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BEFORE THE
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
Washington, D.C.

COMMISSION AUTHORIZED

Passenger Automobile Average Fuel Economy Standards for Model Years 1989 and 1990	)	49 CFR Part 531 [Docket No. FE-88-01; Notice 2]

COMMENTS OF THE STAFF OF THE BUREAU OF ECONOMICS OF THE FEDERAL TRADE COMMISSION*

Washington, D.C. 20580
September 15, 1988

* These comments are the views of the staff of the Bureau of Economics of the Federal Trade Commission. They are not necessarily the views of the Commission or of any individual Commissioner.

I. Introduction and Summary

On August 29, 1988, the National Highway Traffic Safety Administration (NHTSA) issued a Notice of Proposed Rulemaking (NPRM) in which it proposed that the Corporate Average Fuel Economy (CAFE) standards for model years (MY) 1989 and 1990 be reduced from the planned 27.5 miles per gallon (MPG) to some value in the 26.5 to 27.5 MPG range.[1] In the NPRM, NHTSA has asked for public comment on the following questions: "[t]o what extent, if any, would fuel economy improvements adversely affect consumer choice of vehicles or engines?";[2] and "[t]o what extent, if any, are U.S. jobs affected by the level of the MY 1989-90 CAFE standards and thus at issue in this rulemaking?"[3] In response to these questions, the staff of the Bureau of Economics of the Federal Trade Commission ("the staff") submits the following analysis of the consequences of a 27.5 MPG CAFE standard for consumer welfare, automobile industry profits,[4] automobile worker employment, and energy consumption.[5,6]

Our analysis indicates that adopting a 27.5 MPG standard instead of a

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[1] 53 Federal Register 33,081, August 29, 1988 (hereafter cited as "NPRM"). NHTSA has set a deadline of September 15 for comments on MY 1989, and a deadline of October 28 for comments on MY 1990 standards. We ask that these comments be considered in the latter rulemaking as well.

[2] Question 13, 53 Fed Reg. at 33,092.

[3] Question 15, 53 Fed. Reg. at 33,093.

[4] NHTSA has observed that compelling firms to comply with CAFE standards through the elimination of car models with low MPG performance could result in substantial reductions in sales for individual manufacturers. NHTSA observed further that these sales losses "could have an adverse economic impact on the industry and the economy as a whole, and could run counter to the statutory criterion of economic practicability and the Congressional intent that the CAFE program not unduly restrict consumer choice." 53 Fed Reg. at 33,092.

[5] In considering regulatory adjustments to the statutorily established CAFE standards, NHTSA is required *inter alia* to take account of "the need of the Nation to conserve energy." 53 Fed. Reg. at 33,081.

[6] These comments are the views of the staff of the Bureau of Economics of the Federal Trade Commission. They are not necessarily the views of the Commission or of any individual Commissioner. Inquiries regarding these comments should be directed to staff economist Andrew N. Kleit, Bureau of Economics, Federal Trade Commission, Washington, D.C., 20580, (202)-326-3481.

26.6 MPG standard[7] would result in a significant number of consumers paying more than they otherwise would for new large cars with lower fuel economy. Despite increases in the production of new small cars, employment in the domestic auto and auto-related industries would likely also be reduced by the higher CAFE standard. Small car production requires less labor per vehicle than large car production, so the reduced sales of larger cars causes a net reduction in total employment. The NHTSA is required by law to compare these costs against the benefits of the CAFE program. Our evaluation, however, fails to find any benefits to higher CAFE standards. In particular, our results indicate that imposition of higher CAFE standards may actually lead to increased net gasoline consumption in the years following the imposition of the standard.

We evaluate the impact of a higher CAFE standard under two alternative scenarios. Scenario 1 assumes that the 27.5 MPG standard is first imposed in MY 1989, while Scenario 2 assumes that the 27.5 MPG standard is first imposed in MY 1990.[8] We estimate that imposing a 27.5 MPG standard instead of a 26.6 MPG standard in MY 1989 would cost consumers almost $650 million (because of increased prices for large cars with low MPG ratings) in MY 1989. Domestic auto industry profits would fall by about $1.553 billion that same year. Total employment in domestic auto and auto-related industries would likely decline by about 11,500 jobs. Meanwhile, we estimate that the higher standard would, by decreasing the retirement rate for existing large cars and increasing the rates of production and utilization of new small cars, actually increase gasoline consumption by a total of approximately 245 million gallons over the 15 year period following the imposition of the standard. For the most part, the changes in gasoline consumption identified here do not occur in the model years to which the CAFE standard would be applied. Rather, they are the summation of gasoline consumption changes for the ensuing 15 years.[9]

Similar results are obtained under scenario 2, which assumes that the 27.5 MPG standard is first imposed in MY 1990. Enforcement of the 27.5 MPG standard instead of the lower standard would cost consumers approximately $950 million, and reduce auto companies' profits by about $700 million, in MY 1990. Employment in auto and auto-related industries would decline by about 20,000 jobs, and gasoline consumption would increase by about 200 million gallons between 1990 and 2005.

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[7] Our analysis assumes that any CAFE standard below 26.6 MPG is nonbinding for all manufacturers. Any standard below 26.6 MPG (e.g., 26.5 MPG) could therefore be expected to have the same effects as a 26.6 MPG standard.

[8] The changes in consumer and producer welfare, employment, and gasoline consumption that are generated under the second scenario thus should not be interpreted as incremental changes (relative to those changes arising under scenario 1); rather, they should be regarded as alternative estimates that correspond to a different assumption about the timing of the regulatory change.

[9] These future consumption changes are discounted at a rate of 4 percent.

These results are based on the assumption that GM is unable to overturn recent court decisions and gain additional CAFE credits. Should GM win its court challenge, we estimate that imposing the higher CAFE standard will result in lesser, though still significant harm to the economy. Imposing a 27.5 MPG CAFE standard rather than a lower standard would, under these circumstances, also lead to increased gasoline consumption during the ensuing 15 year period.

Overall, our analysis suggests that enforcement of higher CAFE standards would yield few social benefits, and that it would impose substantial costs on the U.S. economy. We therefore recommend that NHTSA adopt a standard no greater than 26.6 MPG for MYs 1989 and 1990.

II. Federal Trade Commission Experience

The FTC is an independent regulatory agency responsible for fostering competition and safeguarding the interests of consumers.[10] The staff of the FTC, upon request by federal, state, and local government bodies, regularly analyze regulatory proposals to identify provisions that may impair competition or increase costs without offering compensatory benefits to consumers. The FTC also has a statutory responsibility to review complaints that the CAFE standards harm competition.[11]

In 1986 the FTC staff submitted comments when NHTSA was considering modifying CAFE standards for model years 1987 and 1988.[12] Our comments were cited as an important justification for NHTSA's decision in

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[10] 15 U.S.C. Section 41 *et seq.*

[11] The Secretary of the Department of Transportation may modify or waive CAFE civil penalties under certain limited circumstances, one of which is certification by the FTC that modification is necessary to prevent harm to competition. 15 U.S.C. § 2008 (b)(3)(C). The statute provides that a manufacturer may petition the FTC for a certification that modification of the civil penalty "is necessary to prevent a substantial lessening of competition in that segment of the automobile industry subject to the standard with respect to which such penalty was assessed." 15 U.S.C § 2008 (b)(4).

[12] Comments of the Bureaus of Competition, Consumer Protection, and Economics of the Federal Trade Commission, *Passenger Automobile Average Fuel Economy Standards Model Year 1987-88*, National Highway Traffic Safety Administration, Docket No. FE-85-01, March 26, 1986 (hereinafter cited as FTC Staff (1986)).

that rulemaking.[13] In addition, members of the FTC staff have conducted a series of empirical studies of the effects of the CAFE law.[14]

III. Description of the CAFE Program

The CAFE program, as enacted in 1975, called for all auto manufacturers producing more than 10,000 units per year to satisfy the mandated CAFE levels. The CAFE program defines average MPG standards that apply to a manufacturer's entire fleet, rather than to the fuel efficiency of individual models. CAFE levels were scheduled to rise from 18.0 MPG in 1978 to 27.5 MPG in 1985 and all subsequent years. Failure to satisfy the standard can result in the imposition of civil penalties.[15]

The CAFE legislation divided each manufacturer's fleet into two distinct groups -- foreign and domestic. All domestic cars and all foreign cars[16] sold by each firm were to be averaged separately.[17] This provision was designed explicitly to prevent U.S. manufacturers from meeting the CAFE standard by importing small, high MPG foreign cars. Instead, domestic firms are induced to produce high MPG cars in the U.S.[18]

Although the CAFE standards are defined by statute,[19] NHTSA is empowered (through regulatory rulemakings) to adjust the CAFE standard for model year 1985 and any subsequent year to the "maximum feasible average fuel economy level." In determining this maximum feasible level, NHTSA is required to consider four factors: (1) technological feasibility, (2) economic practicability, (3) the effect of other federal motor vehicle standards on fuel economy, and (4) the need of the nation to conserve energy.[20]

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[13] 51 Federal Register 35,598, October 6, 1986.

[14] See Andrew Kleit, "The Economics of Automobile Fuel Economy Standards," Ph.D. dissertation, Yale University, 1986. Also see Andrew Kleit, "The Impact of Auto Fuel Standards," FTC Working Paper No. 160, February 1988, and "Enforcing Time Inconsistent Government Regulations," FTC Working Paper No. 161, March 1988; Robert P. Rogers, "The Short-Run Impact of Changes in the Corporate Average Fuel Economy Standards," manuscript, March 1986.

[15] So far, however, no domestic manufacturers, and only a few small European firms, have actually paid fines.

[16] A foreign car is defined as one having less than 75% of its value added produced in the United States.

[17] NPRM, p. 33,080.

[18] NHTSA Annual Report on Fuel Economy, 1982, p. 9.

[19] Title V of the Motor Vehicle Information and Cost Savings Act (hereafter "the Act"), 15 U.S.C. 2001 *et seq.*

[20] NPRM, p. 33,081.

IV. CAFE Standards and Current U.S. Energy Policy

When first promulgated in 1975,[21] the CAFE program was part of a complex scheme of regulation designed to reduce consumption of gasoline directly. These controls on consumption were promulgated because policymakers believed that increases in the price of energy would not reduce gasoline consumption to levels consistent with national security interests.

Events subsequent to the enactment of the CAFE law suggest that consumers do respond to market forces.[22] However, there is debate over whether market-determined prices fully reflect all of the costs gasoline consumption imposes on society. It is possible that consumption of gasoline creates external social costs, or "externalities", which are costs associated with consumption and production decisions that are ignored by private decisionmakers. If true, the volume of gasoline produced and consumed would differ from what it would be if all costs were fully taken into account. For example, the original goal of the CAFE program was to ensure political and social stability by reducing dependence on imported petroleum supplies. Social instability caused by oil embargoes and other supply disruptions has been characterized by some as an externality.[23] Similarly, the burning of gasoline has been linked to both short-term and long-term environmental degradation.

Federal and state legislative bodies have available to them methods for internalizing external costs that are more efficient than performance standards. If gasoline consumption is the source of an externality, an efficient alternative to a CAFE standard is the imposition of an excise tax

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[21] 15 U.S.C. § 1901, 2001-2012.

[22] Studies have found that consumers in fact purchase more fuel-efficient cars when gasoline prices increase. In Europe and Japan, where gasoline prices are much higher than those in the United States, consumers purchase cars offering much higher gas mileage. Indeed, empirical research indicates that American consumers have responded to higher gasoline prices by buying more fuel-efficient vehicles. According to one study, rising gasoline prices caused the change in average new car mileage between 1970 and 1983 to be the same as it would have been had the CAFE program not existed. See Robert Crandall, "Why Should We Regulate Fuel Economy at All," *Brookings Review* (Spring 1985), p. 4 (hereafter Crandall (1985)), and Robert F. Crandall, Howard K. Gruenspecht, Theodore E. Keeler, and Lester B. Lave, *Regulating the Automobile*. Washington: The Brookings Institution, 1986, p. 134-5.

[23] See, for example, Harry Broadman and William Hogan, "Oil Tariff Policy in an Uncertain Market," Discussion Paper E-86-11, Energy and Environmental Policy Center, John F. Kennedy School of Government, Harvard University, November 1986.

on gasoline consumption.[24] A large body of research that measures consumer responses to variations in gasoline prices shows generally that the quantity of gasoline demanded falls when prices rise.[25] If Congress, or any of the individual states, wishes to discourage gasoline consumption because it creates externalities, the most direct and reliable technique for doing so would be to raise the price of gasoline through higher taxes. Setting performance standards such as CAFE, by contrast, is an indirect, imprecise method for reducing gasoline consumption, and one that may (as our model simulations suggest) actually *increase* total gasoline consumption and total external costs.

V. Economic Analysis of the Imposition of CAFE Standards

Model Year 1989 will begin at about the time NHTSA determines the MY 1989 CAFE standard. Although the auto companies have been aware of the potential for a 27.5 MPG standard for some time, GM and Ford now have little time left to increase the fuel efficiencies of individual automobile models. Technological changes of this sort generally take several years to accomplish. Indeed, NHTSA recognizes that significant technological changes cannot be made at this late date even for MY 1990.[26] Thus, if NHTSA refuses to lower the CAFE standard, these firms may have to "mix-shift" to satisfy a CAFE standard of 27.5 MPG. "Mix-shifting" means that these manufacturers will raise the price, and reduce the quantity sold (relative to the prices and quantities otherwise dictated by market forces), of cars having low MPG ratings, and reduce the price, and raise the quantity sold, of cars offering high MPG ratings.

Given that the CAFE standard will force automakers to raise the price of larger cars relative to the price of small cars, it establishes an internal

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[24] While we believe that excise taxes are preferred to performance standards as a means for eliminating externalities *when these externalities have been shown to exist*, this should not be construed as an endorsement of any specific proposal to increase existing excise taxes on gasoline. We have not attempted to measure the externalities that might be generated by current gasoline consumption levels, and therefore are not in a position to evaluate the benefits and costs of altering these consumption levels.

[25] The long-term price elasticity of gasoline demand has been estimated to be between -0.6 and -1.1. Elasticity of demand is the percentage change in quantity demanded divided by the percentage change in price. Thus, if the elasticity of demand is -0.6 and the price of gasoline rises 10 percent, the demand for gasoline will fall 6 percent. For a discussion of the literature measuring the response of consumer to changes in gasoline prices, see Carol A. Dahl, "Gasoline Demand Survey," *Energy Journal*, January 1986.

[26] NPRM, p. 33,092.

system of quasi-taxes and subsidies for the autos of each manufacturer.[27] The change in price of each type of car depends on the relation of that car's fuel efficiency to the CAFE standard -- i.e., the lower the fuel efficiency of a particular model, the greater the increase in price -- the cost to any particular firm of meeting the standard, and various other supply and demand conditions.

It is clear that purchasers of new large cars are harmed by mix-shifting and that purchasers of new small cars benefit. Overall, however, new car purchasers are likely to incur a net loss from the imposition of CAFE standards because many more large cars than small cars are demanded at the prices prevailing before the imposition of the higher standard.[28]

It is not clear whether CAFE regulations will achieve their goal of reducing the total amount of domestically consumed gasoline. Total domestic gasoline consumption is determined by three factors: (1) the average number of gallons of gasoline required to drive a mile, (2) the average number of miles driven per vehicle, and (3) the total number of vehicles owned by American consumers. By establishing standards for newly produced cars, CAFE regulations directly address only the first of these factors. If the latter two factors do not change subsequent to the imposition of the regulations, and if the rate of replacement of existing large cars is not reduced in response to the standards, then the program will fulfill its objective of reducing total fuel consumption. It is unlikely, however, that these factors would remain constant; rather, it is quite plausible that CAFE standards could cause both of the latter factors to change in ways that would partly, and perhaps totally, offset any reduction in total gasoline consumption brought about by greater per-vehicle fuel efficiency.

For example, one effect of imposing a higher CAFE standard would be to increase the number of miles driven in newly produced cars. This is because lower rates of fuel consumption per mile will induce an increase in

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[27] By artificially decreasing large car production, and increasing small car production, imposing a higher CAFE standard is conceptually similar to placing a tax on large cars, and a subsidy on small cars. Because of these taxes and subsidies, automobile prices would no longer accurately reflect true resource costs. As a consequence, consumers' choices would become distorted, which in turn generates deadweight welfare losses to the economy. See John E. Kwoka Jr., "The Limits of Market Oriented Regulatory Techniques: The Case of Automotive Fuel Economy Standards," *Quarterly Journal of Economics* (1983), 695-704, and Kleit (1987) and (1988).

[28] Absent externalities, competitive market forces will produce the quantities of large and small cars that maximize social welfare. Since the CAFE standards cause a movement away from these quantities (i.e., too few large automobiles, too many small automobiles), the standards reduce total social welfare.

the total number of miles driven.[29] This increase in total mileage will offset, to some extent, the reduction in fuel consumption brought about by the higher fuel consumption standard.

Additionally, the total number vehicles owned by American consumers may increase because of the imposition of CAFE standards. As discussed above, the CAFE regulation may cause the price of new small cars to fall, and price of new large cars to rise, relative to market-determined prices. Depending on the comparative magnitudes of these price changes, the increase in the number of small cars produced could more than offset the decline in large car production.[30] Although this lower price for new small cars will induce some of the owners of old, large cars to replace their vehicles with new small cars, the increase in the price of new large cars will induce other large car owners to hold on to these vehicles longer than they would have otherwise.[31] The price increase for new large cars would also induce increased production of large cars by producers currently unconstrained by the CAFE standard.[32]

VI. Simulating the Effects of CAFE Standards

This section will estimate the effects of various CAFE levels on the automobile market and on energy consumption. Part A analyzes the effects of CAFE on consumer welfare, auto industry profits, and auto industry employment. This appraisal will take account of savings that result from the introduction of new cars whose prices and quantities are affected by the CAFE standard, as well as any changes in the stock of used automobiles that are attributable to the changes in the price of new cars. Part B examines the change in energy consumption that will occur if the higher CAFE standard is enforced.

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[29] See Roger D. Blair, David L. Kaserman, and Richard C. Tepel, "The Impact of Improved Gasoline Mileage on Gasoline Consumption," *Economic Inquiry* (1984), 209-217.

[30] See Kwoka, p. 702.

[31] This phenomenon has been observed in other regulatory contexts. For example, it has been argued that increasing the stringency of pollution controls could actually increase pollution by deterring the replacement of older, more pollution-intensive automobiles. See Howard K. Gruenspecht, "Differentiated Regulation: A Theory with Applications to Automobile Emission Controls," Yale University Ph.D. dissertation, 1982a, and Gruenspecht, "Differential Regulation: The Case of Auto Emissions Standards," *American Economic Review* (1982b), 328-331.

[32] Chrysler, for example, is not currently constrained by the CAFE standard. If prices for large new cars (e.g., Cadillacs, Lincolns) were to rise, Chrysler could profitably increase its production of its large models (e.g., the New Yorker) without jeopardizing its compliance with the standard.

Our model is an approximation of the markets for automobiles and gasoline. It is based, however, on a set of reasonable assumptions that reflect the most recent research into the auto industry. As with all models, its predictions contain an element of uncertainty. Nevertheless, we believe that this model generates useful insights into the likely impact of higher CAFE standards.

A. Automobile Market Model

To quantify the costs to consumers, and to the auto industry, of imposing a 27.5 MPG CAFE standard, rather than a 26.6 MPG standard, for MYs 1989 and 1990, we have constructed a model that estimates the production shifts, price changes, and employment effects that would result from the standard. This model is an extension of the model used by Kleit (1987, 1988) and is very similar to the simulation used by FTC staff in its 1986 submission to NHTSA. A description of this model is contained in the technical appendix attached to these comments.

Table A-1 of the technical appendix contains the simulation results obtained from the automobile market model corresponding to a 27.5 MPG CAFE standard for Model Year 1989. The model predicts a net loss to consumers of $644 million in MY 1989. General Motors' profits in that year fall by $463 million, while Ford's profits decrease by $1.209 billion. Chrysler's (which is currently unconstrained by CAFE regulation) profits increase by $139 million. The net loss to the domestic economy (the sum of consumer and producer losses) is approximately $2.177 billion. Overall employment in the auto and auto-related industries falls by 11,500 jobs.

Table A-2 gives the projected impact of a 27.5 MPG CAFE standard for MY 1990. The net loss to consumers in that year is $955 million. General Motors' MY 1990 profits are reduced by $208 million, while Ford's profits fall by $704 million. Chrysler's profits rise by $223 million. The net loss to the domestic economy is approximately $1.644 billion. Overall employment in the auto and auto-related industries falls by almost 20,000 jobs.

Should GM successfully pursue its current court challenge and gain additional CAFE mileage credits, the net harm to the economy would be smaller than predicted above. Tables A-4 and A-5 contain our estimates of the economic impact of CAFE under this alternative scenario. In model year 1989, imposing the 27.5 MPG instead of a 26.6 MPG standard increases consumer welfare by $336 million, decreases U.S. manufacturers' profits by $1.624 billion, and increases employment in auto and auto-related industries by 7,490 jobs. In model year 1990, the 27.5 MPG standard reduces consumer welfare by $234 million, decreases auto profits by $856 million, and reduces employment by about 6,600 jobs. In both years, Ford is obliged to make more product changes than GM to satisfy the standard.[33] Under either scenario, consumers are worse off in MY 1990 than in MY 1989 because GM

[33] Thus, Ford's losses are proportionately (and absolutely) greater than GM's.

must make a larger product change in that year. However, losses for GM and Ford are lower in MY 1990 because the model assumes that, given one year's lead time, GM and Ford will be able to produce more high MPG cars in an attempt to comply with a 27.5 MPG CAFE standard.

B. Gasoline Consumption Model

To measure the change in gasoline consumption that will result from changing the CAFE standard, it is necessary to estimate and compare (1) the lifetime gasoline consumption of new cars sold under the standard, (2) the estimated gasoline consumption of the cars that would have been produced had the higher CAFE standard not been imposed, and (3) the "scrappage effect" (the change in the stock of used cars that results from a change in the price of new cars) to determine the total stock of cars in operation.[34] Many of the changes in fleet composition reflect large car buyers switching to new small cars in response to changes in relative car prices. But because smaller cars use less fuel, the marginal cost of driving declines, and driving is encouraged. The model uses Blair *et al.'s*[35] findings to adjust for changes in the rate of use of new cars induced by higher CAFE standards.

Data on miles driven and scrappage rates are incorporated into the gasoline consumption calculations.[36] The scrappage rates are adjusted for new car price changes using Gruenspecht's estimates.[37] Gruenspecht showed that if the price of new cars is raised (lowered), it causes a significant decrease (increase) in the scrappage rates of used cars. Here we assume that Gruenspecht's results can be applied to each of the three classes of automobiles (Basic Small, Luxury Small, and Large). For purposes of the gasoline consumption model, Japanese cars are combined with their corresponding American segments.[38]

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[34] Several studies, such as Gruenspecht (1982a and 1982b), have found that scrappage rates of used cars are significantly affected by new car prices. See also James A. Berkovic, "New Car Sales and Old Car Stocks," *RAND Journal of Economics* (1985), 195-214 and Richard W. Parks, "Determinants of Scrappage Rates for Postwar Vintage Automobiles," *Econometrica* (1977) 1099-1115.

[35] Blair, Kaserman, and Tepel (1984).

[36] Figures obtained from the Motor Vehicle Manufacturer Association, *Motor Vehicle Facts and Figures* (1987).

[37] Gruenspecht (1982b).

[38] The MPG values for each of the three classes can be determined from the information used in the automobile market model. The entire fleet fuel efficiency for 1973 is known to be about 14.2 MPG. The model assumes that the ratio of fuel efficiencies between classes is the same for each year.

The simulation was performed for both the 1989 and 1990 scenarios with the additional scrappage and substitution effects (described above) for various CAFE levels. As we noted earlier in § V of these comments, CAFE standards could, paradoxically, *increase* gasoline consumption because of the interplay of four factors: a reduced retirement rate of existing fuel-inefficient large cars, an increased rate of production, and rate of use, of new small cars, and an increased production rate of new large cars by firms currently unconstrained by the CAFE standards.

For the most part, the changes in gasoline consumption identified here do not occur in the model years to which the CAFE standard would be applied. Rather, they are the summation of gasoline consumption changes for the ensuing 15 years. A real discount rate of 4 percent is used.

Our results are consistent with this possibility. The consumption model predicts that gasoline use would actually increase if the higher CAFE standard were enforced. The model predicts that establishing a 27.5 MPG standard instead of a 26.6 MPG standard in model year 1989 would increase gasoline consumption by approximately 245 million gallons over the ensuing 15 year period. Imposing a 27.5 MPG standard for MY 1990 raises gasoline consumption by approximately 200 million gallons. When the simulation is performed under the "alternative scenario" (i.e., if GM obtains its additional mileage credits), gasoline consumption over the 15 year period following the imposition of the standard increases by 341 million gallons and 288 million gallons, respectively, for MYs 1989 and 1990.[39] Thus, rather than achieving its intended effect of reducing consumption of gasoline, raising CAFE standards appears likely to accomplish the exact opposite.

With this assumption, knowledge of the fraction of cars in each class for 1973, and the entire fleet fuel efficiency for 1973, the fuel efficiency for each class of new car in 1973 can be estimated. We also assume that, for each class of car, fuel efficiency grew at a constant rate between 1973 and 1987. MPG's are then calculated accordingly. The fuel efficiency of cars produced before 1973 is assumed equal to be to the 1973 level.

[39] Changes in gasoline consumption do not vary directly with changes in the CAFE standard. That is, increasing the standard may increase gasoline consumption when the change in the standard does not exceed some threshold level; increases in the standard beyond that threshold will cause total consumption to decrease. Gasoline consumption appears to increase when the CAFE standard is increased by less than 1.0 MPG, and decrease for larger CAFE level increases (Kleit (1987), p. 99). Decreasing gasoline consumption through higher CAFE standards appears to be very costly to society. Kleit (1988) estimates this cost to be in the range of $4.00 - $5.00 per gallon.

VII. Conclusion

Our comparison of a 27.5 MPG CAFE standard to a 26.6 MPG standard suggests that the higher standard will harm consumers and auto producers, reduce employment in the auto industry, and increase total fuel consumption. This analysis assumes that GM will be unable to overturn recent court decisions and gain additional CAFE credits. Should GM win its court challenge, we estimate that imposing the higher CAFE standard will result in lesser, though still significant, harm to the economy, as well as increased gasoline consumption. We therefore recommend that NHTSA adopt a CAFE standard no greater than 26.6 MPG for MYs 1989 and 1990.

Technical Appendix*
Andrew N. Kleit

* This appendix has been prepared by a staff member of the Bureau of Economics of the Federal Trade Commission. It has not been reviewed by, nor does it necessarily reflect the views of, the Commission or its members.

I. Description of Automobile Market Model

The automobile market model presented here is an extension of the model used by Kleit (1987, 1988), and is very similar to the simulation used by the FTC staff in its 1986 submission to NHTSA. Model year 1987 serves as the base period. In the model there are five types of automobiles: (1) Asian Basic Small, which includes regular minicompacts and subcompacts such as the Sentra, the Corolla, and the Hyundai; (2) Asian Luxury Small, which includes specialty subcompacts and regular compacts such as the RX7 and the Stanza; (3) American Basic Small, which includes minicompacts and subcompacts such as the Cavalier and the Escort; (4) American Luxury Small, which includes specialty subcompacts and regular compacts, such as the Reliant K and the Mustang; and (5) American Large, which includes intermediate and large cars such as the Cutlass, the LTD, and the New Yorker. This breakdown is based on categories used by *Ward's Automotive Yearbook*.[1] Luxury European cars, which constitute about 4 percent of the market, are excluded from the model. Volkswagen and Yugo cars are included in the American Basic small segment. On-shore Asian production is included in the Asian segments. "Captive" imports (autos built by Asian firms but sold under American nameplates) are included in the Asian segments.

During the 1980s, Japanese car sales in the United States have been restricted by import quotas ("voluntary restraint agreements"). Currently the quota is set at 2.3 million units. However, during the 1987 model year Japanese imports were only about 2.25 million units. Thus, the initial implicit tariff is set to 0.

Each segment is divided into constrained and unconstrained production. Constrained are Japanese imports (potentially by the import quota) and General Motors and Ford (by CAFE standards). Unconstrained production includes on-shore Japanese and off-shore Korean output, Chrysler, Volkswagen, and Yugo. The quantities, prices, and fuel efficiencies for each type of car for model year 1987, are shown in Table A-3.

Equilibrium prices and quantities are computed through a series of five demand and thirteen supply equations. Quantity demanded is determined by a set of linear demand curves[2]

(1) $Q = AP + B$

where Q is the vector of five quantities, P is the price vector, A is a five by five matrix of slope coefficients, and B is a vector of intercepts.

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[1] *Ward's Automotive Yearbook* (1988), p. 155 and 233.

[2] With the imposition of a standard, linear curves generate less deadweight loss than constant elasticity curves.

Quantity supplied is determined by a set of linear supply curves

$$(2)\ Q = C(P-T) + D(P-V) + E + F$$

where C is a diagonal five by five matrix of supply coefficients for GM and constrained Japanese firms, D is a diagonal matrix of supply coefficients for Ford (with the first two diagonal elements equalling zero), E is a diagonal five by five matrix of supply coefficients for the unconstrained firms, F is a vector of supply curve intercepts, and T is a vector of implicit taxes, $T' = (T_1, T_2, T_3, T_4, T_5)$. T is applied to General Motors and offshore Japanese production. T_1 and T_2 are the implicit tariffs for each type of off-shore Japanese car, $T_1=T_2$. T_3, T_4, T_5 are the implicit CAFE taxes applied to each type of American car produced by GM.[3] V is a vector of implicit taxes applied to Ford. $V' = (V_1, V_2, V_3, V_4, V_5)$, where $V_1 = V_2 = 0$. The level of these implicit taxes will be generated by the model.

CAFE standards are assumed to be just nonbinding in the initial conditions (that is, that the levels reached by automobile companies under a lower CAFE standard are the same as those they would have reached without any CAFE standard at all), but differentially binding on the "Big Two" (General Motors and Ford) if the policy is enforced.[4] This is likely to yield an underestimate of deadweight loss (DWL), as DWL is a function of the implicit tax squared. Crandall and Graham[5] suggest that even without relief CAFE standards would be binding on GM and Ford, meaning that an implicit tax already applies to these two firms. If CAFE standards are imposed, they are assumed to be binding, and the implicit tax per "Big Two" car is calculated accordingly. The system of 21 equations (five demand curves, thirteen supply curves, two CAFE constraints, and one import constraint) in 21 unknowns (five prices, thirteen quantities, and three implicit taxes) is solved and the implicit tariff and the shadow tax per MPG for GM and Ford are iterated until the desired quota and CAFE standard level are reached.

Based on past studies of the demand for automobiles we assume that a 10 percent increase in the small car price will generate a 20 percent decline in the quantity of small cars demanded and that a 10 percent increase in the

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[3] Assume that under one scenario the implicit tariff on Japanese cars is $500 and the implicit CAFE tax is $300 per MPG for General Motors. Using the formula for calculating implicit CAFE taxes (see below) and the MPG per class in Table A-3 yields an implicit tax vector $T' = (500, 500, 300*27.5*((27.5/32.45)-1), 300*27.5*((27.5/27.42)-1), 300*27.5*((27.5/25.31)-1)) = (500, 500, -1258, 24, 714)$.

[4] Chrysler is assumed not to be bound by CAFE regulations in the simulation. Its supply of credits earned in previous years is more than sufficient to cover any likely shortfall.

[5] Robert W. Crandall and John D. Graham, "The Effect of Fuel Economy Standards on Automobile Safety," *Journal of Law and Economics* (Forthcoming, 1989), p. 19.

price of large cars will lower the quantity of large cars demanded by 30 percent.[6]

The point elasticities of demand at the original 1987 equilibrium are shown in Table A-3. The own-price elasticity of demand for automobiles is assumed to be one. (This is consistent with the results reported in Irvine (1983).[7]) The cross-elasticities shown should not be interpreted as precise figures, but merely internally consistent with the overall market demand and the own-elasticities for each of the segments from 2 to 3. The method for the derivation of the cross-elasticities is available upon request.

To our knowledge, no study exists of short-run cost curves for automobile production. Results obtained by Friedlander *et al.*[8] indicate that the industry may have constant long-run marginal cost curves. In the short-run, however, it seems likely that marginal costs are increasing. Thus, the point elasticity of supply (marginal cost) in the model is set equal to 2 for MY 1989. This assumes that while the industry has a competitive structure, there are short-term economic rents to be earned in the sale of automobiles. We assume that given a year to prepare, automakers would be in a better position to comply with a CAFE standard of 27.5 MPG in MY 1990. Thus, we assume that the supply elasticity for that year is 4.

Documents we have received from two major auto companies indicate that GM is better situated than Ford to satisfy the 27.5 MPG standard. Absent the standard, GM expects to reach 26.86 MPG in MY 1989 and 26.72 MPG in MY 1990. Ford expects to reach 26.6 MPG in both years. Thus, the higher CAFE standard would require a "stretch" of 0.64 MPG for GM in MY 1989 and 0.78 MPG for GM in MY 1990. The stretch for Ford would be 0.9 MPG in both years. We assume that GM and Ford meet the standard and do not choose to pay civil penalties. The economic effects we generate in our model are relative to those that would occur should NHTSA set the CAFE standard for the relevant model years between 26.5 and 26.6 MPG.[9]

Should GM prevail in its current court challenge, and win additional CAFE mileage credits, it expects to reach 27.1 MPG in MY 1989, and 26.9

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[6] These sensitivity (or elasticity) estimates are those found in James Langenfeld and Michael Munger, "The Impact of Federal Automobile Regulations on Auto Demand," unpublished draft, Federal Trade Commission (June 1985) and were those used in FTC Staff (1986).

[7] F. Owen Irvine Jr., "Demand Equations for Individual New Car Models," *Southern Economic Journal* (1983), 764-782.

[8] A. F. Friedlander, C. Winston, and K. Wang, "Costs, Technology, and Productivity in the U.S. Automobile Industry," *Bell Journal of Economics* (1982), 1-20.

[9] Our analysis assumes that any CAFE standard below 26.6 MPG is nonbinding for all manufacturers. Any standard below 26.6 MPG (e.g., 26.5 MPG) could therefore be expected to have the same effects as a 26.6 MPG standard.

MPG in MY 1990. We also compute the economic effects of the higher CAFE standard under this scenario.

To calculate the employment changes we use data from the Congressional Budget Office that provides the additional hours of work required to produce an additional domestic automobile.[10] From this information we compute a coefficient that shows the change in the number of jobs that would result from a given change in the number of each type of automobile produced. We have computed such a coefficient for the three types of cars sizes (see Table A-3). Multiplying these coefficients by the change in the sales of domestic small and large cars, we arrive at an estimate for the employment changes brought about by an adjustment to a 27.5 MPG CAFE standard. The employment effect is more adverse than would be suggested solely by examination of changes in total automobile production. This is because the production of large cars involves more domestic labor than the production of small cars. Because on-shore assembly requires approximately only one-third as much American labor per vehicle as would on-shore domestic production (because most of the components are manufactured overseas), we assume that the amount of domestic labor required is only one-third of what it would be for similar domestic segments.

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[10] See *Domestic Content Legislation and the U.S. Automobile Industry*, Subcommittee on Trade of the House Committee on Ways and Means (August 16, 1982), p. 34-48.

Table A-1
Simulation Results
Model Year 1989

GM MPG Increase: 0.64 MPG   Ford MPG Increase: 0.90 MPG
GM Implicit Tax= $1133/MPG   Ford Tax = $1094/MPG
Japanese Implicit Tariff= $0

Price and Output Effects
(Prices in thousands and Quantities in millions)

Class	Price	Qty	Pchange	Qchange
1	8.655	1.734	-0.034	-0.014
2	14.170	1.242	0.406	0.069
3	6.692	1.733	-1.681	0.565
4	10.898	2.024	0.179	0.140
5	15.896	3.066	0.819	-0.588

Output Effects by Firms

Class	GM[11]	Ford	Other	GMChange	FChange	OthChange
1	1.332	0.000	0.402	-0.011	0.000	-0.003
2	0.963	0.000	0.280	0.054	0.000	0.016
3	0.749	0.811	0.174	0.333	0.350	-0.117
4	0.965	0.508	0.552	0.081	0.042	0.018
5	1.824	0.929	0.314	-0.419	-0.199	0.031

Welfare Effects on Consumers and Firms
(in billions of dollars)

Class	Cons.	Firms	DWL	GMChange	FChange	Othchange
1	0.059	-0.059	0.000	-0.046	0.000	-0.014
2	-0.490	0.490	0.000	0.380	0.000	0.110
3	2.846	-4.123	1.277	-1.814	-1.918	-0.391
4	-0.338	0.331	0.007	0.153	0.081	0.097
5	-2.721	2.071	0.651	1.199	0.628	0.244

Economic Welfare Changes
(in $ billion)

Consumer Change = -0.644
American Firms Change = -1.533   Asian Firms Change = 0.430
GM Change = -0.463   Ford Change = -1.209
Chrysler Change= 0.139   Other Firms Change = -0.118
Gasoline Consumption Savings: -245 million gallons
Change in Employment(000s): -11.646

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[11] This category also includes off-shore Japanese production constrained (potentially) by the Voluntary Restraint Agreement.

Table A-2
Simulation Results
Model Year 1990

GM MPG Increase = 0.78 MPG Ford MPG Increase = 0.90 MPG
GM Implicit tax= $822/MPG Ford Implicit Tax = $726/MPG
Japanese Implicit Tariff = $60

Price and Output Effects
Prices in thousands and Quantities in millions)

Class	Price	Qty.	Pchange	Qchange
1	8.706	1.725	0.017	-0.023
2	14.104	1.273	0.340	0.100
3	6.820	1.706	-1.553	0.538
4	10.881	2.052	0.162	0.168
5	15.968	3.013	0.891	-0.641

Output Effects by Firms

Class	GM	Ford	Other	GMChange	FChange	OthChange
1	1.317	0.000	0.408	-0.026	0.000	0.003
2	0.983	0.000	0.290	0.074	0.000	0.026
3	0.817	0.814	0.075	0.401	0.353	-0.216
4	0.974	0.511	0.566	0.090	0.045	0.032
5	1.731	0.932	0.350	-0.512	-0.196	0.067

Welfare Effects on Consumers and Firms
(in billions of dollars)

Class	Cons.	Firms	DWL	GMChange	FChange	Othchange
1	-0.029	0.029	0.000	0.022	0.000	0.007
2	-0.418	0.418	0.000	0.324	0.000	0.094
3	2.718	-3.506	0.788	-1.675	-1.547	-0.284
4	-0.312	0.311	0.001	0.145	0.077	0.089
5	-2.913	2.369	0.544	1.322	0.766	0.282

Economic Welfare Changes
(in $ billion)

Consumer Change = -0.955
American Firms Change = -0.689 Asian Firms Change = 0.447
GM Change = -0.208 Ford Change= -0.704
Chrysler Change = 0.223 Other Firms' Change = -0.137
Gasoline Consumption Savings: -204 million gallons
Change in Employment(000s): -19.957

Table A-3
Parameters Used in CAFE Simulation

Elasticity Table

Class	1	2	3	4	5
1) Asian Small	-2.000	0.243	0.334	0.355	0.704
2) Asian Luxury Small	0.217	-2.500	0.125	0.837	2.661
3) Domestic Small	0.856	0.446	-2.000	0.583	1.160
4) Domestic Lux. Sma.	0.165	0.539	0.103	-2.500	2.237
5) Large	0.015	0.083	0.010	0.103	-3.000

Totals by Class

Class	Price (Initial) ($000)	Quantity (Initial) (million)	MPG	Cars/Job
1	8.689	1.748	35.51	22.65
2	13.764	1.173	29.57	19.38
3	8.373	1.168	32.45	7.55
4	10.719	1.884	27.42	6.46
5	15.077	3.654	25.31	5.40

Initial Quantities by Firms
(millions of units)

Class	GM	Ford	Chrysler	Other	Constrained Asian	Uncstr. Asian
1	0.000	0.000	0.000	0.000	1.343	0.405
2	0.000	0.000	0.000	0.000	0.909	0.264
3	0.416	0.461	0.150	0.140	0.000	0.000
4	0.884	0.466	0.534	0.000	0.000	0.000
5	2.234	1.128	0.283	0.000	0.000	0.000

Supply Elasticity: 2.0 (all firms and classes, Model Year 1989)
4.0 (all firms and classes, Model Year 1990)

Source for prices: *Ward's Automotive Yearbook*, 1988, pp. 216-221 and 287-293.
Source for quantities and fuel efficiency: Patricia S. Hu and Linda S. Williams, "Light Duty Vehicle MPG and Market Shares Report: 1st Six Months Model Year 1988," Oak Ridge National Laboratory (Forthcoming) E-41 to E-44.

Table A-4
Simulation Results
Model Year 1989
Alternate Scenario

GM MPG Increase: 0.40 MPG Ford MPG Increase: 0.90 MPG
GM Implicit Tax= $802.80/MPG Ford Implicit Tax = $1047.51/MPG
Japanese Implicit Tariff= $0

Price and Output Effects
(Prices in thousands and Quantities in millions)

Class	Price	Qty	Pchange	Qchange
1	8.625	1.722	-0.064	-0.026
2	13.994	1.212	0.230	0.039
3	6.859	1.643	-1.514	0.475
4	10.745	2.006	0.026	0.122
5	15.629	3.251	0.552	-0.403

Output Effects by Firms

Class	GM	Ford	Other	GMChange	FChange	OthChange
1	1.323	0.000	0.399	-0.020	0.000	-0.006
2	0.939	0.000	0.273	0.030	0.000	0.009
3	0.632	0.825	0.186	0.216	0.364	-0.105
4	0.955	0.514	0.537	0.071	0.048	0.003
5	2.003	0.945	0.304	-0.240	-0.183	0.021

Welfare Effects on Consumers and Firms
(in billions of dollars)

Class	Cons.	Firms	DWL	GMChange	FChange	Othchange
1	0.112	-0.112	0.000	-0.086	0.000	-0.026
2	-0.275	0.275	0.000	0.213	0.000	0.062
3	2.425	-3.403	0.977	-1.193	-1.849	-0.361
4	-0.038	0.024	0.014	0.010	0.000	0.014
5	-1.888	1.581	0.307	1.009	0.410	0.162

Economic Welfare Changes
(in billions of dollars)

Consumer Change = 0.336
American Firms Change = -1.624 Asian Firms Change = 0.163
GM Change = -0.174 Ford Change = -1.439
Chrysler Change = -0.011 Other Firms' Change = -0.174
Gasoline Consumption Savings: -341 million gallons
Change in Employment (000s): 7.490

Table A-5
Simulation Results
Model Year 1990
Alternative Scenario

GM MPG Increase: 0.60 MPG Ford MPG Increase: 0.90 MPG
GM Implicit Tax = $687.69/MPG Ford Implicit Tax = $ 691.26/MPG
Japanese Implicit Tariff= $0

Price and Output Effects
(Prices in thousands and Quantities in millions)

Class	Price	Qty.	Pchange	Qchange
1	8.661	1.725	-0.028	-0.023
2	13.987	1.249	0.223	0.076
3	6.917	1.646	-1.456	0.478
4	10.779	2.035	0.060	0.151
5	15.775	3.147	0.698	-0.507

Output Effects by Firms

Class	GM	Ford	Other	GMChange	FChange	OthChange
1	1.325	0.000	0.400	-0.018	0.000	-0.005
2	0.968	0.000	0.281	0.059	0.000	0.017
3	0.737	0.820	0.089	0.321	0.359	-0.202
4	0.975	0.514	0.546	0.091	0.048	0.012
5	1.872	0.939	0.335	-0.371	-0.189	0.052

Welfare Effects on Consumers and Firms
(in billions of dollars)

Class	Cons.	Firms	DWL	GMChange	FChange	Othchange
1	0.049	-0.049	0.000	-0.038	0.000	-0.011
2	-0.270	0.270	0.000	0.210	0.000	0.061
3	2.433	-3.095	0.662	-1.332	-1.487	-0.276
4	-0.107	0.102	0.004	0.046	0.024	0.032
5	-2.339	2.003	0.336	1.191	0.596	0.216

Economic Welfare Changes
(in $ billion)

Consumer Change = -0.234
American Firms Change = -0.856
GM Change= -0.095
Chrysler Change = 0.105
Change in Employment (000s): -6.647
Gasoline Savings: -288 million gallons

Asian Firms Change = 0.221
Ford Change = -0.866
Other Firms Change = -0.133

II. The Mathematics of Harmonic Averaging

Assume that a firm makes only two types of cars; a large relatively fuel-inefficient model, and a small relatively fuel-efficient model. As discussed in the comments above, the explicit fine, F, on a firm for failing to reach the CAFE standard is equal to

$$(3) \quad F = 50^{*} (Q_L+Q_S)^{*}(S\text{-}MPG) \quad MPG<S$$

if the firm does not reach the standard, where S is the level of the CAFE standard, Q_L and Q_S are the number of large and small cars sold by the firm, and MPG is the firm's average fuel efficiency.

The measurement of a firm's CAFE level was not defined as the simple average of a manufacturer's fleet MPG. Instead, a firm's CAFE level is the harmonic average of that firm's fleet MPG.[12] The harmonic average for the firm is calculated by

$$(4) \quad MPG = (Q_L+Q_S)/((Q_L/M_L)+(Q_S/M_S))$$

where M_L and M_S are the fuel efficiencies of the two types of cars.

Using the harmonic average, the marginal CAFE fine to the firm of producing a car of type 1 is

$$(5) \quad dF/dQ_1 = 50^{*}(S\text{-}2MPG+(MPG^2/M_S))$$

Assume now that the standards are binding. In that case MPG=S, the explicit fine of $50 per MPG per car is replaced by a shadow tax L and the implicit CAFE tax on a car of type 1 becomes

$$(6) \quad dF/dQ_1 = L^{*}S^{*}((S/M_S)\text{-}1)$$

where L is the value of the constraint discussed above.[13]

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[12] Public Law 46:15-2003. One property of a harmonic average is that if it is doubled fuel consumed by driving the same number of miles in each type of car is halved.

[13] The marginal fine derived above presents a more difficult problem to manufacturers than would occur with a standard based on simple averaging. Consider a firm that is deciding whether or not to produce an additional car with fuel efficiency equal to 20.0 MPG where the binding CAFE standard is 27.5 MPG. If simple averaging were used, the firm would have to offset that additional unit by producing one car with fuel efficiency of 35.0 MPG (or the equivalent). Under harmonic averaging, however, to produce another unit of 20.0 MPG, the firm must also produce the equivalent of one unit with fuel efficiency of 44.0 MPG. Thus, compared to simple averaging, the harmonic averaging used makes the CAFE standard more difficult to meet.