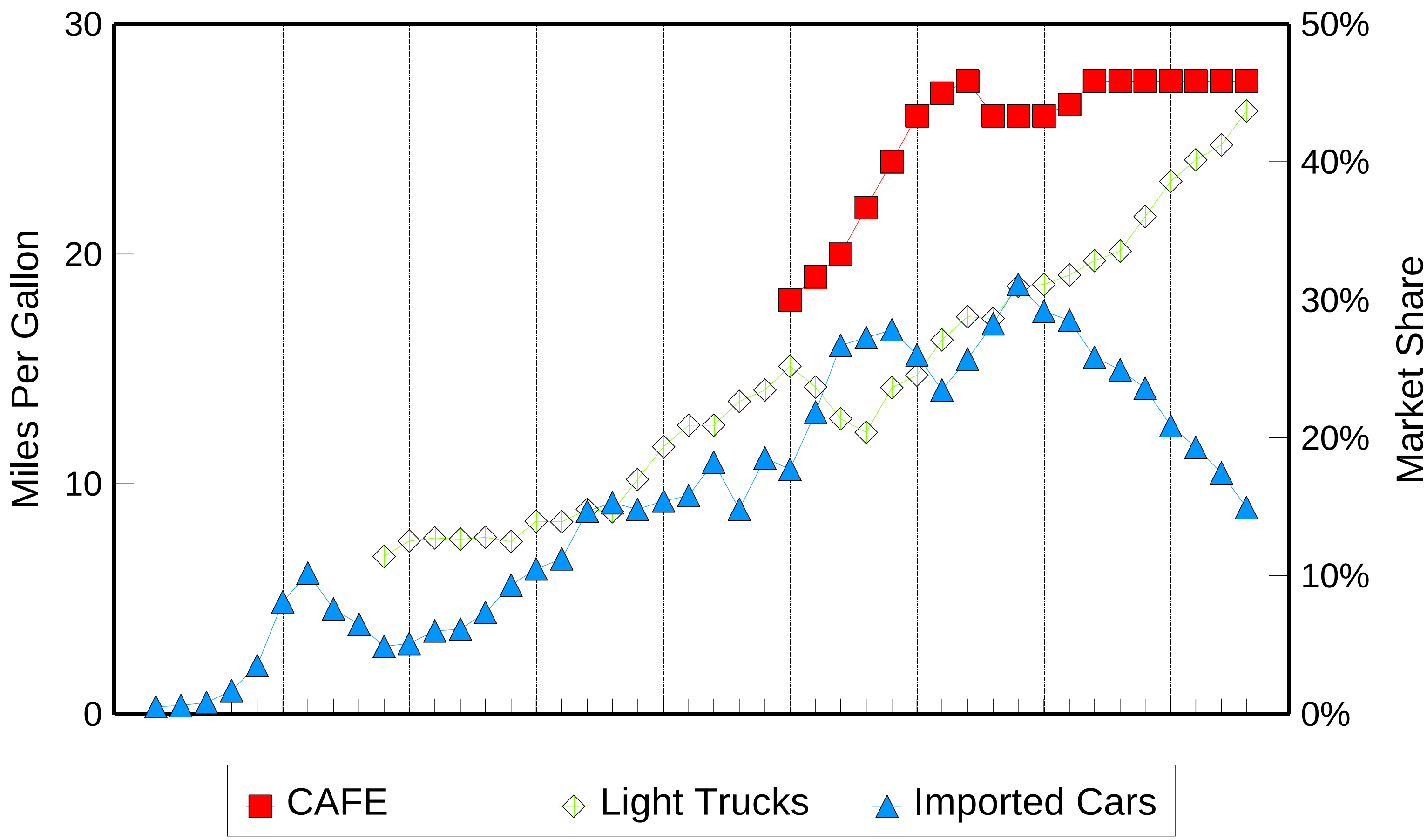
Thus, recent estimates of the rebound effect based on the full experience with fuel price and fuel economy changes over the past 25 years provide very strong evidence that it is quite small, on the order of -0.1 in the short-run and about -0.2 in the long-run. The implication is that 80 percent to 90 percent of the maximum potential reduction in fuel consumption and greenhouse gas emissions due to a technical change in vehicle efficiency will be realized, even after the increase in vehicle miles due to lower per mile fuel costs has had its full effect. Once again, the prima facie evidence is entirely consistent with this conclusion. Despite an 80 percent increase in light-duty vehicle travel from 1975 to 1995, light-duty vehicle fuel use has increased by only 20 percent. The difference is attributable to a 50 percent increase in on-road fuel economy over the same period. The average annual growth in VMT of 3 percent is consistent with historical trends. The rebound effect has not obviated the potential benefits regulatory-driven fuel economy gains. Instead, those improvements now reduce U.S. gasoline use by about 45 billion gallons of gasoline per year and save motorists about $55 billion per year in gasoline costs.

4.2 THE SHIFT TO LIGHT TRUCKS

Another rebound argument asserts that CAFE standards may cause consumers to buy light trucks instead of cars because the stricter CAFE standards for cars force manufacturers to make design trade-offs that car buyers dislike. Certainly the market share of light trucks has increased over the period during which the CAFE standards have been in effect. But historical data suggest that this may have been a continuation of a long-term trend that began much earlier (Figure 4). The dramatic rise in light truck market share since 1982 is mainly due to the success of two innovations introduced during the mid 1980s: the minivan and the sport-utility vehicle (Figure 5). These two new vehicle types are clearly passenger vehicles and are the most car-like of the light truck types. The issue is whether these innovations in truck design were a result of the stricter emissions and fuel economy standards imposed on passenger cars, or whether they were instead prompted by trends in demographics, income, and life styles (e.g., the rise of the sun belt, changes in the roles of women, baby boomers raising families, etc.). While such questions cannot be definitively resolved by scientific analysis, one can at least calculate the impacts of increased light truck market share on the combined MPG of light-duty vehicles.

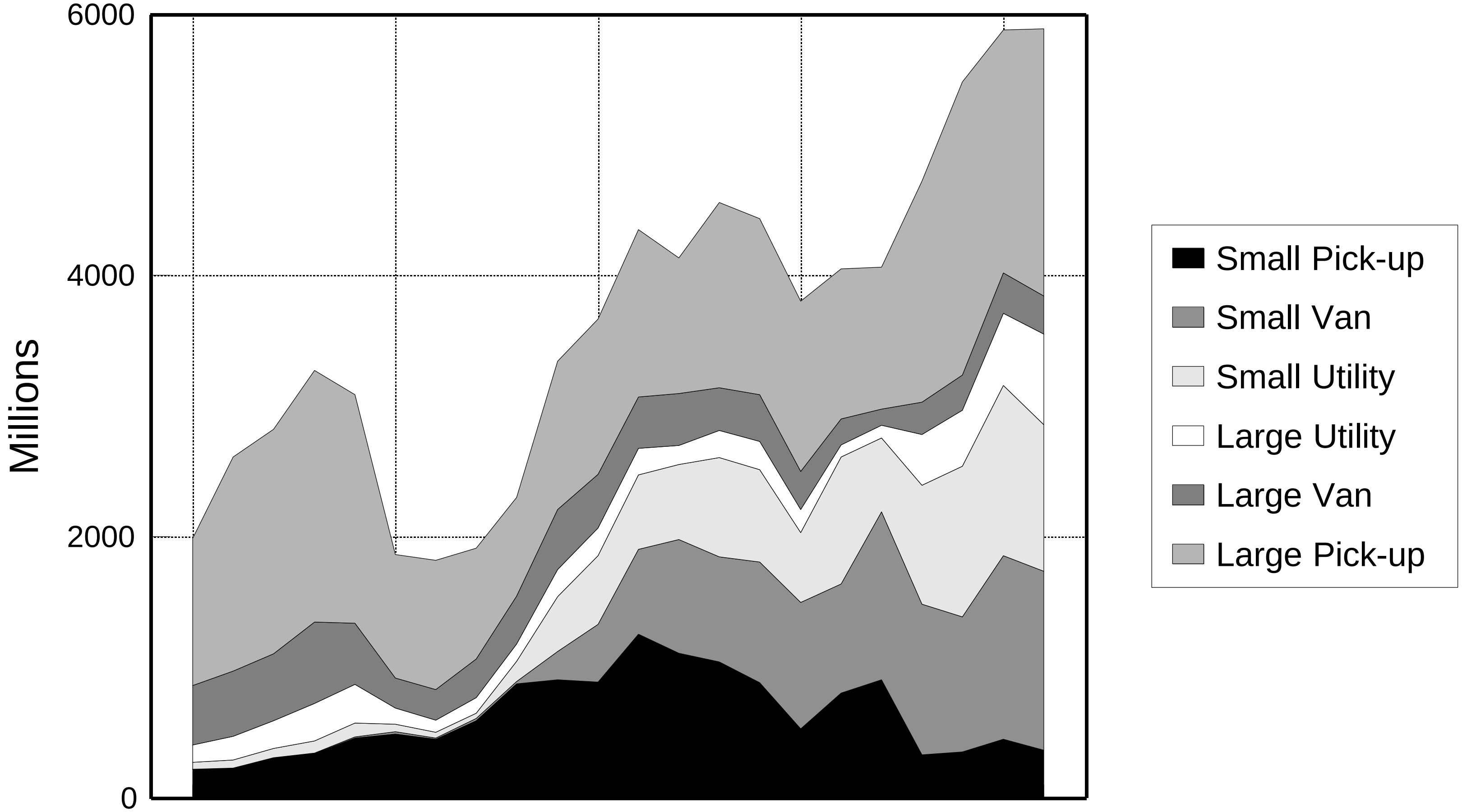
Had light truck market share remained at pre-CAFE levels, combined light-duty vehicle fuel economy would have been 1.5 to 2.0 MPG higher than it actually was in 1996 (Table 1). Using

Figure 4. Sales of Light Trucks as a Share of Light-Duty Vehicles Sales of Imported Cars as a Share of Passenger Cars



Source: Davis, 1997, Transportation Energy Data Book, Ed. 17, tables 2.22, 3.7 and 3.16; MVMA, 1974 Motor Truck Facts, p.9; Wards 1971 Automotive Yearbook, p. 11; Automotive News Market Data Book, 1997, p. 46.

Figure 5. Light Truck Size Class Sales, 1975-1996



Source: Heavenrich and Hellman, 1996, appendix G.

Table 1. Effect of Increased Light Truck Market Share on Light-Duty Vehicle Fuel Economy

	1996 v. 1978				Combined MPG Using 1978 Share & 1996 MPG	"Loss" Due to Greater Light Truck Share
	1978 MPG	1978 Share	1996 MPG	1996 Share		
Passenger Cars	19.9	77.4%	28.5	59.5%		
Light Trucks	15.3	22.6%	20.5	40.5%		
Combined	18.6	100.0%	24.6	100.0%	26.2	-1.6
Combined, assuming Lt. Truck MPG of 21.8			25.4		26.6	-1.3
	1996 v. 1975				Combined MPG Using 1975 Share & 1996 MPG	"Loss" Due to Greater Light Truck Share
	1975 MPG	1975 Share	1996 MPG	1996 Share		
Passenger Cars	15.8	80.6%				
Light Trucks	13.7	19.4%				
Combined	15.3	100.0%			26.5	-1.9
Combined, assuming Lt. Truck MPG of 24.7			26.8		27.7	-0.8

Source: Heavenrich and Hellman, 1996, table 1. The numbers in this source differ slightly from the official NHTSA CAFE numbers. For example, NHTSA reports 1996 Passenger Car and Light Truck MPGs as 28.7 and 20.7, respectively. Heavenrich and Hellman, however, provide a consistent set of MPG estimates back to 1975 while the NHTSA data do not.

1975, the year in which the CAFE legislation was enacted, as the base year results in a 1.9 MPG impact. Using 1978, the first year of binding CAFE standards, results in a 1.6 MPG loss. But this hypothetical loss of fuel economy is not only due to the increased popularity of light trucks. It is also due to the unequal standards established for the two vehicle types. Whereas the 27.5 MPG passenger car standard represented a 75 percent increase over the 1975 average of 15.8, the 20.5 MPG light truck requirement represents only a 50 percent increase. Had light truck MPG improved as much as passenger car MPG, the impact of the shift to light trucks would have been half as large, about 0.8 MPG (Table 1). The difference in stringency of passenger car and light truck standards is attributable to the fact that passenger car targets were set in the law itself, whereas the light truck standards were left to be determined by rulemakings of the Department of Transportation. In retrospect, it is clear that the decision not to set equally challenging standards for light trucks has cost about 1 MPG in overall light-duty vehicle fuel economy.

In the early years following the implementation of the CAFE standards, there was great concern about the "shortfall" of MPG achieved in real world driving versus the EPA's test estimates. After extensive study of the phenomenon (e.g., Murrell, 1980; Falcon Research, 1981; McNutt et al., 1982), the EPA decided upon correction factors to adjust test estimates to better reflect average fuel economy experienced by motorists: (1) a 10 percent reduction for urban driving, (2) a 22 percent reduction for highway driving, and (3) a 15 percent combined discount (Hellman and Murrell, 1984). At the time, there was concern that the on-road versus test gap might continue to grow over time. Follow-up studies by the U.S. DOT (NHTSA, 1986) and the U.S. DOE (U.S. DOE/EIA, 1996) have shown that the gap has remained essentially constant. As a result, a given percentage improvement in EPA test MPG translates into essentially the same percentage improvement in real world fuel economy.

In general, the fuel economy improvements that occurred from 1975 to 1993 had almost nothing to do with sales mix shifts among light-duty vehicle (interior volume) size classes. Using Divisia analysis to estimate the factors responsible for fuel economy changes in the light-duty vehicle fleet from 1975 to 1993, Greene and Fan (1995) found that, (1) salesmix shifts within light truck size classes had a beneficial effect on MPG, (2) salesmix shifts within car size classes had a slightly beneficial effect on MPG, and (3) the shift from cars to light trucks had a negative effect on MPG. The net result, however, was about a one-half MPG *improvement* in the combined fuel economy of passenger cars and light trucks over what it would have been had the size class market shares been frozen at 1975 values.[7] This, despite CAFE standards requiring nearly a doubling of passenger car MPG.

4.3 VEHICLE SCRAPPAGE AND FUEL ECONOMY

It is also claimed that because fuel economy standards create market distortions, they will cause new cars to be higher-priced and inferior in the eyes of consumers. As a result, the relative value of older cars will increase and consequently they will be kept longer by motorists. This should show up as an

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[7]Greater detail on the salesmix shift analysis can be found in Greene and Fan (1994).

increase in the age and expected lifetime of vehicles. Retarding scrappage rates will eventually lead to an older and therefore less efficient vehicle fleet, frustrating the intention to improve fleet fuel economy and reduce petroleum consumption.

In fact, the average age of vehicles and the expected lifetime of vehicles have both increased noticeably since 1970. The average age of a passenger car increased from 5.6 years in 1970, to 6.6 years in 1980, to 8.5 years by 1995 (Davis, 1997, table 3.4). But average age is also affected by the rate of growth of sales and even by the fluctuations in sales due to business cycles. Expected lifetime, a better measure of longevity, has also grown from 10.7 years for a 1970 model year automobile, to 12.1 years for a car manufactured in 1980, to 13.7 years for a 1990 edition. But what effect has this had on fuel economy, and were the CAFE regulations responsible?

If one computes the fleet average fuel economy for the 1995 fleet of passenger cars, first using the actual 1995 distribution of vehicles by model year and, then using the 1978 model year distribution, an indication of the effect of the shift in the age distribution can be obtained.[8] Using the actual 1995 car population, one obtains an average EPA MPG of 26.5. Using the younger 1978 fleet, 27.5 MPG is obtained. Whether or not CAFE is responsible, the difference is 1 MPG or 4 percent.

But is CAFE responsible for any or all of the 4 percent difference? Other factors that have affected the age distribution of the passenger car fleet include the continuing shift to light trucks which has reduced the growth of passenger car sales necessarily leading to an older fleet, manufacturer's successful efforts to improve durability, and the fairly steady increase in new car prices over the past twenty five years, from under $12,000 per car in 1970 to nearly $16,000 today (1990 $) (Figure 6). Hamilton and Macauley (1997), for example, attribute most of the increase in passenger car longevity over the past 25 years to improved product quality as a result of increased competition.

4.4 CAFE AND AIR POLLUTION

If CAFE standards had caused significantly greater vehicle travel, substantially prolonged the life of older vehicles, and meaningfully magnified the shift to light trucks (whose emissions standards are less strict) then CAFE standards could also have caused a significant increase in urban air pollution (see, e.g., Khazzoom et al., 1990). But we have seen that CAFE's effects in these areas,

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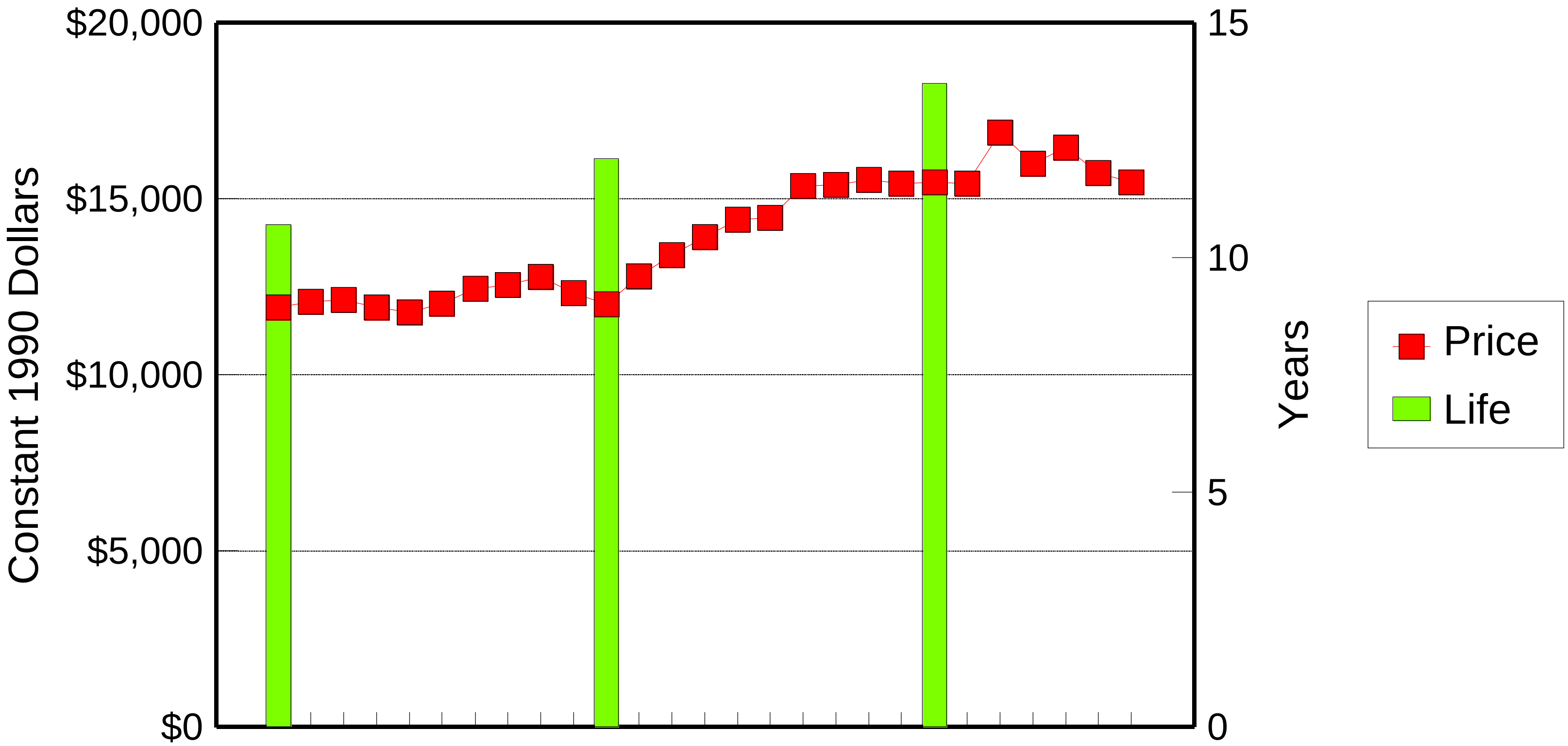
[8]This calculation consists of estimating the population-weighted harmonic mean fuel economy, taking into account the fact that vehicle use declines by about 4.5 percent per year as vehicles age. No correction is made for EPA test versus in-use vehicle fuel economy.

Figure 6. Average Sales Price and Expected Lifetime of a New Passenger Car



Source: Davis, 1997, Transportation Energy Data Book, Ed. 17, tables 2.22 and 3.5;

though they exist, are relatively minor. In addition, there are also important ways in which greater fuel economy reduces emissions.

Improving fuel economy reduces fuel consumption, thereby decreasing emissions from refueling through refining and oil production. These upstream reductions in hydrocarbon emissions are significant even for new, properly operating vehicles (Delucchi et al., 1994). Although it has been argued that tailpipe emissions do not depend on fuel economy (Dowlatabadi et al., 1996), Harrington (1997) recently demonstrated that while new cars of very different fuel economies produce about the same quantity of emissions, as vehicles age and pollution control equipment deteriorates, emissions of HC and CO become very closely related to fuel economy. Comparing 12-year-old 20 MPG and 40 MPG vehicles, Harrington's statistical analysis predicts that the average HC emissions for the gas guzzler will exceed those of the fuel efficient car by 2.1 to 3.5 grams per mile (gpm). Since the average emissions rate for a 12-year-old vehicle is 3.1 gpm, the gas guzzler will emit approximately twice as much of these pollutants as the higher fuel economy vehicle. For these two pollutants at least, raising fuel economy has clearly reduced air pollution.

5. SIZE, WEIGHT, SAFETY, AND CONSUMERS' SURPLUS: IF THINGS ARE SO BAD, HOW COME THEY'RE SO GOOD?

If CAFE standards have been binding on manufacturers, they should have forced changes in vehicle design, technology, and cost that would otherwise not have occurred. Since these changes are not what the market would have produced in the absence of standards, and if one assumes that the market for fuel economy is efficient (an assumption we have challenged above), then it follows that fuel economy standards will cause consumers to be less satisfied with new vehicles than they would have been without the standards. On the other hand, if there exist significant externalities associated with petroleum product consumption in motor vehicles, and if the market for fuel economy is sluggish besides (as we have argued), then regulations could actually improve social welfare.

The first question to be addressed is whether the CAFE standards or something else, like fuel prices, have been responsible for fuel economy related changes in MPG since 1975. We conclude that the regulations were primarily responsible for the fuel economy improvements that took place after 1975, but that higher fuel prices also played a role particularly between 1979 and 1982. The second set of questions to be addressed is whether those changes had a significant negative impact on consumer welfare. We conclude that they did not, despite the fact that real trade-offs were made to achieve higher fuel economy. These include increased vehicle cost, reduced weight, acceleration performance, and, to some extent, safety.

5.1 CAFE OR PRICE?

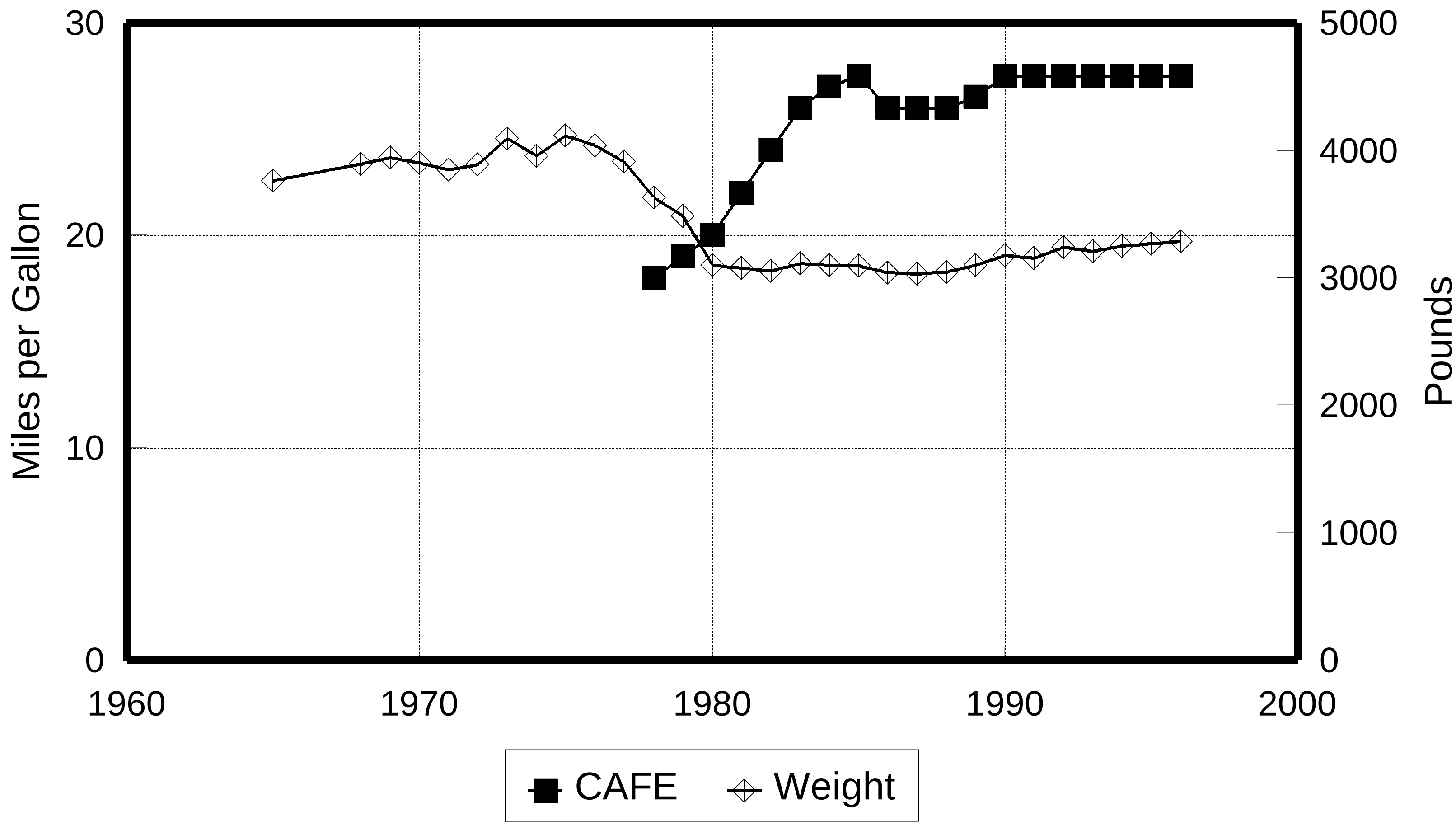
Paradoxically, some argue simultaneously (1) that the CAFE standards have done enormous harm to consumer welfare and (2) that they have not been binding, at least not during the period when both fuel prices and MPG were rising prior to 1983. For example, Crandall et al. (1986, pp. 123-124) argued that CAFE could not have significantly affected the vehicle design decisions of U.S. manufacturers during the 1970s. "Any effects of this new set of government regulations on automobile design might have begun to appear by the 1978 model year, but the major impacts would have been in evidence no earlier than the 1979 or 1980 model years." Based on their own calculations of what would have happened in response to fuel prices alone, in the absence of fuel economy standards, Crandall, et al. (1986, p. 135) concluded that essentially all of the fuel economy improvement that occurred from 1970 to 1983 was stimulated by fuel price shocks. "Overall, it appears that the improvement in fuel economy for the industry was very close to what would have been expected without the CAFE standards."

Of course, this early period is precisely the period in which vehicle weight and performance decreased (Figure 7). From 1975 to 1979 the average weight of domestically manufactured U.S. passenger cars decreased by 670 lbs., from 4,380 to 3,711 lbs. (Heavenrich and Hellman, 1996, table E-1). Average weight continued to decrease reaching 3,310 lbs. in 1983, a total reduction of 1,070 lbs. Weights of domestic light trucks show a similar, though less pronounced downweighting (Heavenrich and Hellman, 1996, table E-4), decreasing from 4,227 lbs. In 1975 to 3,977 in 1983, only a 250 lb. reduction. (While the light truck market experienced the same changes in fuel prices, light truck fuel economy standards were not nearly as stringent.) Since 1983, the period during which CAFE critics agree that the standards were binding on manufacturers, the average weights of domestic passenger cars and light trucks have actually increased, by 380 lbs. for light trucks and 110 lbs. for passenger cars.

If CAFE standards were not binding until 1983 or later, then fuel prices (or other factors) must have been responsible for the 1,000 lb. reduction in passenger car weight. If so, then it follows that any fuel economy or safety impacts of that weight reduction must be attributable to fuel prices and not CAFE standards. On the other hand, if CAFE standards were at least partially binding during this period, then they share with the oil price shocks responsibility for both weight decreases and MPG increases with the fuel price changes occurring over that period. It is clearly a logical contradiction to maintain both that CAFE had little or no effect on fuel economy from 1975 to 1983 *and* that CAFE was responsible for the decrease in vehicle weight that occurred over that period. Yet, opponents of CAFE still make this argument. Nivola and Crandall (1995, pp. 126-131) present a set of regression analyses which they claim prove both that CAFE has been responsible for most of the reduction in vehicle weight since 1968 *and* that fuel price and not CAFE is responsible for essentially all of the fuel economy improvement.

In a statistical test of the question of whether or not CAFE standards were binding for individual manufacturers over the period 1978 to 1989, Greene (1990) found that the standards were a significant constraint on all domestic and some foreign manufacturers. A test for structural change

Figure 7. Passenger Car Weight v. CAFE Standards, 1965-1996



did not reject the hypothesis that the effect of CAFE standards on these manufacturers were the same both before and after 1983. Greene (1990, p. 52) concluded, "There is no evidence here to support the assertion that the automotive fuel economy standards were not binding on manufacturers prior to 1983. On the contrary, it appears that their effect has been strong and consistent throughout the period." Greene (1990, p. 55) also found that for manufacturers unconstrained[9] by the CAFE standards, the fuel price elasticity of MPG was quite small, on the order of 0.2 in the long run. This result is also supported by Dahl's (1995) literature survey which found long-run elasticities of MPG with respect to gasoline of 0.2, or less.

Another possibility which is rarely considered yet very plausible, is that the "Gas-Guzzler Tax" also influenced the down weighting of the automobile fleet. Beginning in 1980, any passenger car with an MPG of less than 15 was subject to a gas guzzler tax. The tax does not apply to light trucks. The MPG limit was increased every year until in 1986 any car getting less than 22.5 MPG was defined as a guzzler. The graduated tax rates also increased over time from a range of $200 to $550 (depending on MPG) in 1980 to $1,000 to $7,700 today (Davis, 1997, table 3.43). The effect of the Gas-Guzzler Tax on passenger car design and sales appears not to have been studied. Yet it would seem reasonable to presume that it had some effect on depressing the market for the largest, least efficient passenger cars.

5.2 SMALL CARS, LIGHT CARS AND SAFETY

Vehicle weight, as normally applied in constructing motor vehicles, significantly affects the safety of a vehicle's occupants. Enough credible work has been done on this subject that this assertion cannot seriously be questioned (see, e.g., Evans, 1991, pp. 62-78; Kahane, 1991; Klein et al., 1991; Partyka and Boehly, 1989; Kahane, 1997). On the other hand, the nature of the trade-off between vehicle mass and safety is often misunderstood, and the implications for fuel economy regulations are generally misinterpreted. The relationship between fuel economy, mass and public safety is complex, yet it is probably reasonable to conclude that reducing vehicle mass to improve fuel economy will require some trade-off with safety. The rational person will realize that individuals, manufacturers and governments are constantly making trade-offs between safety and cost, safety and other vehicle attributes, safety and convenience, etc. (NRC, 1992, p. 7). An essential feature of a rational economic consumer is the willingness to trade-off risk for money and, since fuel economy saves money, to trade-off safety for fuel economy.

One source of uncertainty is the difficulty researchers have encountered in distinguishing between the effects of vehicle size versus weight on safety (e.g., Khazzoom, 1996, pp. 112-113). Not even the most recent, extensive study by the National Highway Traffic Safety Administration (NHTSA, 1997) was been able to successfully disentangle the correlation between size and weight to estimate their separate effects on safety. What NHTSA (1997) reports is the combined effect of both. The NHTSA

[9] An unconstrained manufacturer was defined as one whose current year salesweighted average fuel economy exceeded the CAFE standard for three years in the future by at least 1 MPG.

study is quite clear on this point. This is extremely important for programs such as the Partnership for a New Generation of Vehicles (PNGV), which are attempting to reduce weight but not size via substitution of low-density, high-strength materials. The NHTSA relationships are not valid for predicting the effects of such unconventional design changes.

The National Research Council (NRC, 1992) report on fuel economy made two key points about fuel economy and safety that have been too frequently ignored in analyses of the issue (e.g., Crandall and Graham, 1989). First, a distinction must be made between the private and public safety benefits of increased vehicle mass. The individual who buys a larger, heavier vehicle reduces his own risk of death or injury in a crash, but increases the risk to all other motorists who may collide with his larger, heavier vehicle. This principle extends from vehicle-to-vehicle collisions to include vehicle pedestrian and cyclist collisions. In this regard, NHTSA's (1997) most recent study of the car size versus safety issue is a major step forward. It predicts that a uniform decrease in the weight of all cars of 100 lbs., accompanied by proportionate size reductions, as well, would be expected to increase vehicle fatalities by 1.1 percent. On the other hand, it predicts that a reduction in light truck weights of 100 lbs., also accompanied by proportionate size reductions, would *reduce* motor vehicle fatalities by 0.3 percent. In other words, public safety would be hurt by a uniform reduction in car size and weight but improved by a uniform reduction in light truck size and weight. According to the NHTSA analysis, half of the increase in fatalities resulting from the 100 lb.-equivalent size and weight reduction for cars comes from increased fatalities in collisions with light trucks. A roughly equivalent increase comes from greater risk of fatality in collisions with fixed objects and rollover crashes. Pedestrians, bikers, and motorcyclists are benefitted by the reduction in car size and weight as are, surprisingly, the occupants of cars in car-to-car collisions.

The second key point made in the NRC (1992) study's assessment of the safety issue is that not just the average weight change, but the change in the distribution of weights matters. In fact, this point follows from the first. That is, if weights of heavier vehicles are reduced more than the weights of lighter vehicles, there could be no change in fatalities. This phenomenon can be illustrated using the results of the 1997 NHTSA analysis. Using the marginal impacts of a 100 lb. size and weight reduction published in the NHTSA study, the effects of a 500 lb.-equivalent reduction in light truck weight (from about 4,300 to 3,800 lbs.) together with a 66 lb.-equivalent reduction in passenger car weight (to about 3,200 lbs.) are calculated in Table 2. These weight reductions were deliberately chosen so that the net effect would be about zero. Note that there are winners and losers. Pedestrians, cyclists, and car occupants win, light truck occupants lose.

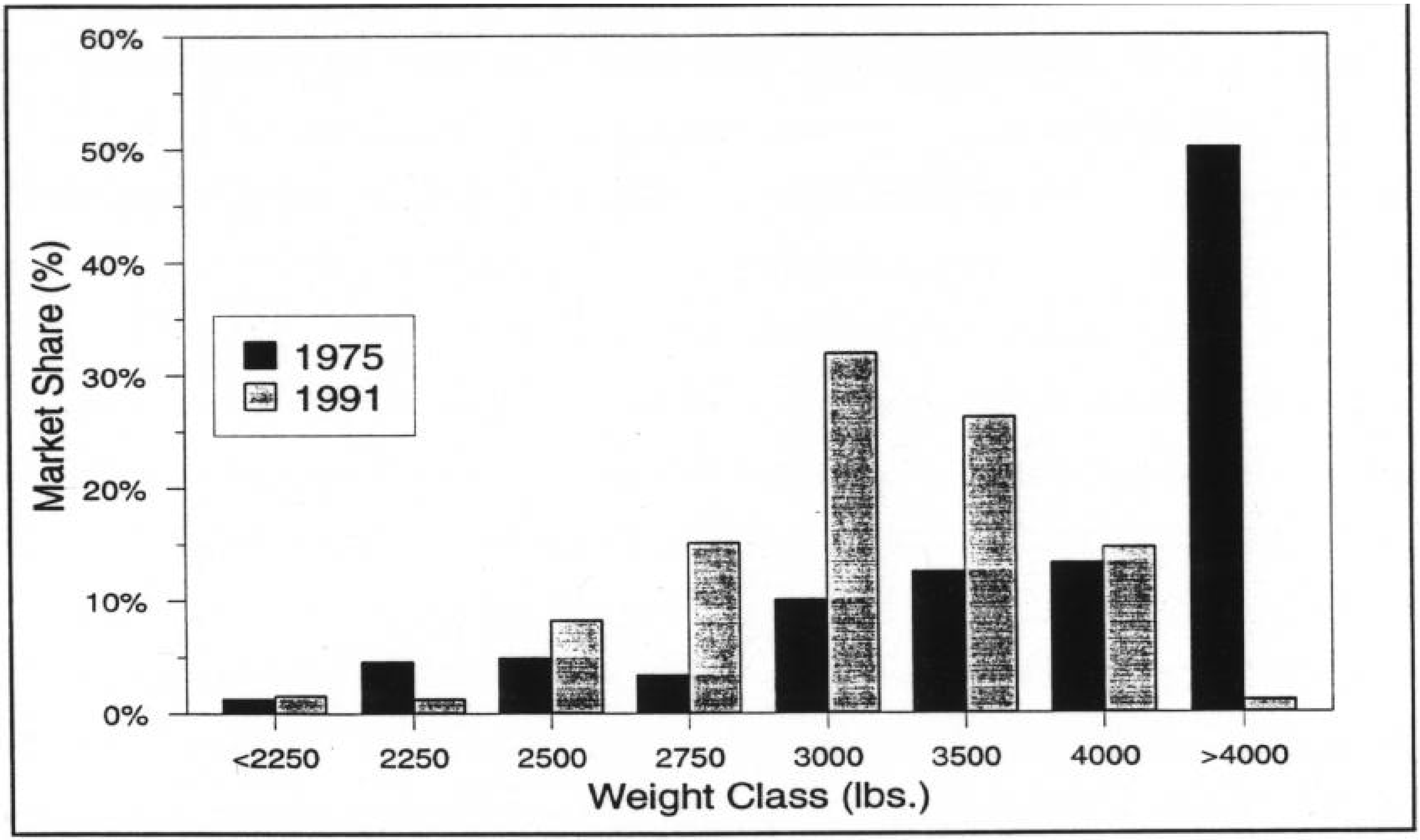
The point is that the distribution of weight changes matters, and it matters a lot. A 100 lb.-equivalent uniform reduction in the weights (and sizes) of all cars would give quite different results from a change that reduced the weights (and sizes) of heaviest cars and increased the weights (and sizes) of lightest cars, thereby making the distribution of weights more uniform at the same time the average weight was reduced. In fact, this appears to be exactly what happened from 1975 to 1991, as was apparently first noted by the U.S. General Accounting Office (U.S. GAO, 1991) and is illustrated in Figure 8. The heaviest cars (>4,000 lbs.) all but disappeared and the numbers of the

Table 2. Effect of a "Well-Chosen" Weight Reduction on Fatalities in Passenger Car and Light Truck Crashes

Crash Type	Light Trucks: NHTSA-Estimated Change in Fatalities per 100 lb. Weight Equivalent Reduction	Light Trucks: Hypothetical Effect of a 500 lb. Equivalent Reduction	Passenger Cars: NHTSA-Estimated Change in Fatalities per 100 lb. Weight Equivalent Reduction	Passenger Cars: Hypothetical Effect of a 66 lb. Equivalent Reduction	Estimated Net Result
Rollover	15	75	80	53	128
Fixed Object	47	235	84	55	290
Pedestrian/Cyclist	-45	-225	-19	-13	-238
Big Truck	29	145	37	24	169
Passenger Car	-80	-400	-31	-20	-420
Light Truck	-6	-30	151	100	70
TOTAL	-40	-200	302	199	-1

Source: NHTSA (1997, pp. 6 and 8).

Figure 8. Changes in the Distribution of Passenger Car Weights, 1975-1991



lightest vehicles (2,250 lbs. and below) also decreased. This may well be why the increase in fatality rates that might have been expected from the weight reductions that occurred over this period of time does not show up in the aggregate fatality rates, which continued to follow a long-term declining trend (Figure 9).

This is not to say that car size and weight do not affect public safety nor is it intended to claim that there is no trade-off between safety and fuel economy. It is to say that the trade-off is complex, and by no means as unambiguous as some would have us believe. It is also important to note that the relationship between fuel price and car size choice suggests that fuel taxes would also have an impact on the weight distribution of vehicles and, therefore, on public safety (Farrington et al., 1997). This topic has received little attention.

One thing that car buyers do know about fuel economy is that it is associated with car size. When gasoline prices rise, car buyers opt for smaller cars. Figure 10 shows the pattern of gasoline prices and the market share of mini-compact, subcompact, and two-seater automobiles (these size classifications are based on interior volume). Clearly, the share of small cars waxes and wanes in direct correlation with the price of gasoline. Certainly, other factors influence small car shares, but the correlation with fuel price is quite striking. The implication is clear: fuel price increases, whether due to oil price shocks or motor fuel taxes, will cause a downsizing of the automobile fleet. Obviously, the effects of fuel price and fuel economy standards on the size distribution of new cars is strikingly different. Fuel price increases drive consumers toward smaller vehicles, fuel economy standards apparently do not.[10]

5.3 THE PUBLIC PERCEPTION OF CAFE

If the CAFE standards have resulted in more expensive, less safe automobiles with reduced consumer amenities, why do consumers like the standards so much? Poll after poll has shown overwhelming public support for higher fuel economy standards or increased fuel economy.[11] In December 1995, in a poll conducted for the Sustainable Energy Budget Coalition by R/S/M, Inc., 94 percent of respondents favored "improving vehicle fuel efficiency" as a means of addressing the problem of U.S. oil dependency. Three-fourths of the respondents said they strongly favored improving fuel efficiency. Similar results obtained in similar polls over the past decade are summarized in Table 3. Clearly, these polls indicate overwhelming support for the idea of increasing automotive fuel economy in general, and for fuel economy standards as a means of achieving that end, in particular. If the fuel economy standards in effect since 1978 have been a disaster for consumers, why do they like them so much?

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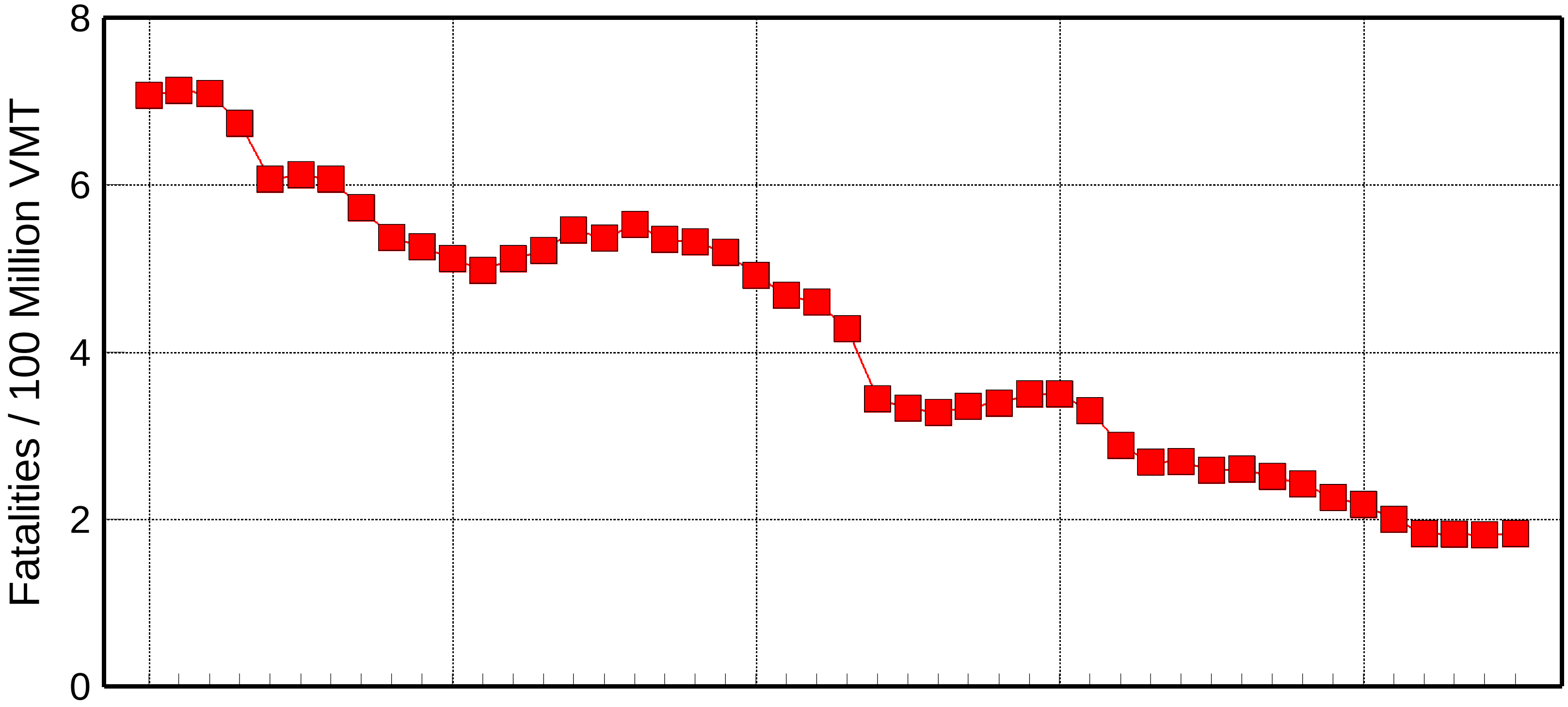
[10]It is important to keep in mind that for cars, the measure of size used here is the EPA's interior volume measure. For light trucks, size classes are not based on a single metric.

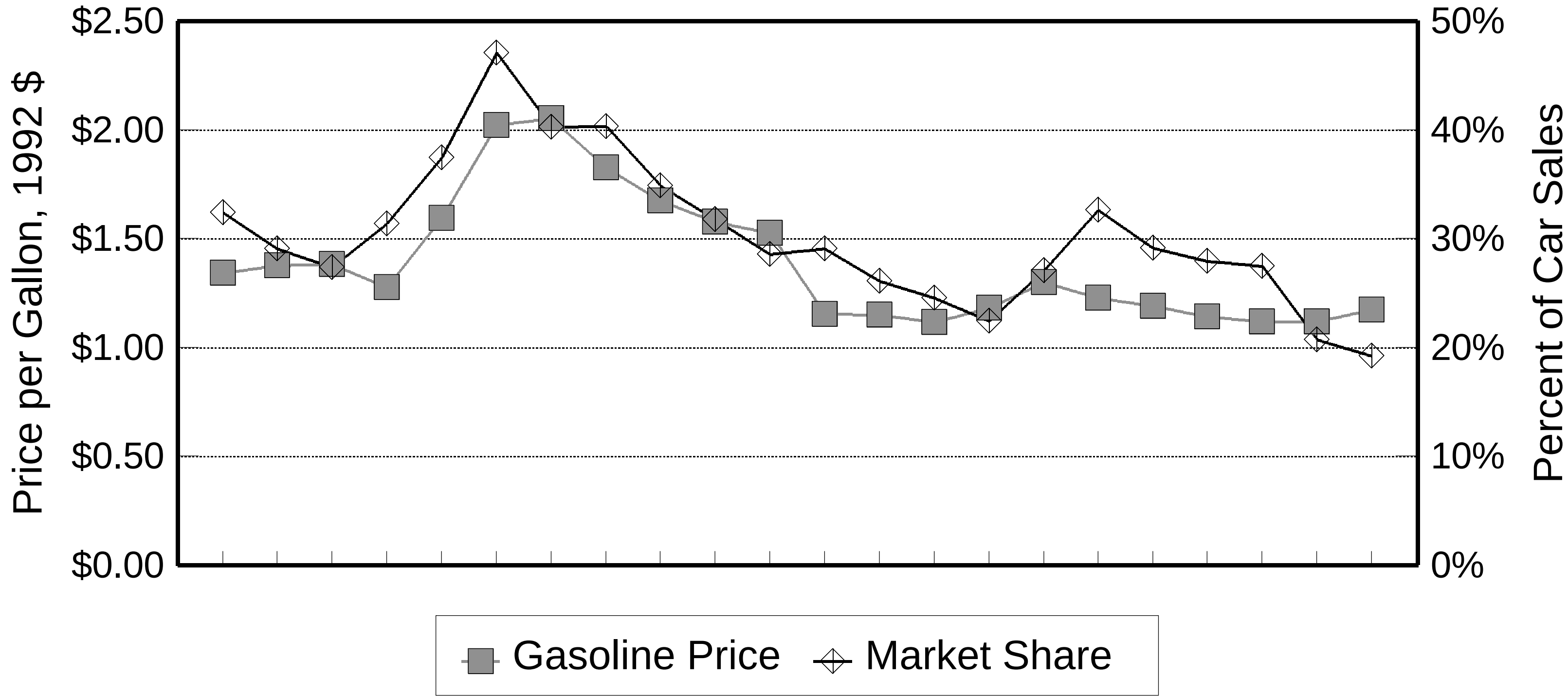
[11]The author is grateful to John DeCicco of the American Council for an Energy Efficient Economy for supplying documentation of the polls cited here (8/5/97).

Figure 9. Highway Fatality Rates, 1950-1995



Sources: National Safety Council, Accident Facts, 1996 Edition, pp. 104-105.

Figure 10. Small Passenger Car Market Share and Gasoline Prices, 1975-1996



Sources: Heavenrich and Hellman, 1996, table 1; U.S.DOE/EIA, 1997, table 5.21.
Small cars comprise the EPA classes two-seater, mini-compact, subcompact and small wagon.

Table 3. Summary of Recent Public Opinion Polls on Higher Fuel Economy and Fuel Economy Standards

Proposition	Response	Date	Source
“improving vehicle fuel efficiency”	support: 95% strongly support: 75%	Dec., 1995	R/S/M, Inc. for Sustainable Energy Budget Coalition
“increasing the CAFE standards to 45 miles-per-gallon”	favor: 72%	Dec. 1-4, 1992	American Automobile Association
“raising CAFE standards to 45 MPG by the year 2000"	favor: 82%	Dec. 11-13, 1991	Federick/Schneiders for the Energy Conservation Coalition
“Increasing federal fuel economy standards to 40 mpg by the year 2000"	support: 84% strongly support: 63%	Dec. 7-11, 1990	Breglio & Lake for the Alliance to Save Energy and the Union of Concerned Scientists
“an increase in federal fuel economy standards...requiring...45 miles to a gallon by the year 2000?”	favor: 82% strongly favor: 56%	Sept., 1988	The Analysis Group
“an increase in federal fuel economy standards...requiring...45 miles to a gallon by the year 2000?”	favor: 78% strongly favor: 51%	October, 1989	RMS, Inc.

Source: Memoranda provided by Mr. John DeCicco, American Council for an Energy Efficient Economy, Washington, DC, August 5, 1997.

The effects of changes between 1978 and 1985 in car size, weight, performance, fuel economy and price on consumers' surplus were estimated by Green and Liu (1988). Changes in the characteristics of a full array of makes and models of passenger cars were considered using two different random utility modeling frameworks. A range of values of attributes drawn from the extant literature were tried. The results showed that benefits and costs to consumers were roughly in balance: the average consumers' surplus gain was just slightly greater than the average increase in cost (about $500).

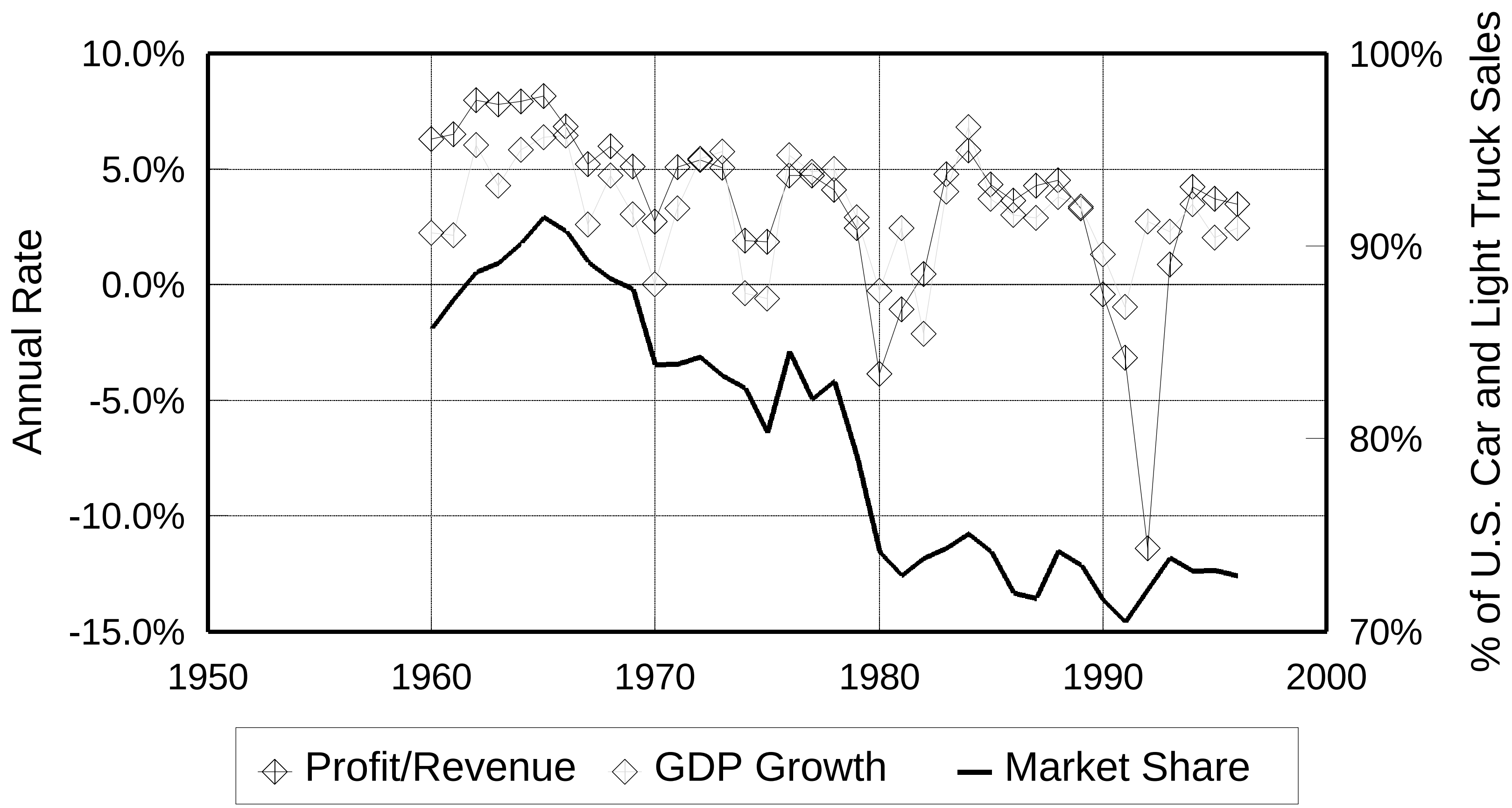
The kernel of the issue is this. If the market for fuel economy were operating efficiently, and if the external costs or other market failures associated with petroleum use by motor vehicles were a relatively minor concern, then fuel economy standards should cause distortions in the marketplace that cost manufacturers profits and force inferior vehicles on consumers. But if the market for fuel economy does not operate efficiently, and if the market failures associated with motor vehicle consumption of petroleum are significant, then regulation could produce a result that is preferred by consumers, profitable to manufacturers, and beneficial to society. Clearly, consumers overwhelmingly believe that fuel economy standards have made them better off. And when one looks for empirical evidence of the damage that fuel economy regulations might have done, the expected negative impacts are hard to find.

6. EFFECTS ON THE DOMESTIC AUTOMOBILE INDUSTRY

It has been argued that because domestic manufacturers were constrained by the CAFE standards and many foreign manufacturers, especially Japanese manufacturers, were not, that the standards may have caused domestic manufacturers to suffer competitively. This loss of competitive edge might be expected to show up as a loss of market share for domestic cars or as lower profits for domestic manufacturers. Indeed, domestic manufacturers did lose market share from 1979 to 1982 (4). But the trend of imported car penetration of the U.S. market is clearly part of a longer-term trend that began as far back as the 1950s. It may also be that the fuel price shock of 1979, inasmuch as it drove consumers to smaller cars, the market niche dominated by the imports, was primarily responsible for the shift to imported cars. In fact after 1982, the period in which CAFE critics like Nivola and Crandall (1995) believe is the only period in which CAFE standards were binding, domestic market share improved considerably.[12] Sales of domestically manufactured cars made the greatest gains against imports after 1986, years in which fuel prices fell and the CAFE standards should have been the most onerous.

[12]Nearly all of this increase in domestic market share is attributable to traditionally Japanese and European manufacturers' establishment of production facilities in the United States. As shown in Figure 11, the market share of the "Big 3" domestic manufacturers remained essentially constant from 1980-1996.

Figure 11. Big 3 Corporate Profits Versus GDP Growth and Market Share



Sources: Automotive News Market Data Books, 1996 and 1997, American Automobile Manufacturers Association 1997.

Profit rates for the Big 3 U.S. manufacturers, Ford, GM, and Chrysler were, on average, higher for the 1960-1977 period than from 1978 to the present (Figure 11). Annual profits divided by total revenues averaged 5.5 percent from 1960 to 1977. Since then the average rate has been 1.5 percent. Even disregarding the disastrous year of 1992 in which GM alone reported a $23 billion loss, profit rates have averaged only 2.3 percent since 1978. It would be understandable then for the domestic Big 3 to associate CAFE with lower profitability.

The correlation between CAFE and lower profit rates disappears, however, when the rate of GDP growth and the Big 3's loss of domestic market share are taken into account. From 1965 to 1981 the Big 3's share of U.S. passenger car and light truck sales dropped almost 20 points, from 92 percent to 73 percent. Increased competition from foreign manufacturers and a loss of market power are a more compelling explanation for reduced profit rates than CAFE standards. At the same time, the annual rate of GDP growth since 1978 has averaged 2.6 %/yr., down from 3.8%/yr. for the 1960-77 period. When these two factors are accounted for, no statistically significant relationship between the existence of CAFE standards and the Big 3's profits remains.

Another potential economic loss due to CAFE arises from the possibility that the standards would distort the pricing of large and small vehicles, causing manufacturers to subsidize smaller, more efficient vehicles and raise prices on larger cars. Several studies have attempted to estimate the consumer and producer surplus costs of meeting the CAFE standard. Most assume that technology and vehicle design are constant and that manufacturers must meet the CAFE standard by adjusting the prices of makes and models (Greene, 1991) or size classes (Kleit, 1990; Falvey et al., 1986; Kwoka, 1983) so as to induce a sales mix change that will cause their salesweighted MPG to achieve the standard. These analyses generally conclude that achieving fuel economy in this way is likely to be very expensive. Perhaps this is why salesmix shifts have had essentially no role in the fuel economy improvements of the last twenty years. Greene and Fan (1995) calculated that only one-half MPG of the increase in new light-duty vehicle fuel economy since 1975 could be attributed to salesmix shifts. All the rest was due to changes in technology and design.

The CAFE law permits the U.S. Department of Transportation some flexibility to lower fuel economy standards on grounds of economic practicability. DOT exercised this option in 1986, the year world oil prices fell from $33 to $17 per barrel (1990 $), by reducing the standard from 27.5 to 26.0 MPG. It was raised again to 26.5 in 1989 and 27.5 in 1990, where it has remained since (Davis, 1997, table 3-40). This action was apparently taken to avoid hardship to domestic manufacturers due to the unanticipated fall in oil prices.

7. CONCLUSIONS

Simply put, CAFE worked. Fuel economy regulation can be economically efficient, in theory. When there are external costs of fuel consumption, economic theory allows for the existence of an efficient level of fuel economy regulation, used in conjunction with an efficient tax on vehicle use (or fuel use as a surrogate). Furthermore, even if the efficient level of tax is not imposed, setting a fuel economy standard at the efficient level in the absence of the tax will still improve social welfare.

Fuel economy regulation has worked, in practice. The CAFE standards played the leading role in bringing about the 50 percent increase in on-road fuel economy for light-duty vehicles from 1975 to 1995. This increase in fuel economy held down gasoline consumption with an effectiveness of 80-90 percent, taking into account the rebound effect. Today, consumers spend over $50 billion per year less on motor fuel than they would have at 1975 MPG levels.

The many potential threats to the success of fuel economy regulation either did not materialize or were relatively minor considerations in comparison to the overall trends. Vehicle life expectancy increased, vehicle travel increased, there was a major shift from cars to light trucks, domestic manufacturers' market shares waxed and waned, yet petroleum consumption in personal transportation was greatly reduced over what it would have been, vehicle emissions were reduced and urban air quality improved, traffic fatality rates continued to decline, and domestic car companies retained market share. Consumers were sufficiently satisfied to support raising fuel economy standards even further.

But all this was the past; what of the future? Fuel economy standards can be increased, but care must be taken to insure that the technology is available to achieve efficient levels of MPG at costs that are not much greater than the direct fuel savings to consumers. Care must be taken to insure that manufacturers have the time necessary to respond efficiently in changing over capital equipment and testing out new vehicle designs. Attention must continue to be paid to potential risks. The fact that standards in the past avoided threats to their success does not imply that any arbitrarily designed standard will do. Considerable research and analysis went into the formulation of past standards. The same will be needed for future standards. And, finally, simply because a corporate average fuel economy formula worked well in the past does not mean that a more efficient formulation does not exist. Proposals ranging from the volume average fuel economy standard to feebates deserve careful evaluation (McNutt and Patterson, 1986; Davis et al., 1995).

Fuel economy regulation can be an efficient and effective strategy for improving the energy efficiency of transportation, reducing petroleum dependence, curbing greenhouse gas emissions, and contributing to reducing air pollution. With a proven track record of success, it deserves full consideration as a key policy for creating a sustainable transportation system.

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APPENDIX A

Regulatory standards, in combination with a tax on the activity producing an external damage, can be economically efficient. A rigorous though simplified derivation of the conditions for an optimal regulatory standard is now provided. We assume society would like to maximize total social welfare, W, which is taken to be a simple sum of utility, which depends on miles traveled, U(M), plus the external, social cost of emissions, C(E) produced by vehicle travel, the market cost of the travel, $P_M M$, and the market cost of expenditures required to meet emissions regulations, $P_x x$. A constraint is added which simply states that carbon emissions equal miles traveled times fuel economy, g, times the carbon content of fuel, k. The variable x, represents how much technology is used to control emissions. It is necessary to determine both the optimal level of travel and the optimal level of technology, x. The problem is restated in equation (A.1) as a mathematical optimization problem.

$$\begin{aligned} Max_{M,\,x} \quad W &= U(M) - C(E) - (gP_f)\, M(gP_f) - P_x\, x \\ s.t. \quad E &= k\; g(x)\; M(gP_f) \quad . \end{aligned} \tag{A.1}$$

The price of travel is assumed for simplicity to be only the fuel cost of travel, which is equal to the price of fuel, P_f, times fuel intensity, g, measured in gallons per mile.

First-order conditions for optimization are obtained by setting the partial derivatives of (A.1) with respect to M and x equal to zero. We first consider the marginal condition for miles traveled.

$$\begin{aligned} \frac{\partial W}{\partial M} = \frac{\partial U}{\partial M} - \frac{\partial C}{\partial E}\,(kg) - P_f\, g &= 0 \\ \frac{\partial U}{\partial M} = \frac{\partial C}{\partial E}\,(kg) + P_f\, g & \end{aligned} \tag{A.2}$$

Equation (A.2) states that the marginal utility of travel should be set equal to the fuel cost per mile of travel, *plus* the marginal social damage done by the additional carbon emissions produced by a mile of travel. This, of course, is the familiar formula for optimal taxation of an external cost first derived by Pigou (1918). This could be accomplished either by taxing fuel or by taxing miles, assuming g is set at its optimal level. If fuel is taxed, either its carbon content must be a constant or the tax must be levied on the carbon content of the fuel. The former is approximately true, and the latter is easily done in any case.

The derivative of W with respect to x indicates how to determine the optimal value of g, in other words, what the efficient fuel economy standard should be. This expression is somewhat more complicated, since miles traveled depend on the fuel efficiency of travel which depends on x.

$$\frac{\partial W}{\partial x} = \frac{\partial U}{\partial M}\frac{\partial M}{\partial x} - \frac{\partial C}{\partial E}\frac{\partial E}{\partial x} - \left(MP_f \frac{\partial g}{\partial x} + P_f\, g \frac{\partial M}{\partial x} \right) - P_x = 0 \qquad \text{(A.3)}$$

It is useful to expand the derivatives of M and E with respect to x, first to note that both contain as a common factor the term dg/dx, and second to evaluate the sign of the derivative of E with respect to x.

$$\frac{\partial M}{\partial x} = \frac{\partial M}{\partial (P_f\, g)}\, P_f \frac{\partial g}{\partial x}$$
$$\textit{noting that} \quad \frac{\partial (P_f\, g)}{\partial x} = P_f \frac{\partial g}{\partial x} \qquad \text{(A.4)}$$

Equation (A.1) states that the change in miles traveled given a change in technology equals the change in fuel efficiency brought about by that technology, times the price of fuel, times the sensitivity of travel to fuel cost per mile.

Expanding the derivative of emissions, E, with respect to technological effort, x, gives the following.

$$\frac{\partial E}{\partial x} = kM \frac{\partial g}{\partial x} + kg \frac{\partial M}{\partial (P_f\, g)}\, P_f \frac{\partial g}{\partial x} \qquad \text{(A.5)}$$

The first term on the right-hand side of equation (A.2) is the reduction in emissions brought about by increasing the application of technology to control emissions, holding the miles of travel constant. The second term represents the increase in emissions due to the effect of x on fuel efficiency, the effect of fuel efficiency on cost-per-mile and the sensitivity of miles traveled to cost per mile. The first term will be negative for an increase in x, the second positive. We can think of the first term as the intended effect, the second as the take-back effect (Khazzoom, 1980). Which term is larger? Canceling the common factors k and dg/dx and dividing by M, the first term becomes 1, the second term becomes the elasticity of miles traveled with respect to the fuel cost per mile of travel. Recent evidence indicates that the long-run elasticity of vehicle travel with respect to fuel cost per mile is in the vicinity of -0.2 for the United States (U.S. DOE, 1996, Ch. 5). Thus, the intended effect of emissions regulations would be about five times as large, in absolute value as the take-back effect.

Noting that every right-hand side term in both equation (A.1) and (A.2) contains dg/dx, one can see that substituting these expressions in equation (A.3) would insure that every term except $-P_x$ would then contain dg/dx. Thus, we can move P_x to the right-hand side and multiply through by (dx/dg) to obtain an expression for the marginal expenditures on emissions control.

$$\frac{\partial(xP_x)}{\partial g} = \frac{\partial U}{\partial M}\frac{\partial M}{\partial g} - \frac{\partial C}{\partial E}\left(kM + kg\frac{\partial M}{\partial g}\right) - P_f\left(M + g\frac{\partial M}{\partial g}\right)$$
$$\textit{noting that} \quad \frac{\partial M}{\partial(P_f\,g)}\,P_f = \frac{\partial M}{\partial g} \tag{A.6}$$

Holding miles of travel constant, the derivative of E with respect to g is equal to kM. Thus, the middle term on the right-hand side of equation (A.3) is the sum of the change in emissions damage assuming no change in miles traveled minus the change in damage due to the take-back effect of increased miles traveled due to reduced fuel consumption per mile. In other words, it is the net marginal reduction in damage due to increasing fuel efficiency. As we have just noted, according to recent estimates of the size of the take-back effect the net reduction will be about 80 percent as large as the potential reduction with no take-back effect.

The final term on the right-hand side of equation (A.3) is the derivative of total expenditures on fuel, $F = P_f gM$, with respect to a change in fuel efficiency. The sign of this term depends on the relative sizes of the two terms, M and g(dM/dg). Typical values for automobile fuel efficiency are on the order of 0.05 gallons per mile. We also note that if the elasticity of miles traveled with respect to fuel cost per mile is about -0.2 then equation (A.7) follows.

$$g\,\frac{\partial M}{\partial g} = g\,P_f\,\frac{\partial M}{\partial(P_f\,g)} \approx -0.2\,M \tag{A.7}$$

Once again, the savings in fuel expenditures are about 80 percent of the potential savings in the absence of a take-back effect.

Equation (A.3) can be written in a more simplified form for ease of interpretation. In words, equation (A.5) states that the marginal social expenditures on pollution abatement should equal the sum of the marginal gain in utility due to increased travel as a result of the take-back effect, the marginal net reduction in environmental damage due to reducing carbon emissions, and the marginal net savings in fuel expenditures due to improved fuel economy.[13]

$$\frac{\partial(xP_x)}{\partial g} = \frac{\partial U}{\partial g} - \frac{\partial C}{\partial g} - \frac{\partial F}{\partial g} \tag{A.8}$$

[13] A regulation calling for a reduction in g, fuel consumption per mile, would increase expenditures on technology. Thus, $d(xP_x)/dg$ would be >0 since dg would be <0. Utility also would increase with a reduction in g, and the remaining terms on the right-hand side of equation (A.5) would also be >0 by virtue of the minus signs that precede them. Thus, all terms in equation (A.5) are positive for a reduction in the rate of fuel consumption per mile.

This condition can be satisfied by imposing a well chosen fuel efficiency standard as well as by imposing a Pigouvian externality tax. That is, provided that the standard is set at the point where equation (A.5) is satisfied. Then, the second first order condition can be satisfied by imposing a tax on miles or fuel, equal to the residual social damage done by an additional mile of travel or gallon of fuel consumed in travel.

An interesting feature of the fuel economy, or carbon emissions regulation problem that distinguishes it from a classical pollutant emission problem which would have no take-back effect, is that the largest term on the right-hand side of equation (A.5) is almost certainly the savings on fuel expenditures (Greene and Duleep, 1993). As a result, to be economically efficient, fuel economy standards would have to require improvements that are nearly cost-effective from the consumers' viewpoint. Fuel economy improvements can be somewhat less than cost-effective, however, due to the additional benefits of lower carbon emissions and increased utility of additional travel.

It has been demonstrated that an economically efficient regulatory level of carbon emissions or, equivalently, fuel efficiency, exists. It requires that the marginal social costs of a reduction in fuel consumption equal the marginal social benefits it produces. The economically efficient regulation, however, still requires a tax be imposed on the activity producing the residual (post regulation) emissions. The tax should equal the marginal social damage done by emissions per mile, at the post-regulation rate. Interestingly, even if the emissions regulation is not set at the optimal level, imposing a tax on the residual emissions equal to their marginal social damage will still increase social welfare (e.g., see Freeman, 1997). This is true whether the regulatory standard is too strict or too lax. Thus, an optimal level of regulation exists but it must also be accompanied by an externality tax on vehicle travel to achieve maximum economic efficiency. If, on the other hand, it is impossible to impose an externality tax, imposing the regulatory standard without the tax will still increase social welfare versus doing neither.