POLICY OPTIONS FOR ENVIRONMENTAL POLLUTION CONTROL INCLUDING A CASE STUDY: ROAD TRANSPORT ALTERNATIVES

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May 1, 2001

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1. INTRODUCTION

It can be assumed that some level of government intervention to meet environmental and welfare needs of society is desirable. The question is, then, to determine what level of intervention and what method of implementation. Level can be used to represent level of standards – the level of acceptable risk, or the level of government intervention – local, state or federal. This paper will not attempt to describe or analyze the former obligation of regulators – the establishment of an acceptable level of risk (which would differ if determined based on science or economics) and will only indirectly address the latter – the benefit of local, state or federal policies. Assuming these levels can be and have been determined and that it is not zero, regulators also have to use the appropriate and effective mechanism to impose, monitor and enforce this regulation.

During the past 25 years, the United States has primarily enacted environmental regulations that are classified as command and control – a certain level of emissions or type of control technology is specified. Several studies have shown that these regulations may be reaching a point of diminishing returns. Improvements in health and environmental risk reduction are possible only through large increases in control costs.

Any method that cannot be classified as zero-risk or technology-based is a balancing approach. Benefits and risk reduction as well as costs must be considered in evaluating the correct level of control and regulation. Moving to these types of policies places regulators in a difficult position and requires difficult decisions to be made. Simply justifying this balance – between health and a firm's economic success – is difficult. However, it must be considered that forcing companies to spent excessive amounts of funding and resources for pollution control may cost citizens more than health. The financial returns of these companies, and the costs they spend on pollution control are eventually passed on to consumers. Reduced income of consumers translated to less spending on goods and services they value. At some level of control, protection of health poses a cost to society of forgone health, education, shelter or other valued things.

If these control costs, and economics in general, are to be considered in designing environmental policy, a basic goal of environmental policy is to reach a Pareto level of efficiency. This efficiency, and basic economic principals, demonstrates that the optimal level of abatement will occur when marginal costs equal marginal social benefits as shown in Exhibit 1. Other important policy goals are cost-effectiveness in which the pollution control is achieved at the lowest possible cost and all sources are experiencing the same marginal abatement costs. Several market and non-market failures may prevent efficiency and cost-effectiveness from occurring including incomplete or non-enforced property rights, incomplete or missing markets, inadequate prices that do not represent all externalities, imperfect information, agency problems with monitoring or enforcement, access to financing and others. A policy can be judged on whether it corrects or accounts for these problems, how the policy affects and reacts to uncertainties of economic growth, price inflation, technological changes, distributional effects, visibility to the public, transaction costs and strategic behavior. Policies must take advantage of the interests of the many stakeholders and incentives involved, the World Bank and other organizations have begun to develop a new model, as depicted in Exhibit 2.

Exhibit 1. Pareto-efficient Level of Emissions Abatement

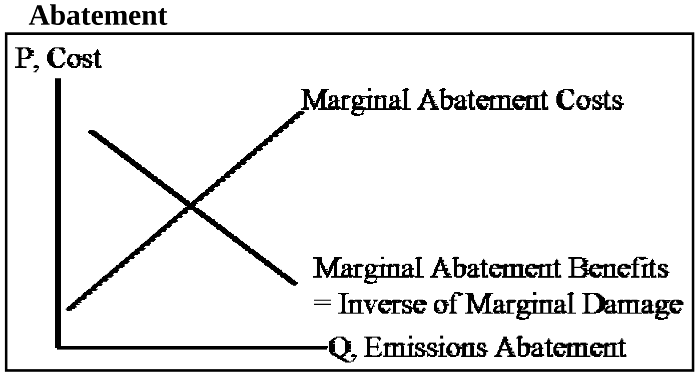
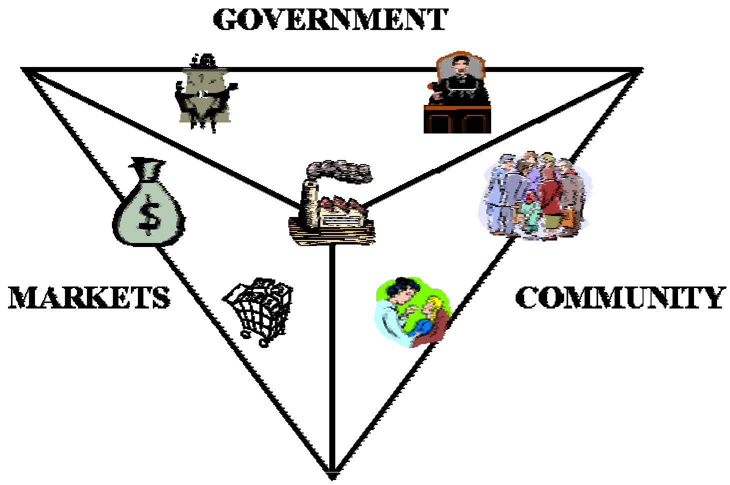


Exhibit 2. The New Pollution Management Model



Using these principals, governments can select from many instruments which differ in several ways including the degree of control retained by the government, the distribution of costs for policy implementation, whether the policy controls the price or quantity of the product, which portion of the market is controlled by the policy and the time frame of the policy intervention. These policies can be generally classified as command-and-control, economic-incentive based and voluntary. A discussion of these policies follows and theoretical conclusions on optimal situations for employment can be made. For each instrument type, subtypes are defined and described, advantages and disadvantages are mentioned and examples provided. The second half of this paper is devoted to an analysis of instrument application to the issues surrounding road transport, primarily fuel efficiency.

2.COMMAND AND CONTROL REGULATION

Command and control (CAC) policies require firms to implement certain technologies and practices or reach certain levels of emission through either technology-based or performance-based standards. Technology-based standards specify either a certain technology (equipment or method) that companies must use or specify that companies must employ the best available control technology (BACT). Performance-based standards set either a quantity of emissions that must be abated or a maximum level of emissions that can be released.

2.1 Technology-based Standards

Technology based standards allow pollution that is remaining after sources have installed “best available” or other state-of-the-art technology or implemented specified control practices.

The government retains the highest level of control when technology-based standards are used. There are no trade offs between cost savings for less strict pollution control methods permitted. Once a technology standard is selected site inspection can make certain that the technology has been put in place. This eliminates the need for and cost of emissions or ambient concentration monitoring, which is useful in situations when these costs are high. Small firms may prefer these standards because they may not have the resources for research and innovation of their own. Additionally, if a firm can invent and patent better control equipment, they have a ready market.

One of the drawbacks in this approach is that there is no undeniably “best” technology; emissions can always be reduced further if more expensive choices are made. Also, firms are unable to select the technology that would be the most cost efficient for their operation. It is indirectly assumed that the chosen control is worth the cost, regardless of the situation. Diverse geography may make a control necessary to reduce risk in a densely populated area but have minimal effect on the risk in a remote, unpopulated area. Once an agency has selected a control method, there is little ability to evolve the standards as technology develops. It is unlikely that polluters will implement one costly technology and be asked to replace it the following year if technology has improved. Since companies realize that they will be regulated at the most stringent levels technically possible, there is also little incentive for the development of better control technology, through research and development.

Congress chose technology-based standards for regulation of several hazardous air pollutants in the 1990 Clean Air Act Amendments and pollution discharges in the 1972 Clean Water Act. These regulations set air and water quality goals that all parts of the country must meet and also limit degradation in the already clean areas.

2.2 Performance-based Standards

Under a performance-based standard, companies are given the discretion to select the form of abatement control most suited for their operation. Whatever control measure is adopted, companies must meet either uniform emissions standards or uniform ambient standards. At a company level, this could result in cost-effective selection.

Performance-based standard implementation requires significant resources to undertake monitoring activities. Regulators must monitor emissions or ambient concentrations and correlate these levels to a specific source. Even though costs can be minimized at the firm level, most cost heterogeneity is across, not within, firms.

For example, the National Appliance Energy Conservation Act of 1987 (NAECA) mandated that minimum energy efficiency standards be met by room air conditioners and gas water heaters after January 1, 1990 and central air conditioners after January 1, 1992 or 1993. Corporate average fuel economy (CAFE) standards, implemented through the 1975 Energy Policy Conservation ACT (EPCA) established fuel economy standards for vehicle car fleets. This policy will be discussed in more detail in the second half of this paper.

2.3 Command and Control Summary

The regulator retains a larger degree of power in command and control types of standards. CAC methods appeal to agencies because of their ease of implementation; after a standard has been determined, all firms are required to adhere to that level. Firms are given similar shares of the pollution-control burden through uniform standards, regardless of the relative control costs to them.

But while CAC standards may effectively limit aggregate emissions of pollutants, they typically exact high costs in the process by forcing some firms to resort to unduly expensive means of controlling pollution. Holding all of the firms to the same target can be expensive. The cost of controlling emissions may vary greatly among firms and even among sources within the same firm, the appropriate technology in one situation may not be cost appropriate or effective in another. Those who set CAC standards do not consider marginal compliance costs and provide little incentive for technological improvement once compliance has been achieved. When comparing environmental policy instruments and their effect on technology change, it is important to ask what effects do the instruments have on the rate and direction of relevant technological change and whether the instruments encourage efficient rates and directions of technological change. Jaffe and Stavins (1995) found that CAC approaches have no discernable effects on technology diffusion.

Because companies have little freedom, the correct abatement level is difficult to determine. A high level of information collection about firms' performance is required for EPA to make this determination, but firms have clear incentives to withhold such information. If regulators expect abatement to be difficult and/or costly, standards may be set at less stringent levels. CAC approaches will have little effect if they are set below standards of practice.

EPA has also allowed for "grandfathering" of pollution rights; creating barriers to entry for new firms. For many situations where CAC standards have been used, the required level of pollution abatement has been set at a far more stringent level for new sources than existing ones. There is evidence that such differential environmental regulations have lengthened the time before plants were retired. This system can actually worsen pollution by indirectly encouraging firms to keep older, dirtier plants in operation (Jaffe, et. al., 2000) and preventing new entrants.

CAC may be preferred in those cases where the consequences of non-compliance are especially serious because the quantity of abatement is required by the policy[1].

Although the majority of regulation can be classified as CAC types, and these methods can often lead to the desired level of pollution abatement, they are not efficient (unless by coincidence) because costs are not minimized. There are economic and environmental benefits in granting companies and communities greater flexibility in determining how to meet the standards of environmental and human health risk reduction. Jonathon Howes, Secretary of the North Carolina Department of Environment, Health, and Natural Resource reported to the Commission on the work of the National Academy of Public Administration that many businesses have found it in their best interest to meet or exceed environmental standards, particularly if they can use their own strategies to achieve the pollution reduction targets that are established (Risk World, 1996 risk report).

3. Economic-incentive-based (Market-based) Policy Instruments

Rather than equalizing pollution levels among firms, market-based instruments equalize the incremental amount that firms spend to reduce pollution (their marginal abatement cost). Market-based standards enable the government to encourage behavior and, thus, emission levels through market signals rather than through explicit directives regarding pollution control levels or methods. These incentives can be in the form of rewards or penalties and are provided to those firms according to their actions to reduce pollution. Companies can then select their appropriate level of abatement and control method. Market based methods assume that all companies will act in their economic best interest and will make decisions to control emission based on their individual (facility or company) marginal abatement curves. Economic-incentive based policies have the flexibility to allow industries to react to pollution control in a variety of ways including process change, technology development and product modification. Hypothetically, this will result in cost-effectiveness, efficiency and dynamic incentives for technology innovation and diffusion. They attempt to eliminate some or all of the market failures and environmental externalities that many command and control policies do not consider, including the ones mentioned in the introduction. Market-based instruments attempt to reach environmental goals not only in the most cost-effective (minimum costs) way.

It is on the basis of prices and charges that society makes its decisions. Market prices and charges are often the most direct way to identify and quantify the many variables involved in making a decision. CAC mechanisms can only approximate this information function and do so at a much greater cost. Actions that directly impact a firm's profits are likely to initiate rapid responses.

Several articles by Jaffe and Stavins (1994, 1995, 1999) address the hypothesis that technological change occurs in three stages: invention, innovation and diffusion. Markets, government policy,

[1] As shown later, however, permit systems also set the quantity of emissions as well as allow for cost-effective decisions.

consumer opinion, competition, etc can influence each stage. Invention can be defined as the act of creating a new technological possibility, innovation is the commercial introduction of the new technical idea (not previously available or at a cost that is lower then previously feasible) and diffusion is the gradual adoption by firms or individuals of commercially available products. Further, innovation can be thought of as the combination of three kinds of energy efficiency shifts: overall technical change, directional technical change and model substitution. Because technology diffusion theoretically lowers the aggregate marginal abatement cost it results in a change in the efficient level of control.

The relative importance of dynamic effects of alternative policy instruments on technological change, and therefore long-term compliance costs, is greater in the case of those environmental problems that are of great magnitude (in terms or anticipated abatement costs) and/or very long time horizon. Hence, it is being given increased attention by scholars and policy makers to address the problem of global climate change.

These types of practices have been used by the Federal government only within the last 15 years. Fourteen members of the Organization for Economic Co-operation and Development (OECD) use between one and 21 economic instruments for environmental protection. Forms of market-based programs include pollution charge systems (taxes, subsidies, deposit-refund systems), tradable permits, barrier reductions (market creation, liability rules and information/educational programs) and government subsidy reductions.

3.1 Pollution Charge Systems

Pollution charge systems can be many kinds but their main defining feature is their reliance on markets and the price mechanism to internalize environmental externalities, thereby attempting to make polluters pay the full social costs of their activities. Pollution charges are best applied where property rights are not evident. Fiscal instruments (taxes) and financial instruments (subsidies) are the most widely used economic instruments (Hawkins, 2000).

3.1.1 Fiscal Instruments/Taxes

Fiscal instruments relate to a government tax or fiscal policy. Two types of tax have been used – the product charge (Pigouvian tax[2]) and the emission charge. The product charge imposes a tax on products whose use or disposal causes pollution and an emissions charge assigns a price to emissions of pollution (e.g., $ per ton). It is assumed that abatement will occur of the marginal cost of abatement is less than the tax and the tax will be paid when additional abatement would cost more than the tax. In other words, it is worthwhile for the firm to reduce emissions to the point where its marginal abatement cost is equal to the tax rate. Therefore, firms will determine their efficient level of abatement – with low-cost controllers controlling more and high-cost controllers controlling less and total abatement, theoretically, being the level determined to be optimal by the regulators.

Exhibit 3. Efficient Tax and Allowance Level

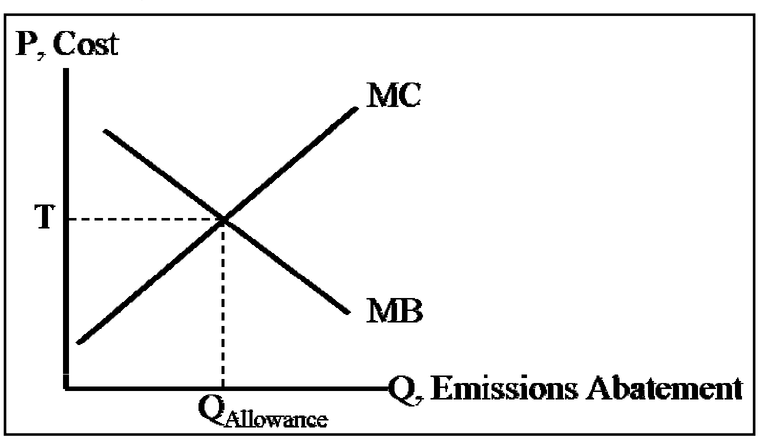


Exhibit 3 shows the preferred level of abatement occurs when

[2] Very few, perhaps none, of the pollution changes used in the world have been Pigouvian taxes and most of them are assessed at levels well below the marginal abatement cost at the efficient level of abatement – intended to raise revenues and not as environmental policy instruments.

marginal costs (polluter aggregate) of abatement equals marginal benefits (to society) of abatement. Regulators use this relationship to set tax and allowance (which will be discussed later) levels. This graph can be used to show the dead weight loss (DWL) to society that will occur if either the tax or allowance level is not set correctly, either because of imperfect information of costs or benefits (expected "E" information is different than realized "R"). Exhibit 4 shows the result of MB uncertainty; Exhibit 5 shows the result of MC uncertainty and Exhibit 6 shows the result if both MB and MC are uncertain. The policy efficiency and preferred instrument is dependent on these uncertainties as well as the relative slopes of the MB and MC curves.

Exhibit 4. Marginal Benefit Uncertainty

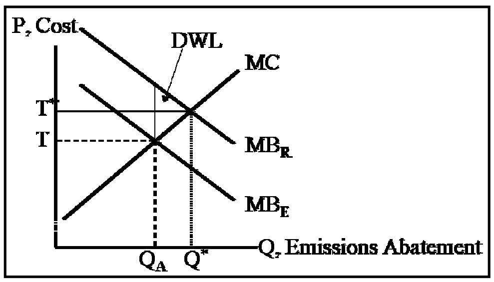


Exhibit 5. Marginal Cost Uncertainty

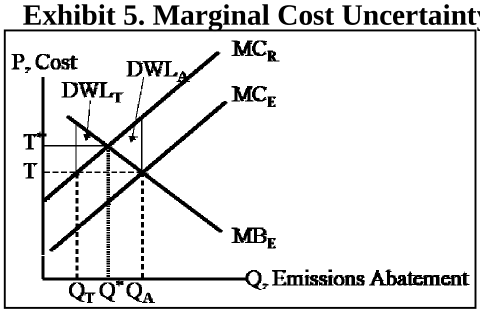
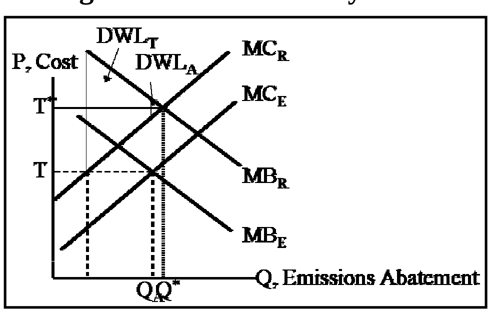


Exhibit 6. Marginal Benefit and Marginal Cost Uncertainty



Taxes raise revenue for government agencies. This may allow them to lower taxes elsewhere, or return the revenue to the taxed industry through research funding, etc. Because firms want to produce less pollution and pay less tax, there is an incentive for technology innovation. However, for both command and control standards and taxes it has been estimated that increases in the standard or level of the tax had ambiguous effects on the level of R&D encouraged, because a direct effect of increasing costs increases the incentives to invest in R&D in order to develop cost-saving pollution abatement methods but an indirect effect of reducing product output reduces the incentive to engage in R&D (Jaffe, October 2000).

Firms also enjoy the ability to select the most appropriate method of abatement. Potential market entrants have knowledge of costs before entering the market and the CAC deterrence is not an issue. However, as new firms enter the market, the demand to pollute may shift and the tax level will be inefficient. Setting tax levels is often an iterative process. As in performance-based standards, there is the difficulty of determining the correct level of control, in order to calculate the correct tax amount. With taxes (and other market based instruments) regulators not only have to estimate the appropriate level of emissions, they must have knowledge of participant marginal abatement cost curves to determine which tax level crosses the aggregate participant cost curve at that level of emission. Each participant will have a different marginal cost curve; if the accurate level is not found aggregate abatement may not be efficient and industry emissions in total may be more or less than the efficient level. This can be demonstrated using Exhibit 3, shown above.

Several economists have hypothesized (the induced innovation hypothesis) that when energy prices rise, the characteristic "energy efficiency" of items on the capital goods menu should improve faster than it otherwise would. In the context of several household appliances, Jaffe and Stavins (1999) estimated that the post-1973 energy price increases account for one-quarter to one-half of the observed improvements in the mean energy efficiency of models offered for sale over the last two decades and that government energy efficiency standards had a significant impact on the average energy efficiency of the product menu. This information could serve as a powerful tool to develop insights into incentives for technology innovation and diffusion.

Effective monitoring and enforcement remains a strong-precondition on the application of charge systems. Failure to do so can lessen their comparative efficiency in relation to CAC.

In the US, as part of global climate change policies, a carbon tax has been proposed to encourage generating companies to switch to lower-carbon fuels, with the possibility of offsets in other taxes. Five European countries have introduced carbon taxes (Crawford, 1995). Another energy use related tax is the policy of a system benefits charge (SBC) in which a non-bypassable wires charge is paid by all end-use consumers of electricity on a per-kWh-consumption basis. Revenues from the tax could then be used to "buy down" the costs of renewable resources to competitive levels, fund R&D for emerging technologies, and/or provide incentives for the delivery of energy efficiency.

Pollution taxes are widely used in OECD countries and are a key instrument in most transition economies. Developing countries, such as Latin America and East Asia, have also introduced such policies. Charges are typically applied for the protection of resources from waste emissions and discharges. Taxes on the landfilling of waste and the differential tax on leaded and unleaded fuel are other examples (Crawford, 1995). In Malaysia, effluent charges have been in operation for 20 years to protect water quality from effluents arising from the palm oil and rubber industries (Hawkins, 2000).

Several pollution tax examples are also available relating to road transport, many as "congestion" taxes. In Singapore, charging drivers for using roads in the city center during peak hours resulted in a 73 percent reduction in traffic in the restricted zone and CO levels. At least 10 cities in the UK are set up to implement similar programs for town centers. Road transport tax reforms to include environmental considerations are also being considered in OECD countries. In contrast to historical emissions taxes, some of the recent policy interest has concerned restructuring the existing tax system to discourage products or activities that cause environmental damage.

3.1.2 <u>Financial Instruments/Subsidies</u>

Financial instruments primarily involve the use of subsidies, and less often investments, to accelerate the development of environmentally benign technologies. Subsidies, in the form of grants, tax credits, direct payments or low interest loans, essentially pay individuals, companies or industries not to pollute. The two main forms of subsidies are abatement equipment subsidies (Pogouvian subsidies) and per unit subsidies on pollution reduction (Coasian subsidies).

Politics and strong interest groups often favor and influence the decision to use subsidies. When subsidies are given based on pollution reduction, incentives for technology development are created. Alternately, subsidies based on abatement equipment purchase could discourage innovation because they subsidize a specified technology. Subsidies may also reward past pollution, by rewarding improvements over historical levels and negating the "polluter pays" principle. When subsidies attract new entrants to the market, emission levels could increase above non-subsidized levels. Subsidies are a cost to government agencies; taxes must be raised in other areas to make up for this loss.

Standard financial analysis would suggest that taxes and subsidies have equivalent results. However, Jaffe and Stavins (1995) found that the response to energy taxes would be positive and significant but that equivalent percentage technology cost subsidies would be about three times as effective as taxes in encouraging technology diffusion. Similarly, a study by Hasset and Metcalf (1995) suggested that tax credits for adoption would be up to eight times more effective than "equivalent" energy taxes. Both studies analyzed cases of residential energy conservation. Energy efficient adoption subsidies, unlike energy prices, do not provide incentives to reduce utilization. Additionally, subsidies and tax credits require large public expenditures per unit of effect, since consumers who would have purchased the product even in the absence of the subsidy or tax credit still receive it.

3.1.3 Bonds and Deposit-refund Systems

Bonds and deposit-refund systems are both based on the principal of paying up front for the externality imposed and being able to recoup the cost, combining characteristics of taxes and subsidies. A consumer places a deposit (tax) during purchase on potential damage and returns the item (or its packaging) for a refund (subsidy) if the damage did not occur.

The refund encourages an abatement activity that requires no government monitoring but the impacts of such a program may not be able to be monitored or quantified. Often, the administrative costs to the consumer and recyler of the program may outweigh the benefits. A high level of commitment is required from the consumer to store the waste and then return it for a refund.

Deposit-refund policies are best suited for waste that is difficult to monitor, is harmful to the environment and can be recycled. Lead batteries are an example of a material used in a deposit-refund program. Another simple program has been "bottle bills" to control litter from beverage containers and to reduce the amount of solid waste entering landfills. Performance bonds are increasingly used in mineral extraction, forestry and waste management as a form of insurance against long-term environmental damage.

3.2 Market Creation/Marketable Allowances/Tradable Permits

Governments have the power to facilitate the evolution of new national or international markets which are defined by the total permissible pollution or discharge allowed within the market. The system establishes a maximum quantity of allowances for pollutant emissions in the market and allows trading of those allowances while allocating the control burden at a minimum cost. Thus, an artificial currency in the form of credits or allowances/permits is created. It relies on economic motivations to encourage environmental protection and cost-effectiveness. It is assumed that individuals and firms with low abatement costs will sell allowances to those individuals and firms with high abatement costs. When modeled simply, marketable allowances act as pollution charges. However, several differences surface once implemented in real life situations:

- Allowances fix the level of control while charges fix the costs of pollution control.
- Allowances freeze the level of pollution control while charges increase it as technological change makes abatement less costly
- Allowances allow for the transfer of resources within the private sector while charges move resources from the private to the public sector
- Charge systems make costs to the consumer/polluter more visible
- Allowances automatically adjust for inflation while most charges do not.
- Allowance systems may be more susceptible to strategic behavior than charges.
- Allowances are more affected by transaction costs
- If benefit or cost uncertainty exists, the relative efficiency of allowances or charges is dependent upon the relative slopes of the industry aggregate marginal benefit and marginal cost functions (Portney, 2000)

Marketable allowance programs may differ in the way allowances are initially distributed, identification of participants, adjustment of the allowance amount, time period and renewability of the permit, geographic boundaries of trading and others. All of these factors influence the participation and effectiveness of the program.

Some programs have awarded allowances on the basis of past emissions. If emissions allowances are grandfathered, the worst emitters are rewarded (as in some subsidy cases). Another option is to auction allowances, which would generate revenue during the auction period. It may be difficult to identify all of the firms in the market and whether there will be brokers and speculators – which would create a new interest group. If there are a few powerful firms in the market, they may have the capability to purchase allowances and not sell them to competitors, despite the poor economics. Marketable allowances perform best in a large market, so that a true price signal may develop. Changing the allowance after the initial allocation may pose political difficulties. There has been problems establishing an allowance as an entitlement or a property right – if allowances are a property right, it is difficult for the government to remove or decrease this right.

If the allowance amount changes yearly there may not be an incentive to undertake long-term abatement actions. By reducing emissions below their allowance level, a firm can bank allowances for further use, which may encourage a higher initial decrease in emissions. If technological advances occur the banked allowances may never be used. Geographic boundaries of the program should be established around areas that share similar marginal abatement benefits. If a large number of high emitters are located within one area, “hot spots” may form. Additionally, for some pollutants such as toxic air pollutants, where sources create localized risks, marketable allowances may not be effective. Monitoring of emissions must also occur, and this could be done through either ambient readings or source based emissions measurements.

If marginal damages (and therefore benefits) are not constant, the optimal policy is determined by the interaction of marginal damages and marginal abatement costs for both taxes and permits. In the face of uncertainty, the marginal cost and benefits curves affect which instrument is preferred (as shown above in Exhibits 3-6).

An example of the use of a marketable allowance is the use of tradable sulfur dioxide emissions allowances to reduce acid rain. This program was mandated under the 1990 Clean Air Act Amendments (CAAA) and requires electric utilities to reduce emissions of sulfur dioxide to allowable levels and permits them to sell the portion of their allowance that is unused, if they reduce emissions below this level. The regulatory program has established a sulfur dioxide cap below historical emission levels. The current cost of a ton of SO_2 emission allowance has fallen below projected costs, possibly as a result of technological development and a lowering of marginal abatement costs (1998 Risk World Risk Report). Similar programs are now being considered to reduce regional nitrogen oxide emissions.

The Kyoto Protocol has components that would enable carbon allowance trading from one country to another. Negotiation over the protocol has resulted in the expected problem of determining the correct allowance cap and allocating these allowances among participants. Additionally, there is the question of whether government/countries will trade internationally or if legal entities have the freedom to trade. If any legal entity (firms) can trade, the national policies implemented to reach country reduction targets must be the same for all Kyoto participants, so that the same unit is traded internationally. The Russian Federation and Ukraine negotiated targets far above the level their emissions would reach by 2010 even with no reduction efforts. If other countries then purchased these excess allowances, their target levels would be significantly relaxed also. The Clean Development Mechanism (CDM) of the protocol, functioning similarly to carbon trading, allows industrialized countries to earn credit for carbon reduction activities in developing countries that did not sign the protocol, which have no emissions limits.

3.3 Market Barrier Reductions

Several reasons exist naturally in markets that may discourage this exchange. Information on technological improvements and other topics could be considered a public good, one that, once created, can be used by many people at minimal additional cost. This creates the problem of free riders; such public goods will tend to be underprovided by ordinary market activity. Additionally, if adopting a new technology provides information to others, the act of adoption creates a positive externality by providing information to others for which the adopter is not compensated. Finally, those with information may not be the ones who could adopt the new technology. If energy producers or retailers know of energy saving practices, adoption will not occur because it is only the energy bill-paying consumer who would adopt these measures to save money. By simply removing existing implicit or barriers to market activity, substantial environmental protection gains can be realized.

3.4 Education Programs/Public Disclosure

The goal of public disclosure programs is regular collection of information about firms' environmental performance. Public disclosure has the potential to affect the demand for a firms' goods and stock, affect firms' ability to hire and retain employees, influence investors decisions, convince private citizens to initiate tort law actions against polluters, build support for new pollution control legislation, motivate private suits to force firms to undertake abatement and give rise to judicial actions in countries like Colombia, Ecuador and Chile where the constitution guarantees citizens the right to a healthy environment (Afsah, 2000, Foulon, 1999).

Education programs are not strictly classified as economic-incentive polices but do provide other pollution prevention incentives and therefore improve the functioning of markets. These programs depend on the beneficial effects of informing public and private entities of the dangers of environmental damage as well as providing information on the produced goods and services. Public disclosure is used as a risk-management tool.

Education programs are a relatively inexpensive way to raise public awareness, but it is difficult to measure the effectiveness of such programs. The burden of proof of safety is moved from government agencies to the manufacturers. Evidence suggests that a firm's environmental reputation matters – a suppliers or consumers perception of a firm's environmental performance will affect costs or revenues.

Popularity of public disclosure programs are, in a large part, due to evidence that pioneering approaches such as the United States' Toxic Release Inventory (TRI) have had a significant impact on pollution abatement. Public disclosure programs also impose a minimal burden on regulators. It does not necessarily require an effective enforcement capability or even a well-defined set of regulations. The cost of the administrative activities that are required – data collection and dissemination – appear to be falling due to new information technologies. Public disclosure programs, therefore, hold promise for developing countries where environmental regulatory institutions are chronically short of funding, expertise and local support. It can also be used in industrialized countries to support conventional regulatory instruments for types of pollution that are not yet strictly controlled.

Persuasion and incentives have been successful, but there are always some polluters who resist, and for these there must be a credible threat of real punishment – through fines and occasional jail terms.

These types of programs have been used extensively about lead poisoning in children and homes. EPA also requires labeling of several products including some pesticides. This practice may also come into play during restructuring of the electric and gas utility industries. Markets will be created where buyers have access to an expanded set of choices for all forms of energy and energy services, including those promoted at "cleaner-than-standard."

Market pressure due to public recognition of firm performance has resulted in a wide variety to Codes of Practice and other voluntary guidelines or industrial associations, and NGOs or other groups are becoming more active in promoting the implementation of such commitments. The

World Bank Group, for example, is supporting several initiatives to join industries, local regulators and community groups to discuss local priorities and to improve those industries' environmental performance. One example of the groups work is Indonesia's PROPER program, which rates and publicly discloses factories' environmental performance (Afsah et. al., 2000). These government-certified performance ratings enable environment agencies to reduce expensive legal enforcement procedures by bringing community and market pressure to bear on polluters. In the United States, Right-to-know laws such as the Toxic Release Inventory (TRI) and California Proposition 65 require the disclosure of information about chemical releases to the environment and labeling of chemicals in production, respectively.

Another example of a public disclosure program is Indonesia's Program for Pollution Control, Evaluation and Rating (PROPER), established in 1995 by the Environmental Impact and Management Agency (BAPEDAL). Although the country has had a CAC regulatory system in place since the early 1980s, enforcement has been low and compliance limited. PROPER is a rating system of individual plants using plant-level data, self-reported survey data and inspection data. Once the program was begun, monthly emission reports were submitted by participating plants and compared with past reports. If there are discrepancies and inspection of the plant is conducted. A survey of participating firms show that PROPER spurs abatement by improving factory managers' information about their own plants' pollution and abatement opportunities – essentially an environmental audit effect. This force operates in conjunction with external forces such as capital markets, the threat of future regulation, discretionary enforcement of existing laws and product markets. Together, ratings have improved for over a third of the plants (Afsah et. al., 2000).

3.5 Property Rights

If property rights are not clearly defined, consumers may use the resource more than optimal. Property rights are most commonly used in developing countries and to slow the rate of natural resource depletion. Privately held land is converted to communal ownership, allowing communities to share in the economic costs and benefits of maintaining the asset. In Papua New Guinea, more than 90 percent of the land remains communal and only 13 percent of the forestland has been converted to other uses.

3.6 Liability Rules

Liability systems involve the assignment of whole or part liability of the requirement to cover liability through insurance. Pollution insurance can be seen as one type of economic instrument that provides direct financial incentives away from polluting processes. Liability rules encourage firms to consider the potential environmental damages of their decisions. The European Commission is considering the adoption of a European Union wide system of strict liability for environmental damage.

3.7 Government Subsidy Reductions

Government subsidies are the mirror image of taxes and are intended to provide incentives to address environmental problems. However, in practice, many subsidies promote economically inefficient and environmentally unsound practices. Energy priced at average, rather than marginal costs, or energy subsidies will cause energy prices to differ from the marginal social cost. An example is the below-cost sale of timber by the U.S. Forest Service. The Forest Service sells timber from public lands at a commercial price, but this price may be below the cost the federal government pays to harvest the timber cost which includes subsidies to private lumber companies for road building, production costs and other public goods such as wilderness, recreation and others. The promotion of agricultural production through subsidies for inputs, such as pesticides and water use, can contribute to environmental damage. Altering these negative policies can have as substantial an effect on the environment as subsidies for the provision of pollution abatement.

An overview of the different types of market-based instruments and examples of their applicability are shown in Exhibit 7. Not all of the examples are described in the text of this paper.

Exhibit 7. Economic Instruments for Environmental Protection and Natural Resources Management

Charge Systems/Financial Instruments	**Market Creation**
Road Tolls Access Fees Pollution Charges User Charges Betterment Charges Impact Fees Administrative Charges	Tradable Emission Permits Tradable Catch Quotas Tradable Development Quotas Tradable Water Shares Tradable Resources Shares Tradable Land Permits Tradable Offsets/Credits
Eco Funds/Environmental Funds	**Bonds and Deposit Refund Systems**
Soft Loans Grants Location/Relocation Incentives Subsidized Interest Hard Currency at below Equilibrium Exchange Rate Revolving Funds Sectoral Funds	Environmental Accident Bonds Environmental Performance Bonds Land Reclamation Bonds Waste Delivery Bonds Deposit Refund System Deposit Refund Shares
Fiscal Instruments	**Liability Systems**
Pollution Taxes (on Emissions or Effluents) Product Taxes Input Taxes Export Taxes Import Tariffs Tax Differentiation Royalties and Resource Taxes Land Use Taxes Investment Tax Credits Accelerated Depreciation Subsidies	Legal Liability Non Compliance Charges Joint and Several Liabilities Natural Resource Liability Liability Insurance Enforcement Incentives
Public Disclosure	**Property Rights**
Environmental Performance Reports Emissions Inventories Energy Efficiency Labeling	Ownership Rights User Rights
Government Subsidy Reductions	
Subsidized Resource Sales	
Source: Adapted from Hawkins, 2000 which cited UNEP and Impax, Ltd.	

4. NON-REGULATED PROGRAMS

Much like education programs and public disclosure, non-regulated/voluntary programs rely on the public's attitudes to encourage industry to reduce or eliminate their use or release of toxicants, alter their production process in an environmentally favorable way or produce environmentally friendly products. Voluntary regulation (certification and labeling protocols) and informal regulation are useful tools and have been labeled the "third wave" of environmental regulation, following command and control and market-based approaches. Successful programs must (1) detect environmental concerns and risks; (2) assure reliable information; (3) disseminate the information to those at risk from the pollution; and (4) allow public- and private-sector agents to act on the information to create pressures for pollution control. Reliable and easily compared information on the environmental impacts of energy service options permits buyers to minimize information collection costs and uncertainties in making purchasing decisions. This information also increases the supply and demand for environmental protection and energy-efficiency. Analysts have shown that capital markets react significantly to the release of information; upward when the information reveals a superior performance and downward when a poor performance is revealed (Foulon, 1999). Other analysts have shown that voluntary public disclosure improves the environmental performance of polluters.

4.1 Voluntary Regulation

Voluntary regulations serve, among other purposes, to address one of the non-market failures mentioned earlier – agency problems. They allow a firm to participate in a regulated program voluntarily, for public recognition, access to technology transfer and education among the industry or other reasons. For example, most energy-saving investments in industry operations are small and senior staff may rationally choose to restrict funds for such small projects that cannot be perfectly monitored. Programs such as the Green Lights program attempt to address this type of problem by providing information on savings opportunities at the level of the firm where decisions are made. Small projects become larger as they impact firms' revenues as well as costs.

One of the most prominent voluntary programs in the United States is EPA's Energy Star Program, which recently expanded to the European Union. The program is a voluntary energy-efficiency labeling program of a full range of office equipment, lighting and home appliances. The Energy Star label helps consumers identify products that save them money and help protect the environment by saving energy. Manufacturers and retailers sign voluntary agreements allowing them to place the Energy Star label on products that meet or exceed energy-efficiency guidelines established by the EPA and DOE. The label can also be used in product packaging, promotions and advertising for qualified productions. More than 1,200 manufactures have signed the Energy Star agreement. EPA estimates that in 2000, eight million metric tons of carbon were saved from using Energy Star labeled office equipment in the United Sates.

EPA's Green Lights program is also intended to encourage greater private industry use of energy-saving technologies. The Green Lights program is a voluntary effort by which the EPA encourages and helps businesses and other organizations upgrade their lighting systems to those that are more energy-efficient in order to save money and reduce the emissions from power production.

Another EPA program is Natural Gas Star, a voluntary program for natural gas producers and transmission and distribution operators. Members sign a memorandum of understanding and agree to use best management practices to reduce methane emissions during operation. EPA collects and distributes through documents and workshops information on these practices and technology improvements.

4.2 Informal Regulation

Informal regulation is common in developing countries where state regulators are weak and pressures to abate are generated by private-sector agents. It enables public or interest groups to pressure and provide incentives to firms. Findings in Indonesia and Mexico imply that shareholders, employees and international certification programs can motivate firms to cut emissions. General observations apply to each of these non-regulated instruments. When information costs are low, the threat of regulation is high. Therefore, government actions like public disclosure may spur abatement. In other words, firms may actually be encouraged to over-comply, in an attempt to preempt or weaken future regulation, affect the monitoring and enforcement of existing regulation and to attract "green" consumers. Programs such as the ones described above encourage exchange of technologically superior designs and practices and may influence diffusion of ideas. Both EPA programs publicly recognize member accomplishments.

5. ANALYSIS OF POLICY INSTRUMENTS

It does seem that there is a move away from uniform command-and-control regulations. The theoretical advantage of economic instruments over these types of standards is a greater flexibility and cost-effectiveness. The key to environmental policy is to ensure that the value of the resulting output (control, risk reduction) is greater than that which must be sacrificed (expenditures). Poorly designed programs, however, may not yield measurable economic and environmental benefits. Not only will poor design sabotage the benefits of the program, it will decrease confidence in the theory. The full potential of market-based instruments can only be achieved in the overall context of sound macroeconomic policies.

The challenge facing policy makers is to design policies to enable market forces (whether through market based instruments of through standards that harness consumer market demand) to operate in the environmental sphere. Regulators must consider several criteria when determining the best Pollution control policy instrument to use. From the information presented above, several conclusions can be made:

- *Degree of Mixing* –CAC instruments are preferred for non-uniformly mixed pollutants where "hot spots" may be a concern and it is important to regulate specific polluters. Market based instruments are preferred for uniformly mixed pollutants because the responsible parties do not have to be found and reductions will still occur.
- *Cost-effectiveness* – Cost-effectiveness is more likely to occur through use of market based instruments. These types of instruments allocate abatements costs over participants – they allow for heterogeneous control costs.
- *Flexibility* – There is more flexibility in setting market-based policies.
- *Program Costs* – Enforcement and monitoring costs are higher for market-based instruments.
- Dy*namic Incentives* – There are more long-term incentives for technological change when using market based instruments
- *Revenue Raising* – There is a possibility for revenue raising, and the opportunity to recycle this revenue when using taxes or auctioning allowances.
- *Distribution* – Taxes may cause distribution problems by giving money to the government/public sector but allowances allow all money to remain within those that are incurring the abatement costs – the private sector.
- *Uncertainty* – Marginal Cost uncertainty will result in taxes preferred over allowances if the MC curve is steeper than the MB curve and allowances preferred over taxes if the MB curve is steeper than the MC curve.
- *Political Feasibility* – Taxes may be politically infeasible in the US because of their visibility.
- *Economic Growth* – If there is economic growth, taxes allow the emissions level to rise but allowances fix the emissions level. CAC instruments fix the level of emissions regardless of uncertainty.
- *Technological Change* – If there is technological control improvement (the MC of control falls), taxes cause emissions levels to fall and allowances fix the emissions level.
- *Inflation* – If there is price inflation, taxes allow the emissions level to rise but allowances fix the emissions level.
- *Strategic Behavior* – There is a potential problem of strategic behavior if allowances are used.
- *Barriers to Entry* – Allowances may present barriers to entry.
- *Equity* – Allowances are better at addressing equity issues through initial allocation.

Using these conclusions, however, no hierarchy of efficient and cost-effective policies can be made; the optimal policy instrument will be very case-specific.

ROAD TRANSPORT

Many of the instruments introduced above could be applied within the energy sector – several of the examples applied to electric utilities, demand side management of energy prices and road transport. Road transport, primarily fuel efficiency, will be more closely analyzed in the remainder of this paper to show how and if these instruments apply. The purpose of this analysis is not to perform extensive empirical analysis on the topic, most of which would be a duplication of work already completed, but to synthesize and analyze the available findings and conjecture the effectiveness of current and proposed regulation of fuel economy.

Several issues, relating to automobiles, must be considered when establishing policy including: safety, emissions of air pollutants and greenhouse gases, social costs associated with road use (congestion, accidents, road and environmental damage), interactions between road transport, other modes of transport and spatial development as well as consumer attributes such as price, aesthetics, ride-ability, size and performance (Crawford and Smith, 1995). Many of these are linked to market failures associated with transportation, each of which contributes to the inefficiency of any proposed standard.

6. HISTORY – CAFE

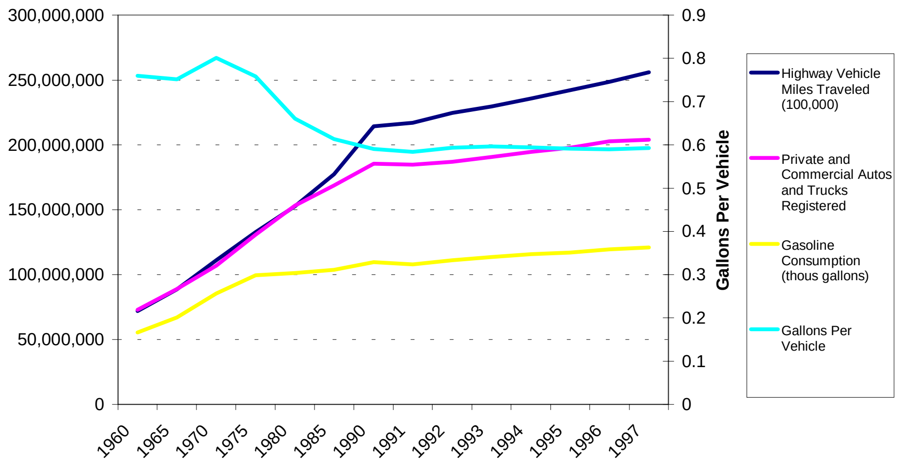
Beginning in the mid-1960s, increased public debate led to policies that resulted in greater safety, lower emissions and greater fuel economy in cars. The federal government began to assume a larger oversight role in 1966 through safety legislation and regulation. Emissions regulation followed in 1968 and, after the fuel economy of new U.S. passenger cars hit it lowest point in recent history in 1974 and OPEC exercised its new found market power by tripling world oil prices, in 1975 the Energy Policy Conservation Act (EPCA) established Federal Automotive Fuel Economy standards (AFES), or corporate average fuel economy (CAFE), standards. The original goal of the CAFE regulations was to reduce fuel consumption in a period of high oil prices.

1974 models average about 14 miles per gallon (MPG) and CAFE standards required new cars achieve 18 MPG in 1978 and 27.5 MPG by 1985[3]. The CAFE number, calculated as the salesweighted harmonic mean MPG of a manufacturer's product, measures compliance with the standards. The targets must be met for domestic and imported (by domestic manufacturers) fleets individually or a fine, $5 per car sold per 0.1 MPG of shortfall, must be paid. By exceeding standards in some years manufacturers can offset shortfalls in other years without penalty. Light duty truck MPG has also increased dramatically since 1975, but in recent years (since 1995) has been below CAFE standards of 20.7 MPG. The difference in stringency of passenger car and light truck standards is attributable to the fact that passenger car targets were set within the law itself while light truck standards were determined by separate Department of Transportation rulemaking. If passenger vehicle fuel economy had not changed through standards or autonomous technological change, the 1,512 billion highway miles traveled by automobiles in 1998 would have required 53 billion more gallons of fuel and cost motorists an additional $64 billion (NHSTA). However, fuel prices have fallen nearly 50 percent since 1982 (DOE/EIA), putting automakers in a position of balancing laws mandating fuel economy and consumer desires for larger, more powerful vehicles. In 1999 there were approximately 131 million private and commercial automobiles and 73 million light duty trucks registered in the US, equating to approximately 1.13 vehicles for each licensed driver. The average US vehicle travels about 600

[3] Standards were relaxed for model years 1986-1989 in response to manufacturer petitions (Bamberger, 2000).

miles per year. These vehicles also use about 80 percent of the petroleum in the US (NHSTA, 1999).

Exhibit 8. Vehicle Registrations, Fuel Consumption, and Vehicle-Highway Miles of Travel



Source: NHSTA, Highway Statistic Series, U.S. Census

There are several arguments for and against the effectiveness of CAFE standards. The primary concern regarding CAFE standards is that (1) price effects, not CAFE standards caused fuel economy improvements. Secondary arguments involve concerns that they (2) force consumers to buy smaller less desirable, unsafe cars (as manufacturers lower vehicle weight to reach fuel economy standards) or less regulated models such as light trucks; (3) slow scrappage rates (because of increased new vehicle costs); (4) make domestic auto manufactures less competitive (as foreign manufacturers do not have to meet US standards); and (5) cause several effects that increas driving (rebound effect) and that these concerns have negated the potential benefits of increased MPG standards. Some analysts, in fact, claim that much of the fuel economy gains since 1975 have been due to consumer desire or to changes in fuel prices rather than regulation (Dowlatabadi, 1996).

Market failures that affect the demand for fuel economy include external damages to the environment, a cartelized petroleum market and a 'sluggish' market for fuel economy (production will be satisfactory rather than optimal). Reasons presented have included (6) imperfect information and satisficing behavior on the part of consumers combined with risk aversion and (7) oligopolistic producer behavior. Each of the numbered items are discussed in more detail below.

6.1 Price Effect Versus CAFE

One of the largest points of contention concerning the effectiveness of CAFE standards are whether it was the standards or fuel prices that were responsible for fuel economy related changes in MPG since 1975. Theoretically, regulations work largely through energy-inefficient models being dropped, since that is the intended effect. Energy price changes, however, induce both commercialization of new models and elimination of old models (Jaffe et. al., 2000). The same phenomenon is observed using hedonic price models. A recent OECD/World Bank study on environmental implications of energy subsidies in Russia shows that air emissions are reduced more by increasing energy prices to unsubsidized levels than by increasing the level of pollution fees in the current system or by introducing a CO_2 tax. Within the US, Atkinson and Halvorsen (1984) found that the fuel efficiency of the new car fleet responds more than proportionally to the expected fuel prices. Wilcox (1984) used a similar model to construct a quality-related measure of automobile fuel economy over the period 1952-1980 (essentially before CAFE standards were constraining) and found that it was positively related to oil prices. Ohta and Griliches (1986) found that gasoline price changes over the period 1970-1981 could alone explain much of the observed change in related automobile characteristics. Again, most of these studies used data before CAFE implementation.

Most studies covering the entire period since CAFE implementation conclude that the regulations were primarily responsible for changes during this period, but that sharp increases in oil prices (such as 1979 and 1982) played a role during certain periods. In one of the more in-depth analyses relating to this debate, Goldberg (1995, 1998) combined a demand-side model of discrete vehicle choice and vehicle utilization (miles driven on each new car purchased) with a supply-side model of oligopoly and product differentiation and location of production (to analyze the trade policy aspect) to estimate the effects of CAFE standards on the fuel economy of the new car fleet. She found that automobile operating costs have a significant effect, although a gasoline tax of a magnitude that could match the effect of CAFE on fuel economy would have to be very large. The elasticity of mileage demand with respect to the "price" per miles is small. Vehicle purchases, however, respond to both car prices and fuel cost. Doubling of the gasoline prices would be necessary to achieve fuel consumption reductions equivalent to the ones currently achieved through CAFE. An increase of this magnitude may or may not be possible. Overall, the analysis showed that there was not significant evidence of utilization effects (for relatively small changes in fuel costs) while the substitution effects towards used cars were small. Therefore, policies oriented towards shifting the composition of the new car fleet towards more fuel-efficient vehicles seem promising. Additionally, producers face most of the incidence of CAFE. Consumers should not face large increases in car prices; while the prices of large cars increase as a result of CAFE, the prices of small cars decrease. CAFE seems to function as a set of internal taxes (on fuel inefficiency) and subsidies (on fuel efficient vehicles) within each firm. This suggests that CAFE may not fare badly from a welfare point of view.

Goldberg's model does not necessarily imply that fuel efficiency standards are superior to an increase in gasoline taxes; the composition of the car sales depends on the gasoline prices and the fuel efficiency of the new car fleet. The model does show that consumers respond to both price and operation cost of new vehicles but that an increase in vehicle prices will have a substantially larger effect on vehicle choice than a proportional increase in fuel costs. However, if these absolute costs are discounted over an average vehicle-holding period, vehicle price and fuel costs elasticities are very similar in magnitude, making changes in operating costs and vehicle costs equally effective as incentives. Operating costs can be effected by changes in the fuel efficiency of new vehicles (MPG) or by variations in the price per gallon of gas.

Green (1996) performed a statistical test to determine the importance of CAFE constraint, using individual manufacturer CAFE data compiled by the National Highway Traffic Safety Administration (NHTSA) for the period 1978-1989 and fuel price data from the Department of Energy's Energy Information Administration. The analysis sought (1) to quantify the importance of EPCA regulations relative to gasoline prices in manufacturer decision-making about new car fuel economy and (2) to derive an estimate of the responsiveness of new car fuel economy to gasoline price in the absence of a fuel economy. The general trend of automobile MPG during this period suggests a strong relationship to the fuel economy standards. This study was limited because it only included the fifteen manufacturers of passenger cars with full data sets for the twelve-year period and excluded low-volume high-performance luxury cars (such as Jaguar, Rolls-Royce). The analysis concluded that the standards were at least twice as important as market trends in fuel prices, and may have completely replaced fuel price trends as a basis for long-range planning about MPG. This would be the result if the standards had been an actual prediction of manufacturer behavior and not a stimulus, but since the CAFE standards are predetermined and penalties are in place this is unlikely. It also showed that importers (car manufacturers unconstrained by the standards) responded to prices two to four years old and domestic manufacturers (those constrained by the standards) responded to current year prices. Overall, the data are not inconsistent with the hypothesis that constrained manufacturers based their MPG product planning solely on the mandated fuel economy standards.

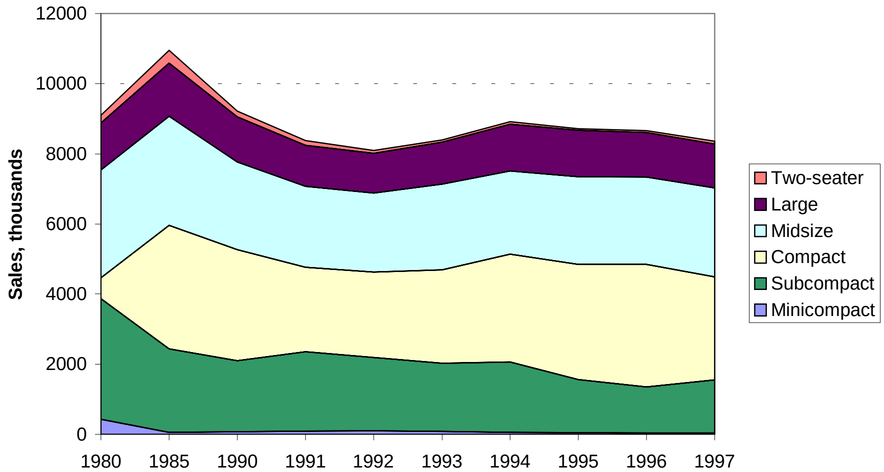
6.2 Vehicle Choice Effects

Critics claim that CAFE standards have caused consumers to switch from cars to trucks and used cars for design and safety reasons. Consumers may prefer to buy light trucks (primarily minivans and sport utility vehicles) instead of cars because the standards for cars force manufacturers to make design trade-offs that car buyers dislike. Others say that this trend began before the standards were an issue. Domestic sales of light trucks rose from 2.2 million in 1980 to 5.9 million in 1995 to 6.5 million in 1997 (NHSTA). Exhibits 9-12 present more detail on the growth of all vehicle sales despite increasing costs and the more pronounced growth in the market share of larger vehicles. By 1996, annual energy consumption for light trucks has risen to approximately 6 quad (1 quad = $1x10^{15}$ BTU) compared to approximately 8 quad for cars (Teotia, 1999).

Exhibit 9. Automobile Sales and Leases

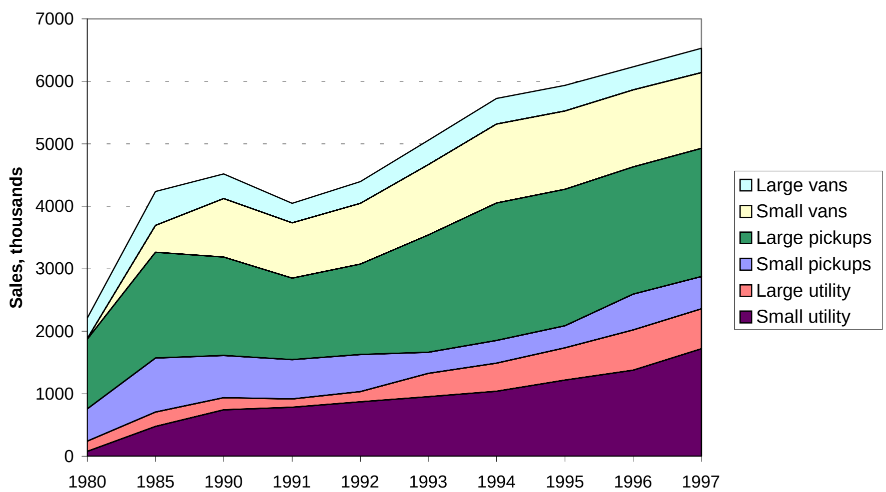
	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998
Domestic Sales – New	7,119	7,053	6,581	8,205	6,897	6,137	6,277	6,742	7,255	7,129	7,254	6,917	
Imports Sales – New	1,280	1,571	2,398	2,838	2,403	2,038	1,937	1,776	9,249	1,506	1,273	1,355	
Total Used Sales					37,530	37,290	36,950	38,057	40,141	41,758	40,828	40,270	40,230
Total New and Used Passenger Car Sales					46,830	45,465	45,163	46,575	49,132	50,393	49,355	48,542	40,230
New Passenger Car Leases					534	667	882	1,197	1,715	1,795	1,808	2,062	1,985
Value of Transactions ($ billions)					219	230	247	279	312	338	337	338	336
Average Price (current $)					5,830	6,157	6,693	7,335	7,781	8,093	8,257	8,399	8,353
Source: NHSTA													

Exhbit 10. Automobile Market Share



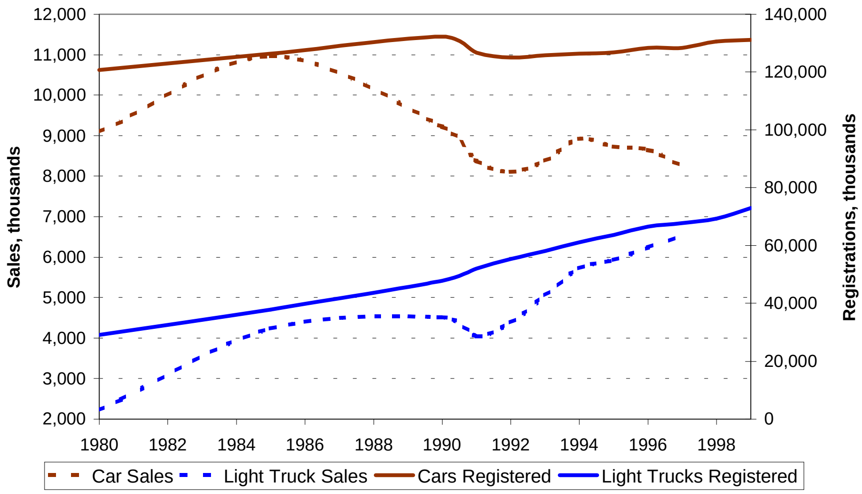
Source: NHSTA, Highway Statistic Series

Exhibit 11. Light Truck Market Share



Source: NHSTA, Highway Statistic Series

Exhibit 12. Sales and Registration of Vehicles



Note: Light trucks registered was calculated to be 90% of trucks registered for 1995-1998, same percentage was assumed for years earlier; Source: NHSTA, Highway Statistics Serices

If the relative price of large cars increased, consumers with a strong preference for these cars may also switch to less fuel-efficient, used vehicles rather than to small cars. As Exhibit 6 displayed, there seems to be little to no growth in percentage share of used car sales – increasing from 80 percent to 83 percent in the 1990s. Goldberg's (1998) model results imply that the substitution effects between new and used cars are relatively small. Her model also shows little substitution of "outside" goods (non-vehicle) for cars. The sum of her model results imply that price changes resulting from the CAFE regulation will have no effect on the sum of the new and used car sells, they will cause small shifts in the allocation between new and used car sales and will have substantial compositional effects within the fleet of new cars (compositional effects are described in rebound effect, below).

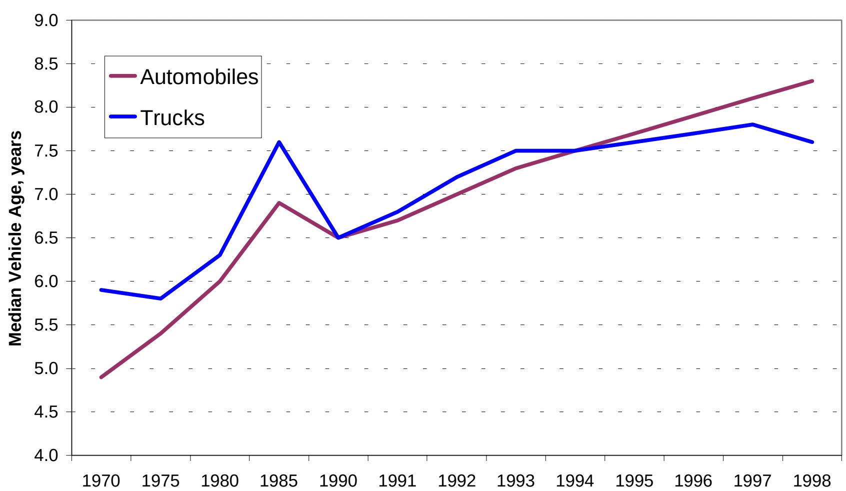
Claims that cars have become less desirable with fuel economy improvements and design changes are also linked with safety issues and social welfare. Decreasing vehicle weight is a commonly applied method to increase vehicle fuel economy. Although even a recent, extensive study by the National Highway Traffic Safety Administration (NHTSA, 1997) was not able to successfully determine the correlation between size and weight to estimate their separate effects on safety, it is reasonable to conclude that reducing vehicle mass to improve fuel economy will require some trade-offs with safety. The average weight of domestically manufactured cars was 4,380 lb in 1975, 3,711 lb in 1979, and 3,310 lb in 1983. By 1988 cars had become 25 percent lighter but maintained their interior size and carrying capacity. Horsepower to weight ratios increased despite decreases in engine size. Trucks followed the same pattern, reducing from 4,227 in 1975 to 3,977 in 1983. However, since 1983 the weights of both cars and trucks have increased (Greene, 1996, 1998). As the demand for light trucks and vans increases, manufacturers are able to meet demands by utilizing more efficient technologies to make these vehicles heavier and with improved acceleration. This years light vehicles have about the same fuel economy as those built 20 years ago. However, if the new light vehicle fleet had the same average weight and performance as it did 20 years ago, it would have achieved 25% higher fuel economy (EPA, 2000).

Another safety issue is to distinguish between private and public safety benefits of vehicle mass. Purchasing a larger, heavier vehicle increases the safety of its occupants but increases the risk of other motorists, cyclists or pedestrians who may collide with this vehicle. A study by NHSTA (1997) analyzed the injury crash rate with 100-pound reductions of passenger cars, light trucks and vans and both. As expected, an increased differential between weights of the vehicles in the crash increased injury to the passengers in the lighter vehicle. Something else to consider is a point made in the NRC (1992) study that the issue is not just the average weight change, but also the change in the distribution of weight that matters.

6.3 Vehicle Scrappage Rates

Another possible result of the standards is that, as consumers feel new cars become inferior, the relative value of old cars increases and they will consequently be kept longer by motorists, i.e., the scrappage rate will decrease. This could show up as an increase in the age and expected lifetime of vehicles and may eventually lead to an older and therefore less efficient vehicle fleet. Whether for this reason or another, data cited by Greene (1998) does show that this has occurred; the average age of a passenger car has increased from 5.6 years in 1970 to 6.6 years in 1980 to 8.5 years in 1995. Expected lifetime, as well, has increased from 10.7 years in 1970 to 12.1 years in 1980 to 13.7 years in 1990. However, Exhibit 13 below shows that the median age of the current fleet is currently only 8.3 years for automobiles and 7.6 years for light trucks (NHSTA).

Exhibit 13. Median Vehicle Age

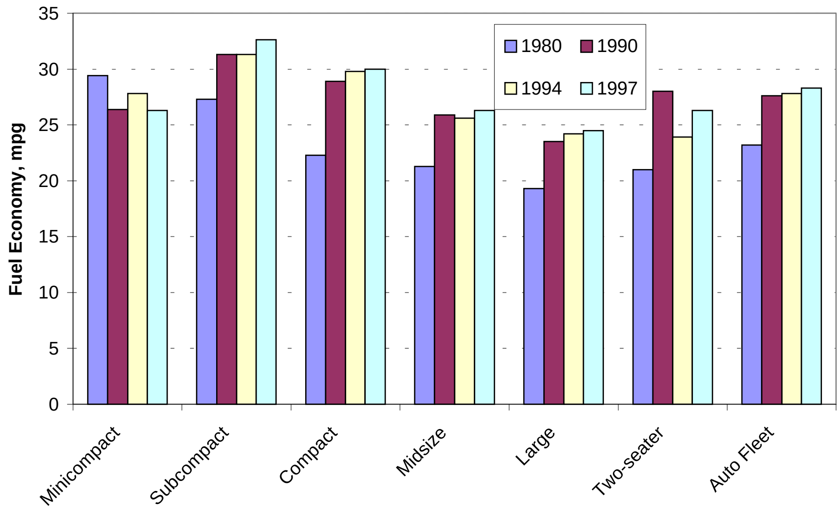


Source: NHSTA, Highway Statistics Series

A better measure may be the fleet average fuel economy, which in 1978 was 27.5 and in 1995 was 28 for automobiles but only 20.2 for light trucks[4]. Exhibit 14 and 15 show the fuel economy changes in the automobile and truck fleet, respectively. As shown, fuel economies have increased in the majority of automobile classes but have decreased in the most popular light truck classes. Whether CAFE was the cause of this change is debated. These measures are also influenced by improved technologies that make vehicles more durable and able to last longer, a consumer preference for light trucks and a steady rise of new car prices.

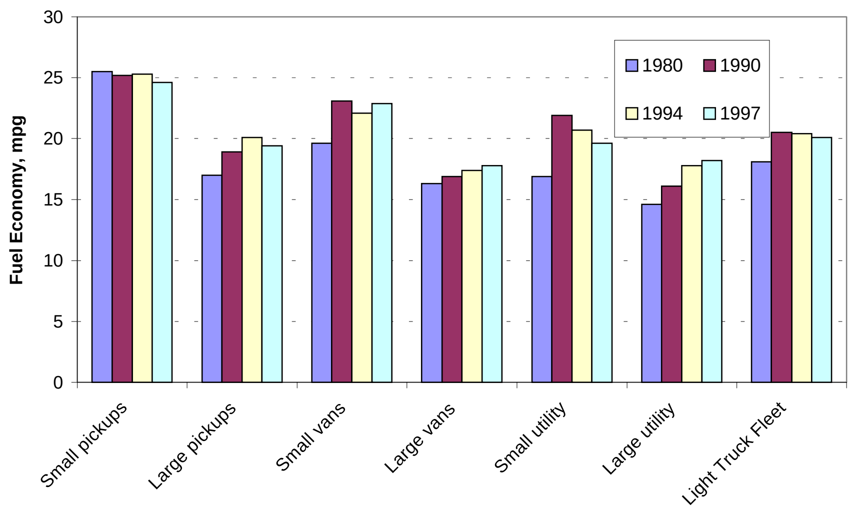
[4] The appendix provides a more detailed data series of the CAFE standards and registered fleet fuel economies.

Exhibit 14. Automobile Fuel Economy



Source: NHSTA, Highway Statistics Series

Exhibit 15. Light Truck Fuel Economy



Source: NHSTA, Highway Statistics Series

6.4 Competition/Economic Loss

A possible trade effect of the CAFE standard is that there is a disincentive for domestic producers to move the production of small cars abroad because fuel efficient imports cannot be used to offset less efficient domestically produced cars. While this serves to protect domestic jobs, Japanese producers with fuel efficient fleets are not effectively constrained by the standard and can therefore compete more successfully in the market for large and luxury cars that has traditionally been dominated by domestic manufacturers. Constraints felt by domestic manufacturers to comply with CAFE standards may have allowed foreign manufacturers to prosper as domestic ones suffer. Some manufacturers, particularly Japanese, consistently exceed even the 1985 standards of 27.5 MPG. Fuel efficiency standards in the US make domestic production costs higher than abroad (possibly due to different labor costs), evidence that there was no consideration of manufacturer marginal costs when setting standards. In order to implement fuel economy improvements, auto manufacturer managers must undertake major changes in vehicle design, usually of the entire fleet. This will cause the manager to incur costs that could be passed on to the consumer, making their product less competitive. Domestically, standards may help reduce the risk of this move by forcing all manufacturers to comply, reducing the competition within the automotive industry and between the industry and other products. However, requiring a technology standard does not account for all cost heterogeneity and differential impacts between manufacturers.

From 1979-1982 domestic manufacturers lost market share, possible as a result of this occurrence. But, the trend for imported car penetration is evident back through the 1950s (Greene, 1998) and after 1986 domestically manufactured cars made the greatest gains against imports even though fuel prices were falling. Profit rates for the Big Three US manufacturers (Ford, General Motors, Chrysler) since 1978, however, have fallen. A more likely cause of this decline is the increased competition from foreign manufacturers and a loss of market share (imports consistently have a stronger hold in smaller car markets).

Another potential economic loss due to CAFE is possible because standards could distort the pricing of large and small vehicles, causing manufacturers to subsidize smaller, more efficient vehicles and raise prices on larger cars. Most studies assume that manufacturers adjust prices to induce a sales mix change that will cause their sales-weighted MPG to achieve the standard. However, Greene and Fan, 1995) estimated that only ½ MPG of the increase in new light-duty vehicle fuel economy since 1975 could be attributed to sales mix shifts. The rest, they stated, was due to changes in technology and design.

6.5 Rebound Effect
Critics of CAFE claim that increasing fuel economy without imposing the appropriate tax will reduce the cost per mile of vehicle use and stimulate increased travel. The large numbers of vehicles and miles driven, resulting in increasing air pollutant and greenhouse gas emissions, could overshadow efficiency improvements. The importance of this "rebound effect" is whether its size is significant when compared with the benefits of the increased fuel economy. The rebound effect is dependent upon the elasticity of vehicle miles traveled (VMT) with respect to the fuel cost per vehicle mile. The conclusion of Greene (1998) is that the elasticity of VMT with respect to fuel cost is small – negating only approximately 10-20 percent of the fuel consumption reductions and greenhouse gas emissions due to fuel efficiency changes. Goldberg (1998) echoes this conclusion by estimating that the shift of composition of the new fleet towards more fuel efficient vehicles are unlikely to be completely neutralized by an increase in the utilization of the fuel efficient vehicles, so that policies with compositional effects (change on fleet characteristics, not size) appear to be promising.

6.6 Imperfect Information
Imperfect information is a factor during the purchase of a new car. Consumers rarely take the time and effort to optimize on each on every feature. Additionally, significant variation exists in the fuel economy information presented to consumers. Economy numbers are already adjusted for the average discrepancy between EPA tests and actual on-road experience, but this will vary by driving style and environmental conditions. Also, city and highway driving values are shown in the new car fleet – the highway number is 30-50 percent higher than the city number (Greene, 1998). The motorist must determine their driving patter and compute the representative overall economy in order to value it. Future fuel prices, future annual driving rates and appropriate discount rates would also have to be considered by the consumer to compute the net present value of the fuel economy improvement. Finally, the car label does not present the consumer with information on how the fuel improvement has affected the price of the car. Consumers cannot

optimize their fuel economy decisions because they lack the necessary information and it is not cost-effective to obtain it.

Quoted in articles supporting and degrading CAFE standards, data from the National Research Council's 1992 study of automotive fuel economy show that estimates of 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 DOE data indicate a similar result for a 10-MPG range above present levels (Greene, 1998). In other words, a change in fuel economy would be valued around ±$100 to the average consumer. The net value of higher fuel economy is assumed to be relatively flat over a fairly wide range of fuel economy increases. This seems to show that the incentive to the customer is not large and, as a result, fuel economy may not directly affect consumer valuation of a vehicle.

6.7 Oligopoly

The automotive manufacturing market can be classified as an oligopoly. The largest manufacturers can observe competitor actions and chose to lead, follow or remain where they are. Even the Big Three violated CAFE standards this year due to the huge market share of vehicles in violation and rather than strive to comply, the industry will pay fines instead. The increase in luxury car price that manufacturers include to cover CAFE fines is not shown. For a 2000 Mercedes-Benz, this amount was about $688, for a new BMW - $900 and for a Porsche - $1,470. To be effective, fines must always be above the level of costs for polluters to control (Jackson).

7. Future Trends – CAFE

Fuel economy continues to be a major area of road transport public and policy interest for three key reasons:

- Environmental – Fuel economy is directly related to CO_2, CO, particulate, NOx, and VOC emissions. Carbon dioxide is the most prevalent pollutant associated with global warming. The Kyoto agreement would require the U.S to achieve a 7% reduction in 1990 levels of CO_2 emissions. Automobiles and light trucks each contribute approximately 20% of all U.S. carbon dioxide emissions (EPA, 2000). These pollutants contribute to health risks as well.
- Political – Automobiles consume approximately 45% of all U.S. oil consumption and light vehicles consume about 40% (EPA, 2000). The oil price increase of 1999 and 2000 has renewed attention to oil dependence.
- Economic – Fuel economy is directly related to the cost of manufacturing a vehicle, fueling a vehicle and is associated with many social costs.

Increasing the CAFE standards has been discussed in Congress since the early 1990s but the controversy over raising the standards has prevented any action. In 1994, the NHSTA issued a notice of proposed rulemaking to explore raising the CAFE standard for light-duty trucks but For the last 5 year, the Department of Transportation (DOT) Authorizations, the omnibus FY1999 spending bill and the FY2000 DOE appropriations have included a general provision prohibiting the use of authorized funds to carry out any rulemaking that would alter the CAFE standards. However, in June 2000 the Senate agreed to a motion that authorizes DOT, pursuant to a study by the National Academy of Science (NAS), to recommend "appropriate" CAFE standards, subject to approval by a Joint Resolution of Congress (Bamberger, 2000).

Fuel economy researchers have supported the notion of increasing CAFE to 50 MPG, believing that the increase will result in additional emissions reductions. These proponents also believe that the efficiency improvement will be able to be done inexpensively and quickly. Public opinion polls quoted by Greene (1998) show approval ratings in the vicinity of 75 percent for maintaining or raising the CAFE standards. A December 1995 poll conducted for the Sustainable Energy Budget Coalition showed that 94 percent of respondents favored “improving vehicle fuel efficiency” as a means of addressing the problem of US oil dependency. However, some feel that choosing to regulate only fuel economy will be a simple policy option but will overlook alternative policies that, while more difficult and contentious, would actually achieve the desired goals of meeting higher CAFE standards while maintaining or increasing economic, social and environmental objectives.

A broad analysis of increasing CAFE standards is shown in Exhibit 16. As shown, a 50 percent efficiency gain beyond current standards would have less fuel savings than the original standard. It is important to determine whether this fuel savings would be the desired and most cost-effective outcome.

Exhibit 16. Gasoline Saved (gallons) from On-road Fuel Economy Increases

	Miles Driven	**Survival Rate**	**Gasoline Used At…(on road fuel economy in MPG)**						
			13.75	**27.5**	**33**	**38**	**40**	**60**	**100**
New Car	13,500	0.966	982	491	409	355	338	225	135
Year 1	12,500	0.989	909	455	379	329	313	208	125
Year 2	12,000	0.979	873	436	364	316	300	200	120
Year 3	11,500	0.964	836	418	348	303	288	192	115
Year 4	10,500	0.941	764	382	318	276	263	175	105
Year 5	9,750	0.910	709	355	295	257	244	163	98
Year 6	8,500	0.866	618	309	258	224	213	142	85
Year 7	7,830	0.809-0.080	569	285	237	206	196	131	78
Year 8-20	180,040		13,094	6,547	5,456	4,738	4,501	3,001	1,800
Gasoline saved (gallons for car surviving 20 years)				6,547	1,091	718	237	1,500	1,200
PDV fuel cost (US$) for average car			6,138	3,069	2,558	2,221	2,110	1,407	844
PDV incremental fuel saved (US$) for average car				3,069	512	337	111	703	563
Source: Dowlatabadi, 1996 and updated									

8. ALTERNATIVE POLICY OPTIONS

Road transport provides considerable opportunities for enhancing the environmental orientation of the tax system. Road transportation is already heavily taxed through vehicle purchase, registration, etc. By restructuring these existing taxes there is the opportunity for introducing environmental incentives. Complicating the issue is the wide range of social costs involved, the complex interactions between road transport, other transport modes and issues of spatial development. The costs of road use should arguably include social costs (externalities) associated with vehicle use including environmental costs (global and local air pollution), noise and aesthetic losses, congestion costs and accident costs and the consumption of public road infrastructure as well as interactions between road transport, other modes of transport and issues of land use and special development. It is impossible to recover all of these social costs. Some of the environmental costs differ in how closely they are related to the characteristics of the vehicle as well as individual transport decisions such as location and time of day of vehicle use.

Taxes would have to reflect the combined and interacting effect of different externalities and simultaneously induce appropriate choices regarding the use of competing transport modes, location decisions and spatial development. To react to and influence all of these factors, an optimal policy mix may be a combination of several instruments. Most likely, direct and complete capture of these costs would be impossible, making any taxation policy one that is “second best.” Therefore, several tax applications as well as a few other policy options that have been applied and suggested for road transport will be mentioned.

8.1 Gas-guzzler tax (luxury tax)

To discourage the production and purchase of fuel inefficient vehicles, the Energy Tax Act of 1978 established a Gas Guzzler Tax on the sale of new model year vehicles whose fuel economy fails to meet certain statutory levels. Beginning in 1980, any passenger car sold with a fuel economy of less than 15 MPG was subject to the tax. The MPG limit was increased each of the next 6 years until any car getting less than 22.5 MPG was defined as a guzzler[5]. Light-duty trucks, which include pickups, minivans, full-size vans and SUVs, were exempted on the theory that many were used in businesses or on farms. At the time, these vehicles made up about a quarter of new-vehicle sales. Now, however, light-duty trucks are almost half of all new sales, and are frequently used more for commuting and other daily chores. The graduated tax rates also increased over time from a range of $200-$550 (depending on the fuel economy) in 1980 to $1,000-$7,700 in 1998. The Internal Revenue Service collected $48 million in gas-guzzler taxes on passenger cars in 1998 mainly on luxury sedans and high-end sports cars (Greene, 1998). The amount of any applicable Gas Guzzler Tax paid by the manufacturer will be disclosed on the automobile's fuel economy label.

There is an ongoing debate regarding extension of the Gas Guzzler Tax to light-duty trucks. Gloria Bergquist, spokeswoman for the Alliance of Auto Manufacturers, which represents 13 major U.S. and foreign auto companies, said extending the gas-guzzler tax to light-duty trucks would raise costs for consumers while not hastening the availability of more fuel-efficient, less polluting vehicles. A recent study by the Washington-based nonprofit group Friends of the Earth concluded that if these vehicles were held to the same 22.5-MPG standard, the industry as a whole would have paid the federal government $10.2 billion in additional gas-guzzler taxes in 1999 - and $43.1 billion over the past five years. However, this statement ignores the fact that if these vehicles were included in the tax, manufacturers would most likely have improved fuel efficiency to avoid at least a portion of these fines. Other environmentalists have said the loophole acts as a subsidy for larger vehicles that burn more gas and cause more pollution. Little quantitative study has been done to determine the effect of this policy, but it can be assumed that the tax had some effect on depressing the market for the largest, least efficient passenger cars.

8.2 Other Taxes

Several other road transport taxes could be applied to aspects other than fuel economy and vehicle purchase including fuel content or fuel or vehicle use. The most appropriate means of control would be a tax the actual use of the vehicle because it is this use that results in environmental damage and resource consumption, but to do this directly would be difficult; the next best option would be to tax fuel use, and assume this price will influence vehicle use. It is often believe that efforts that reduce driving, such as an increase in gasoline tax, are preferable because they target fuel consumption in a direct and transparent way. The effectiveness of either a vehicle or vehicle use tax depends on the efficiency of the market for automotive fuel economy.

8.2.1 Fuel Tax

Elasticities relevant to assess the impact of motor fuel taxation include the “own-price” relationship between the price of fuel and fuel consumption and the “cross-price” relationship between public and private transport. Several European studies have determined the own-price

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[5] The tax does not apply to the actual on-the-road MPG, which may be more or less than the EPA published value. The combined fuel economy MPG value (55 % city, 45 % highway) and a slight adjustment to account for differences in test procedures made since the base year is used to determine tax liability.

elasticity to be between –0.2 and –0.4 (Crawford, 1995). Additionally, studies have shown (Greene, 1998) that when gasoline prices rise car buyers opt for smaller cars. The relationship between fuel price and car size choice suggests that fuel taxes would have an impact on the weight distribution of vehicles and, therefore, on public safety. Fuel economy standards do not influence consumer choice in this way. There is no definitive information on cross-price elasticities.

Goldberg's study, beyond evaluating CAFE effects as discussed earlier, also evaluated two alternative policy proposals: abolishing the current CAFE program and replacing the current fuel efficiency standards with higher gasoline taxes. The simulation was performed for 1989. When the standards were abolished, US fuel consumption increased 19 million gallons. There was a 1.2 MPG drop in the domestic car fuel efficiency due to the absence of CAFE and that small, fuel efficiency cars would now be imported and excluded from this calculation. This creates the illusion of CAFE fuel savings when only a part of this reduction is due to compositional changes and most is due to domestic/import mix. Small car prices rose slightly while others dropped. Small car market share dropped slightly while large car increased. Domestic shares of small cars decreased significantly while large car domestic shares increased. If gasoline taxes were to replace the fuel efficiency standards, the tax would affect both new and used cars and there would be no reason to expect any substitution towards less efficient used cars when taxes are raised. The model shows that an 80 cent per gallon (nearly double the 1989 price) increase would be necessary to be equivalent to get the same fuel savings as CAFE standards.

Distributional effects must also be considered with this and all policy instruments. If a taxation instrument is used at the high levels suggested might be necessary to induce change these effects could be significant. However, the pattern of distributional incidence would vary between country, region, etc. depending on the pattern of vehicle ownership and use. High taxes on petroleum may, in the short run, be unacceptable for their impact on certain groups, such as rural dwellers for whom no alternatives to gasoline consumption may be available. A much greater share of post-tax income may also be taken from lower income households than from higher-income households (Crawford, 1995).

8.2.2 Other Tax Forms

Several different types of road transport taxes (and reform of existing taxes) have been used in western Europe. Sales taxes on new cars may reduce the rate at which the existing vehicle stock is replaced, but some countries have seen environmental benefits in an acceleration of the replacement of older vehicles with new, less polluting vehicles. For example, Greece offers incentives to scrap old vehicles. Several countries have introduced tax incentives for "clean" cars. Germany and the Netherlands have tax incentives to accelerate the take-up of catalytic converters, ahead of EU requirements. Others have lower rates of tax exemptions for electric and/or gas-powered vehicles. Others have begun to differential initial or annual vehicle taxes on private cars by engine size or other factors affecting fuel use. Current debate in the UK centers around subsidies offered for company cars; there is concern whether these subsidies induce higher rates of vehicle ownership, greater mileage driven or the purchase of larger vehicles in the absence of the subsidy. Another concern is commuting tax breaks offered in some European countries, including Germany and the Netherlands, that this may encourage excessive commuting distances or commuting using private cars rather than public transport. Several European countries level specific excise taxes on motor fuel in the form of a fixed amount per volume (rather than a percentage of the price). A Value Added Tax (VAT) is also applied above this tax. For EU member states, this is at least 15 percent. The combined effect of these taxes is the motor fuels are taxes more substantially than other goods and other uses of energy. Recently a tax differential has been introduced in several EU countries between leaded and unleaded petroleum and between petroleum and diesel to encourage switching. Tax incentives for alternative fuels are also in use, and should be great enough to make up for the higher capital costs of such vehicles for those consumers who would not purchase otherwise. Other taxes applied in some countries include a carbon tax, taxes to fund public works on infrastructure and R&D, increased taxes on parking in urban areas and others. Road-use charges and tolls are widely applied in Western Europe, as are explicit congestion charges in city centers (Crawford, 1995). According to the Bureau of Transportation Statistics (NTS, 1999), wasted fuel due to congestion rose 149 percent from 1982 to 1996 when it reached 6,725 gallons.

Only if the taxes closely proxy underlying environmental costs will the incentive provided by the taxation lead to efficient changes in the use of polluting vehicles. Effective taxes would reduce vehicle ownership and vehicle use, increase fuel efficiency, and induce individual substitution from private motoring to public transport. Any revenue-raising tax should be levied over and above any level of taxes imposed for purposes of correcting externalities (Crawford, 1995).

8.3 Other Instruments

With a volume average fuel economy (VAFE) system, the fuel economy standards could be made a function of the interior volume of vehicles on the market. Motor vehicles of differing volume would be given different fuel economy standards. This would avoid many of the problems discussed above for CAFE standards.

A percent improvement standard would not specify a particular fuel consumption standard for vehicles, but would require all manufacturers to improve the average fuel economy performance of their vehicle fleets by a designated percentage over a period of years.

Feebates are a combination of fee and rebate. They would most likely be used for new car purchases – consumers would pay an extra fee if the vehicle were an inefficient user of fuel, or alternatively get a rebate if it were energy-efficient. The neutral point would be set so that fees and rebates balanced, so it became neither an inflationary measure nor a disguised tax.

In mid-April, 2000, the vehicle manufacturer industry indicated its support for a house bill, the Advance Technology Motor Vehicle Fuel Economy Act of 2000, which would provide tax credits (essentially a subsidy) for hybrid vehicles with rechargeable energy storage systems. The legislation would also require a study by the National Academy of Sciences (NAS) of "voluntary, mandatory, and other means and measures…for purposes of conserving energy" in the transportation sector (Bamberger, 2000).

Information programs and methods that rely on public opinion to affect markets may also relate to transportation. Recently, Ford Motor Co. and General Motors have announced that they will be voluntarily increasing the fuel efficiency of their SUVs by 25% by the 2005 model year. If all manufacturers were to make this reduction, the average new light vehicle fleet fuel economy would increase to 30 mpg (EPA, 2000). Another public disclosure-type policy would be energy-consumption labeling, which is already done on new vehicle stickers.

The Clean Car Campaign is a national campaign coordinated by state, regional and national environmental organizations that promotes the development and sale of advanced technology vehicles that meet the "Clean Car Standard" is a performance-based standard that claims to be achievable using the best practices currently used by the global auto industry. It includes improvement of 1.5 times the fleet average fuel efficiency (by class), tailpipe emissions meeting California's Super Ultra Low Emission Vehicle (SULEV) standard, and clean manufacturing processes. The Clean Car Standard essentially forces use of the best available technology, which will not be cost-effective for all manufacturers. However, clean manufacturing is a move towards life-cycle sustainable development. The campaign also works to support public policies that could motivate automakers to invest in vehicle designs and production processes that reduce adverse environmental impacts of their industry and its products. It could also encourage the purchase of cleaner vehicles by consumers and fleet buyers who choose to sign the "Clean Car Pledge."

9. Conclusions – Road Transport

From the information and data presented, several road transport trends are evident including:

- During the past 10 years, fuel economy for automobiles is increasing at a slower pace than before and light truck fleet fuel economy is decreasing, especially in the SUV class.
- Light truck sales have increased dramatically during the past 20 years and now represent over 40% of the private and commercial market.
- Fuel economy is being traded by consumers for weight and power in light vehicle fleet.
- Non-energy costs such as safety, congestion and road maintenance should be considered by manufacturers and regulators.
- There is a low price elasticity of demand for fuel economy.
- The elasticity of VMT in response to fuel cost is small.
- Market failures in the road transport market may make market based instruments less effective.

The combination of the road transport market failures discussed previously (imperfect information, risk aversion, cartel pricing, oligopololistic competition) may make it very likely that fuel economy standards will be more effective than a motor fuel tax. Several of the defining characteristics of the automotive market make application of a tax policy difficult and not optimally effective. Additionally, gasoline taxes are likely to have an unfavorable public and political response and equity issues; studies have shown that they would have to be greatly increased in order to reduce vehicle use and fuel consumption significantly. However, a motor fuel or vehicle use tax is essential if policies are to be economically efficient. CAFE has characteristics of both an internal tax (on fuel inefficiency) and subsidy (on fuel efficient vehicles) within each firm, suggesting that CAFE may provide satisfactory welfare overall. Therefore, it is believed that taxes will be most effective if used in conjunction with fuel economy standards. Because these standards are already in place, the next question is whether taxes should be used in conjunction with fuel economy standards at current or raised levels. Fuel economy standards can be increased, but the technology must be available to achieve increased MPG at costs that are not greater than the direct fuel savings to consumers plus the value of fuel efficiency. If CAFE standards are increased, care must be taken to ensure that cost-effective, marketable technologies are available to meet the standards. If these technologies are already available there is less need for concern for heterogeneous control costs.

Greene (1998) stated that there is no reason why a well-chosen technology standard, in combination with a tax on the activity (vehicle travel), could not achieve precisely the same result as an optimal externality tax imposed directly on the externality itself. However, this may limit incentives for technological development, as discussed earlier. Taxing only the vehicle travel could fail to produce the appropriate changes in technology and would be very difficult to monitor and enforce. If emissions, the precise cause of external damage, is to be taxed, there is the problem of accurately measuring each vehicle's emissions and collecting the tax and emissions vary importantly according to how a vehicle is operated and maintained, and damages vary according to weather conditions, location, and many other factors.

Based on these observations and arguments, several policy options are recommended:

- Include light-duty trucks in the same fuel economy standards as automobiles;
- Replace CAFE standards with VAFE standards or adjust CAFE fines to be binding;
- Support development of environmentally friendly transportation technologies;
- Increase gasoline taxes at the pump so that new and used cars are affected;
- Implement transport management policies to reduce urban congestion; and
- Improve new vehicle labeling to represent actual fuel economy and increase in price due to improve economy or fuel economy fines. Fuel economy labeling should be shown separately from the large amount of information currently shown on new vehicle stickers.

A combination of some of the instruments discussed above is likely to have the best result. Another point, which has not been mentioned often in the literature, is the necessity to perform life-cycle analyses of automobile manufacture, fuel and road transport. Many of the calculations provided neglect the emissions of greenhouse gases associated with materials selected during the manufacture of vehicles. This is especially important as manufacturers switch to lightweight substitutes. It may be possible that other environmental pollution is more important to address than the types improve fuel economy affects. As discussed previously, when an activity such as vehicle travel produces an external cost, even perfectly competitive markets will fail to naturally allocate resources in a way that maximizes social welfare. However, technology change in vehicle production has altered the relation between the level of activity and the amount of environmental damage caused by it. Advanced pollution control technology, such as front wheel drive, three-way catalytic converters, multi-point fuel injection, and electronically controlled combustion has led to estimates by DOT that the average vehicle on the road In 1994 emitted one-half to one-fourth (depending on the pollutant) as much pollution as the average vehicle in use in 1970 (Greene, 1998). Therefore, if emissions control continues to improve, fuel efficiency improvements may reduce fuel consumption but do little for pollutant emissions.

Studies have shown that actions to increase enforcement have decreased pollution and non-compliance, which, in turn, increases self-reporting. This supports the notion of combining regulation with public disclosure and voluntary programs. Public disclosure introduces many more stakeholders and many more forms of incentives. Fuel economy labels on new cars is not enough; consumers should become aware of vehicle emissions, manufacturer processes and environmental consequences. Manufacturers of transportation equipment already fall under the reporting requirements of the Toxic Release Inventory (TRI) and other non-industry specific reporting requirements, but this information should be more available and visibly linked to vehicle purchases. Increased public disclosure of vehicle manufacturer fuel economies, CAFE fines, Gas Guzzler taxes and other environmental compliance indicators may affect consumer choices and fleet emissions. The regulators role may move from designing, monitoring and enforcing rules and standards to gaining leverage through non-traditional programs that harness the power of communities and markets.

Consumers and analysts must realize that trade-offs are constantly being made by individuals, manufacturers and governments between safety and cost, other vehicle attributes, convenience, etc. Consumers perform the same trade-offs as they consider risk versus money and fuel economy, which saves money. Sustainable development, in this and many contexts, cannot be interpreted to imply that all components of human welfare are to be sacrificed in the interests of preserving the environment exactly in the form it happens to be in today. It does, however, have the goal of maximizing society's welfare.

If the market for fuel economy operated efficiently and if external costs and other market failures associated with petroleum fuel use by vehicles were minor then fuel economy standards would cause market distortions that would cost manufacturers profits and force inferior vehicles on consumers. However, the above discussion has shown, this market does not operated 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 by manufacturers and beneficial to society.

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APPENDIX

Fuel Economy Standards for Passenger Cars and Light Trucks: Model Years 1978-1999

Model Year	Passenger Cars	Light Trucks		
		Two-Wheel Drive	Four-Wheel Drive	Combined
1978	18.0	--	--	--
1979	19.0	17.2	15.8	--
1980	20.0	16.0	14.0	--
1981	25.0	16.7	15.0	--
1982	24.0	18.0	16.0	17.5
1983	26.0	19.5	17.5	19.0
1984	27.0	20.3	18.5	20.0
1985	27.5	19.7	18.9	19.5
1986	26.0	20.5	19.5	20.0
1987	26.0	21.5	19.5	20.5
1988	26.0	21.0	19.5	20.5
1989	26.5	21.5	19.0	20.0
1990	27.5	20.5	19.0	20.2
1991	27.5	20.7	19.1	20.2
1992	27.5	--	--	20.2
1993	27.5	--	--	20.4
1994	27.5	--	--	20.5
1995	27.5	--	--	20.6
1996	27.5	--	--	20.7
1997	27.5	--	--	20.7
1998	27.5	--	--	20.7
1999	27.5	--	--	20.7
2000	27.5	--	--	20.7
Source: Bamberger, 2000; all caveats are not provided				

Sales-weighted fuel economies of automobiles and light trucks, mpg

	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997
Auto Fleet	23.2	27.0	27.6	27.7	27.7	27.8	27.8	28.0	28.3	28.3
Minicompact	29.4	32.7	26.4	29.3	30.6	29.9	27.8	27.0	27.2	26.3
Subcompact	27.3	30.1	31.3	31.6	31.8	31.9	31.3	31.7	32.1	32.6
Compact	22.3	29.6	28.9	28.8	28.7	29.3	29.8	30.2	30.4	30.0
Midsize	21.3	24.9	25.9	25.9	25.8	25.7	25.6	25.9	26.4	26.3
Large	19.3	22.3	23.5	23.3	23.7	24.0	24.2	24.1	24.2	24.5
Two-seater	21.0	27.6	28.0	27.3	25.9	24.8	23.9	24.7	25.4	26.3
Light Truck Fleet	18.1	20.4	20.5	20.6	20.4	20.5	20.4	20.2	20.4	20.1
Small pickups	25.5	26.8	25.2	25.7	25.0	24.9	25.3	25.6	25.6	24.6
Large pickups	17.0	19.0	18.9	18.8	18.9	19.6	20.1	19.4	18.9	19.4
Small vans	19.6	23.9	23.1	22.6	22.5	22.9	22.1	22.8	22.8	22.9
Large vans	16.3	16.4	16.9	17.4	16.9	17.3	17.4	17.1	17.2	17.8
Small utility	16.9	22.1	21.9	21.1	20.9	21.3	20.7	20.8	21.1	19.6
Large utility	14.6	16.6	16.1	16.4	16.9	17.5	17.8	17.4	18.2	18.2
Source: NHSTA, Highway Statistics Series										