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Draft Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources

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Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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CHAPTER 13: Economic Impact Analysis

We prepared a draft Economic Impact Analysis (EIA) to estimate the economic impacts of the proposed emission control program on the gas can, gasoline fuel, and light-duty vehicle markets. In this chapter we describe the Economic Impact Model (EIM) we developed to estimate both the market-level changes in prices and outputs for affected markets and the social costs of the program and their distribution across affected economic sectors. We also present the result of our analysis.

We estimate the net social costs of the proposed program to be about $171.5 million in 2020. This estimate reflects the estimated costs associated with the gasoline, gas can, and vehicle controls and the expected fuel savings from better evaporative controls on gas cans. The results of the economic impact modeling performed for the gasoline fuel and gas can control programs suggest that the social costs of those two programs are expected to be about $244.3 million in 2020, with consumers of these products expected to bear about 60 percent of these costs. We estimate fuel savings of about $72.8 million in 2020, which will accrue to consumers. There are no social costs associated with the vehicle program in 2020. These estimates, and all costs presented in this chapter, are in year 2003 dollars.

With regard to market-level impacts in 2020, the maximum price increase for gasoline fuel is expected to be about 0.1 percent (0.2 cents per gallon), for PADD 5.[A] The price of gas cans is expected to increase by about 1.8 percent ($0.20 per can) in areas that already have gas can requirements and 32.5 percent ($1.52 per can) in areas that do not.

13.1 Overview and Results

13.1.1 What is an Economic Impact Analysis?

An Economic Impact Analysis (EIA) is prepared to inform decision makers about the potential economic consequences of a regulatory action. The analysis consists of estimating the social costs of a regulatory program and the distribution of these costs across stakeholders. These estimated social costs can then be compared with estimated social benefits (as presented in Chapter 12). As defined in EPA's *Guidelines for Preparing Economic Analyses* (EPA 2000, p 113), *social costs* are the value of the goods and services lost by society resulting from a) the use of resources to comply with and implement a regulation and b) reductions in output. In this analysis, social costs are explored in two steps. In the *market analysis*, we estimate how prices and quantities of goods affected by the proposed emission control program can be expected to change once the program goes into effect. In the *economic welfare analysis*, we look at the total social costs associated with the program and their distribution across stakeholders.

13.1.2 What is the Economic Impact Model?

[A] PADD: Petroleum Administration for Defense District.

The Economic Impact Model (EIM) is a behavioral model developed for this proposal to estimate price and quantity changes and total social costs associated with the emission controls under consideration. The model relies on basic microeconomic theory to simulate how producers and consumers of affected products can be expected to respond to an increase in production costs as a result of the proposed emission control program. The economic theory that underlies the model is described in detail in Section 13.2, below.

The EIM is designed to estimate the economic impacts of the proposed program by simulating economic behavior. At current, pre-control market equilibrium conditions consumers are willing to purchase the same amount of that product that producers are willing to produce at that price. This is represented by pre-control market prices and quantities. The control program under consideration would increase the production costs of affected goods by the amount of the compliance costs. This represents a "shock" to equilibrium market conditions. Producers of affected products will try to pass some or all of the increased costs on to the consumers of these goods through price increases. In response to the price increases, consumers will adjust their consumption of affected goods. Producers will react to the change in quantity demanded by adjusting their prices and the quantity they produce. These interactions continue until a new market equilibrium price and quantity combination is achieved. The amount of the compliance costs that can be passed on to consumers is ultimately limited by the price sensitivity of purchasers and producers in the relevant market (price elasticity of demand and supply). The EIM explicitly models these behavioral responses and estimates new equilibrium prices and output and the resulting distribution of social costs across these stakeholders (producers and consumers).

13.1.3 What Economic Sectors are Included in the Economic Impact Model?

There are three economic sectors affected by the control programs described in this proposal: gas cans, gasoline fuel, and light-duty vehicles.

In this Economic Impact Analysis we do not model the market impacts on the vehicle program; we model only the impacts on the gas can and gasoline fuel markets. This approach is appropriate for several reasons. As described in Chapter 8, above, the compliance costs for the proposed light-duty vehicle controls are expected to be very small, less than $1 per vehicle. These costs are R&D and facilities costs that are expected to be recovered by the manufacturers over 10 years (completely recovered by 2019) and are not expected to be passed on in the form of higher prices. Such small compliance costs are well within the normal variation of input prices experienced by most vehicle manufacturers at any given time. In addition, a price change this small, even if it is passed on entirely, is unlikely to affect producer or consumer behavior given the price of a new vehicle. On a more practical level, a cost increase of this magnitude is not large enough to disturb an economic impact model like the one used in this analysis. At the same time, however, the light-duty vehicle compliance costs are a cost to society and should be included in the economic welfare analysis. We do this by using the engineering cost estimates as a proxy for the social costs of the light-duty vehicle controls and adding them to the estimated social costs of the gasoline fuel and gas can programs.

With regard to the gasoline fuel and gas can market analyses, we model the impacts on residential users of these products. This means that we focus the analysis on the use of these products for personal transportation (gasoline fuel) or residential lawn and garden care or recreational uses (gas cans) and do not separately model how the costs of complying with the proposed programs may affect the production of goods and services that use gasoline fuel or gas cans as production inputs. The result is that we group residential and commercial users in a single market and assume the behavioral responses to increased costs for commercial users are similar to residential users. This is reasonable because the vast majority of users of these products are residential users. While there are commercial users of gas cans and gasoline fuel, their share of the end-user markets is relatively small. The U.S Department of Energy estimates that about 92 percent of gasoline used in the United States for transportation is used in light-duty vehicles (DoE 2004, Table A-2 and Supplemental Table 34). According to DoE, only about 6 percent of gasoline fuel is used for commercial or industrial transportation, and the remaining 2 percent is used in recreational marine vessels. Similarly, although there is little publicly available national data on the users of gas cans, a recent study by CARB (1999) found that 94 percent of portable fuel containers in California were used by residential households. In addition, for most commercial users the share of these products to total production costs is small (e.g., the cost of a gas can is only a very small part of the total production costs for an agricultural or construction firm). Therefore, a price increase of the magnitude anticipated for this control program is not expected to have a noticeable impact on prices or quantities of goods produced using these inputs (e.g., agricultural produce or buildings).

With regard to the gasoline fuel analysis, it should be noted that this Economic Impact Analysis does not include California fuels in the market analysis. California fuels are only included, as a separate line item, in the economic welfare analysis. California currently has state-level controls that address air toxics from gasoline fuels (Title 13, California Code of Regulations, Section 2262). The California program benzene levels are very similar to those being proposed in this federal program and any actions that refiners may take to comply with the federal program are expected to be small and not affect market prices or quantities in that state. However, because the estimated fuel program compliance costs include a small compliance cost for California, and this cost would be a cost to society, it is necessary to include those costs in the total economic welfare costs of the proposal. This is done by including the estimated engineering compliance costs as a separate line item.

Consistent with the cost analysis, the economic impact analysis for the gasoline fuel market does not distinguish between reformulated and conventional gasoline fuels.[B] Also consistent with the cost analysis, this EIA also does not consider impacts of the fuel program on the benzene market (i.e., the market for recovered benzene). This is because, as explained elsewhere in this RIA, any impacts on that market are expected to be insignificant. Finally, as explained in Section 13.3.2.2, the gasoline fuel analysis is based on post-tax gasoline prices since state and federal taxes are included in the prices consumers pay at the pump.

[B] The cost analysis does not differentiate between conventional and reformulated gasoline because their benzene levels are expected to be similar as a result of the proposed standards and because the cost modeling technique does not allow for estimating how the blending of gasoline blendstocks will occur. See Chapter 9 for more information on how gasoline compliance costs were estimated.

The EIM relies on the estimated compliance costs for the gas can and gasoline fuel programs described elsewhere in this RIA. Thus, the EIM reflects cost savings associated with ABT or other flexibility programs to the extent they are included in the estimated compliance costs.

As summarized in Table 13.1-1, this EIA considers the economic impacts of the proposed program on four gasoline fuel markets and two gas can markets, for a total of six markets. More detailed information on the markets and model inputs is provided in Section 13.3.3, below, and in the industry profiles prepared for this proposal (see Chapter 4 and RTI 2004a and 2004b).

Table 13.1-1. Summary of Markets in Economic Impact Model

Model Dimension	**Light-Duty Vehicles**	**Gasoline (4)**	**Gas Cans (2)**
Number of Markets	Not included in market analysis; engineering costs used to estimate total social costs	Four regions • PADDs 1 & 3 • PADD 2 • PADD 4 • PADD 5 (includes Alaska and Hawaii; California gasoline fuel treated separately) No distinction between conventional and reformulated gasoline	Two markets • States with current controls (12 plus DC) • States without current controls (38)
Geographic scope		50-state; California fuel volumes treated separately	50-State
Market structure		Perfectly competitive	Perfectly competitive
Baseline population		Energy Information Administration (DoE 2003)	Provided by manufacturers (RTI 2004a)
Growth projections		Energy Information Administration (DoE 2005)	2% (RTI 2004a)
Supply elasticity		Literature estimate: 0.2 (inelastic)	Econometric estimate: 1.5 (elastic)
Demand elasticity		Literature estimate: -0.2 (inelastic)	Derived demand estimate: -0.01 (inelastic)
Regulatory shock		Direct compliance costs (fixed + variable) cause shift in supply function	Direct compliance costs (fixed + variable) cause shift in supply function

In the EIM, behavioral responses to price changes are incorporated through the price elasticity of supply and demand (reflected in the slope of the supply and demand curves). The price elasticites used in this analysis are described in Section 13.3, below. The gasoline fuel price elasticity parameters were obtained from the literature; we estimated those for the gas cans. For gasoline fuel, both the demand and supply elasticities are inelastic, meaning that both the quantity supplied and demanded are expected to be fairly insensitive to price changes. For gas cans, however, the demand elasticity is inelastic but the supply elasticity is elastic. This means that producers are expected to be sensitive to price changes but consumers are not. This will allow producers to pass more of the compliance costs on to consumers.

13.1.4 Summary of Results

The EIA consists of two parts: a market analysis and welfare analysis. The market analysis looks at expected changes in prices and quantities for affected products. The welfare analysis looks at economic impacts in terms of annual and present value changes in social costs. For this proposed rule, the social costs are estimated as the sum of market surplus (the aggregate change in consumer and producer surplus based on the estimated market impacts associated with the proposed rule) offset by operating cost savings (the fuel savings associated with better evaporative controls for gas cans).

Economic impact results of our modeling are summarized in this section. More detailed results are included in the appendices to this chapter.

13.1.4.1 Market Analysis Results

The market analysis results for all years are presented in Appendices A and B and are summarized below. Market impacts are the estimated changes in the quantity of affected goods produced and their prices. As explained above, we estimated market impacts for only gasoline fuel and gas cans, and California fuel is not included in the market analysis for PADD 5. The estimated market impacts are presented in Table 13.1-2. In this table, the market results for gasoline are presented for 2015 only because the compliance costs for the gasoline fuel program are constant for all years and therefore the results of the market analysis are the same for all years.[C] The market results for gas cans are presented for 2009 and 2015, reflecting the changes in estimated compliance costs due to amortization of fixed costs over the first five years of the program. After 2013 the compliance costs remain constant for all future years.[D]

With regard to the gasoline fuel program, the market impacts are expected to be small, on average. The price of gasoline fuel is expected to increase by about 0.15 percent or less, depending on PADD. The expected reduction in quantity of fuel produced is expected to be less than 0.03 percent. The market impacts for the gas can program are expected to be more significant. In 2009, the first year of gas can program, the model predicts a price increase of about 7 percent for gas cans in states that currently have regulations for gas cans and about 57 percent for those that do not. Even with these large price increases, however, the quantity produced is not expected to decrease by very much: less than 0.6 percent. These percent price increases and quantity decreases are much smaller after the first five years. In 2015, the estimated gas can price increase is expected to be less than 2 percent for states that currently regulate gas cans and about 32.5 percent for states without such regulations. The quantity

[C] The number of gallons of gasoline fuel produced is expected to decrease in future years but the percent decrease is expected to remain the same; this is due to the growth in fuel consumption generally.
[D] The number of gas cans produced is expected to decrease in future years but the percent decrease is expected to remain the same; this is due to the growth in gas can production generally.

produced is expected to decrease by less than 0.4 percent. These changes are expected to remain constant for future years, even though the absolute quantities produced are expected to increase somewhat.

Table 13.1-2. Summary of Market Impacts

Market	Engineering Cost Per Unit	Change in Price		Change in Quantity	
		Absolute	Percent	Absolute	Percent
2009					
Gasoline Fuel PADD 1 & 3 PADD 2 PADD 4 PADD 5 (w/out CA)	N/A (gasoline fuel control program begins in 2011)				
		$/can		Thousand Cans	
Gas Cans					
States with existing Programs	$0.77	$0.76	6.9%	-6.8	-0.07%
States without existing programs	$2.70	$2.68	57.4%	-88.5	-0.57%
2015					
		¢/gallon		Million Gallons	
Gasoline Fuel					
PADD 1 & 3	0.049¢	0.03¢	0.02%	-3.1	-0.004%
PADD 2	0.202¢	0.11¢	0.07%	-6.9	-0.015%
PADD 4	0.358¢	0.19¢	0.12%	-1.4	-0.025%
PADD 5 (w/out CA)	0.391¢	0.21¢	0.13%	-2.5	-0.026%
Gas Cans		$/can		Thousand Cans	
States with existing Programs	$0.21	$0.20	1.9%	-2.1	-0.02%
States without existing programs	$1.53	$1.52	32.5%	-56.4	-0.32%

13.1.4.2 Economic Welfare Results

In the economic welfare analysis we look at the costs to society of the proposed program in terms of losses to consumer and producer surplus. These surplus losses are combined with estimated vehicle compliance costs, fuel savings, and government revenue losses to estimate the net economic welfare impacts of the program. Detailed economic welfare results for the proposed program are presented in Appendix C and are summarized below. This economic welfare analysis includes the compliance costs associated with affected California fuel.

Estimated annual net social costs are presented in Table 13.1-3. Initially, the estimated social costs of the program are relatively small and are attributable to the gas can program, which begins in 2009, and the vehicle program, which begins in 2010. For 2009 and 2010 the estimated social costs are less than $40 million. In 2011 the estimated social costs increase to $215 million, reflecting the beginning of the gasoline fuel program. In subsequent years estimated social costs increase due to growth. However, they decrease in 2014, to $169 million, when the gas can fixed costs are fully recovered and in 2020, to $171.5 million, when the vehicle program compliance costs are terminated.

Table 13.1-3. Net Social Costs Estimates for the Proposed Program (2009 to 2035) (2003$, $million)

Year	Total Social Costs (includes fuel savings)
2009	$38.4
2010	$39.2
2011	$215.0
2012	$208.6
2013	$202.2
2014	$169.3
2015	$171.6
2016	$173.6
2017	$175.5
2018	$177.3
2019	$179.7
2020	$171.5
2021	$174.2
2022	$176.9
2023	$179.9
2024	$183.3
2025	$186.8
2026	$190.3
2027	$193.9
2028	$197.6
2029	$201.3
2030	$205.2
2031	$209.1
2032	$213.1
2033	$217.2
2034	$221.4
2035	$225.7
NPV at 3%	$2,937.3

Year	Total Social Costs (includes fuel savings)
NPV at 7%	$1,633.0

Table 13.1-4 contains more detailed estimated social costs for 2009, when the gas can program begins, 2011, when the gasoline fuel program begins, and 2015 when gas can fixed costs are fully recovered. The vehicle program applies from 2010 through 2019. According to these results, consumers are expected to bear approximately 99 percent of the cost of the gas can program. This reflects the inelastic price elasticity on the demand side of the market and the elastic price elasticity on the supply side. The burden of the gasoline fuel program is expected to be shared more evenly, with 54.5 percent expected to be borne consumers and 45.5 percent expected to be borne by producers. In all years, the estimated loss to consumer welfare will be offset somewhat by the fuel savings associated with gas cans. Beginning at about $11 million per year, these savings increase to about $68 million by 2015 as compliant gas cans are phased in. These savings accrue for the life of the gas cans.

Table 13.1-4. Summary of Net Social Costs Estimates Associated with Primary Program (2009, 2011, and 2015) (2003$, $million)

Market	Change in Consumer Surplus	Change in Producer Surplus	Total
2009			
Gasoline US PADD 1 & 3 PADD 2 PADD 4 PADD 5 (w/out CA)	N/A (gasoline fuel control program begins in 2011)		
Gas Cans US	-$48.7 *(99.3%)*	-$0.3 *(0.7%)*	-$49.0
States with existing programs	-$7.5	-$0.1	
States without existing programs	-$41.2	-$0.3	
Subtotal	**-48.7** ***(99.3%)***	**-0.3** ***(1%)***	**-$49.0**
Fuel Savings			$10.6
Vehicle Program			$0
California fuel[a]			$0
Total			**-$38.4**
2011			
Gasoline US	-$100.3 *(54.5%)*	-$83.6 *(45.5%)*	-$183.9
PADD 1 & 3	-$21.6	-$18.0	
PADD 2	-$49.1	-$40.9	
PADD 4	-$10.2	-$8.5	
PADD 5 (w/out CA)	-$19.4	-$16.2	
Gas Cans US	-$50.7 *(99.4%)*	-$0.3 *(0.7%)*	-$51.0
States with existing programs	-$7.8	-$0.1	
States without existing programs	-$42.9	-$0.3	
Subtotal	**-$150.9**	**-$83.9**	**-$234.8**

Market	Change in Consumer Surplus	Change in Producer Surplus	Total
	(64.3%)	***(35.7%)***	
Fuel Savings			$33.3
Vehicle Program			-$11.8
California fuel[a]			-$1.7
Total			**-$215.0**
2015			
Gasoline US	-$107.1 *(54.5%)*	-$89.4 *(45.5%)*	-$196.5
PADD 1 & 3	-$23.1	-$19.3	
PADD 2	-$52.4	-$43.7	
PADD 4	-$10.9	-$9.1	
PADD 5 (w/out CA)	-$20.7	-$17.3	
Gas Cans US	-$28.5 *(99.3%)*	-$0.2 *(0.7%)*	-$28.7
States with existing programs	-$2.3	$0.0	
States without existing programs	-$26.3	-$0.2	
Subtotal	**-$135.7** ***(60.3%)***	**-$89.5** ***(39.7%)***	**-$225.2**
Fuel Savings			$68.3
Vehicle Program			-$12.9
California fuel[a]			-$1.8
Total			**-$171.6**

[a]California fuel costs are considered separately. See Section 13.1.3 of the RIA.

The present value of net social costs (discounted back to 2005) of the proposed standards through 2035, contained in Table 13.1-3, is estimated to be $2.9 billion (2003$). This present value is calculated using a social discount rate of 3 percent and the stream of economic welfare costs from 2009 through 2035. We also performed an analysis using a 7 percent social discount rate.[E] Using that discount rate, the present value of the net social costs through 2035 is estimated to be $1.6 billion (2003$).

[E] EPA has historically presented the present value of cost and benefits estimates using both a 3 percent and a 7 percent social discount rate. The 3 percent rate represents a demand-side approach and reflects the time preference of consumption (the rate at which society is willing to trade current consumption for future consumption). The 7 percent rate is a cost-side approach and reflects the shadow price of capital.

Table 13.1-5. Summary of NPV Net Social Costs Estimates Associated with Primary Program (3%, 2009 to 2035) (2003$, $million)

Market	Change in Consumer Surplus	Change in Producer Surplus	Total
Gasoline, U.S.			
PADD 1 & 3	-$384.0	-$320.0	-$704.0
PADD 2	-$871.1	-$726.0	-$1,597.1
PADD 4	-$180.8	-$150.7	-$331.4
PADD 5 (w/out CA)	-$344.2	-$286.9	-$631.0
Gas Cans US			
States with existing programs	-$66.6	-$0.5	-$67.2
States without existing programs	-$572.1	-$3.8	-$575.9
Subtotal	-$2,418.8 *61.9%*	-$1,487.8 *38.1%*	-$3,906.5
Fuel Savings			$1,090.5
Vehicle Program			-$91.1
California fuel[a]			-$30.2
Total			-$2,937.3

[a]California fuel costs are considered separately. See Section 13.1.3 of the RIA.

13.2 Economic Methodology

Economic impact analysis uses a combination of theory and econometric modeling to evaluate potential behavior changes associated with a new regulatory program. As noted above, the goal is to estimate the impact of the regulatory program on producers and consumers. This is done by creating a mathematical model based on economic theory and populating the model using publicly available price and quantity data. A key factor in this type of analysis is estimating the responsiveness of the quantity of gas cans and gasoline fuel demanded by consumers or supplied by producers to a change in the price of that product. This relationship is called the elasticity of demand or supply.

The EIM's methodology is rooted in applied microeconomic theory and was developed following the *OAQPS Economic Analysis Resource Document* (EPA 1999). This section discusses the economic theory underlying the modeling for this EIA and several key issues that affect the way the model was developed.

13.2.1 What Is A Behavioral Economic Model?

Models incorporating different levels of economic decision making can be categorized as *with*-behavior responses or *without*-behavior responses. The EIM is a behavioral model.

Engineering cost analysis is an example of a *without*-behavior response model. These models estimate the cost of a regulation based on the projected number of affected units and engineering estimates of the annualized costs. The result is an estimate of the total compliance costs for a program. However, these models do not attempt to estimate how a regulatory program will change the prices or output of an affected industry. Therefore, the results may over-estimate the total costs of a program because they do not take decreases in quantity produced into account.

The *with*-behavior response approach builds on the engineering cost analysis and incorporates economic theory related to producer and consumer behavior to estimate changes in market conditions. As Bingham and Fox (1999) note, this framework provides "a richer story" of the expected distribution of economic welfare changes across producers and consumers. In behavioral models, manufacturers of goods affected by a regulation are economic agents that can make adjustments, such as changing production rates or altering input mixes, that will generally affect the market environment in which they operate. As producers change their production levels in response to a new regulation, consumers of the affected goods are typically faced with changes in prices that cause them to alter the quantity that they are willing to purchase. These changes in price and output from the market-level impacts are used to estimate the distribution of social costs between consumers and producers.

If markets are competitive and per-unit regulatory costs are small, the behavioral approach will yield approximately the same total cost impact as the engineering cost approach. However, the advantage of the *with*-behavior response approach is that it illustrates how the costs flow through the economic system and it identifies which stakeholders, producers, and consumers are likely to be most affected.

13.2.2 What Is the Economic Theory Underlying the EIM?

The EIM is a partial-equilibrium, single market numerical simulation model that estimates price and quantity changes in the intermediate run under competitive market conditions. Each of these model features is described in this section.

13.2.2.1 Partial Market Equilibrium Model

In the broadest sense, all markets are directly or indirectly linked in the economy, and a new regulatory program will theoretically affect all commodities and markets to some extent. However, not all regulatory programs have noticeable impacts on all markets. For example, a regulation that imposes significant per unit compliance costs on an important manufacturing input, such as steel, will have a larger impact on the national economy than a regulation that imposes very small per unit compliance costs on an input used by only a small number of producers.

The appropriate level of market interactions to be included in an economic impact analysis is determined by the number of industries directly affected by the requirements and the ability of affected firms to pass along the regulatory costs in the form of higher prices. There are at least three alternative approaches for modeling interactions between economic sectors, that reflect three different levels of analysis.

In a *partial equilibrium* model, individual markets are modeled in isolation. The only factor affecting the market is the cost of the regulation on facilities in the industry being modeled; there are no interaction effects with other markets. Conditions in other markets are assumed either to be unaffected by a policy or unimportant for cost estimation.

In a *multimarket model*, a subset of related markets is modeled together, with sector linkages, and hence selected interaction effects, explicitly specified. This approach represents an intermediate step between a simple, single-market partial equilibrium approach and a full general equilibrium approach. This technique has most recently been referred to in the literature as "partial equilibrium analysis of multiple markets" (Berck and Hoffmann, 2002).

In a *general equilibrium model*, all sectors of the economy are modeled together, incorporating interaction effects between all sectors included in the model. General equilibrium models operationalize neoclassical microeconomic theory by modeling not only the direct effects of control costs but also potential input substitution effects, changes in production levels associated with changes in market prices across all sectors, and the associated changes in welfare economy-wide. A disadvantage of general equilibrium modeling is that substantial time and resources are required to develop a new model or tailor an existing model for analyzing regulatory alternatives.

This EIM uses a partial equilibrium approach, and considers gasoline fuel and gas can markets separately.[F] This means there are two separate models, built the same way, that are not linked in this analysis (there is no feedback mechanism between the gas can and gasoline fuel model segments). This approach is appropriate because these sectors represent different aspects of fuel consumption (fuel storage and fuel production), and production and consumption of one is not affected by the other. In other words, an increase in the price of gas cans is not expected to have an impact on the production and supply of gasoline, and vice versa. Production and consumption of each of these products are the result of other factors that have little cross-over impacts (the need for fuel storage; the need for personal transportation).

In addition, this approach is reasonable because, as described above, most of the users of these products are households. Also, with regard to the gasoline fuel market, the estimated compliance costs on a per gallon basis are very small and are well within the normal price variations of gasoline. Therefore, the impacts on the economy more generally are expected to be minimal. With regard to gas cans, these products are used only by a small segment of the general economy and are principally used for non-production purposes (i.e., residential uses). For all of these reasons, the additional costs of using a general equilibrium or multimarket approach far outweigh the additional precision in the results.

13.2.2.2 Perfect Competition Model

For all markets that are modeled, the analyst must characterize the degree of competition within each market. The discussion generally focuses on perfect competition (price-taking behavior) versus imperfect competition (the lack of price-taking behavior). It should be noted that the perfect competition assumption is not primarily about the number of firms in a market. It is about how the market operates: whether or not individual firms have sufficient market

[F] Market impacts were not modeled for the vehicle market; see Section 13.1.3, above.

power to influence the market price. Indicators that allow us to assume perfect competition include absence of barriers to entry, absence of strategic behavior among firms in the market, and product differentiation.

This EIM relies on an assumption of perfect competition. This means that consumers and firms are price takers and do not have the ability to influence market prices.

In a perfectly competitive market at equilibrium the market price equals the value society (consumers) places on the marginal product, as well as the marginal cost to society (producers). Producers are price takers, in that they respond to the value that consumers put on the product. It should be noted that the perfect competition assumption relies not only on the number of firms in a market but also on other market characteristics such as absence of barriers to entry and strategic behavior among firms in the market, and the lack of product differentiation.

In contrast, imperfect competition implies firms have some ability to influence the market price of output they produce. One of the classic reasons firms may be able to do this is their ability to produce commodities with unique attributes that differentiate them from competitors' products. This allows them to limit supply, which in turn increases the market price, given the traditional downward-sloping demand curve. Decreasing the quantity produced increases the monopolist's profits but decreases total social surplus because a less than optimal amount of the product is being consumed. In the monopolistic equilibrium, the value society (consumers) places on the marginal product, the market price, *exceeds* the marginal cost to society (producers) of producing the last unit. Thus, social welfare would be increased by inducing the monopolist to increase production. Social cost estimates associated with a proposed regulation are larger with monopolistic market structures and other forms of imperfect competition because the regulation exacerbates the existing social inefficiency of too little output from a social perspective. The Office of Management and Budget (OMB) explicitly mentions the need to consider these market power-related welfare costs in evaluating regulations under Executive Order 12866 (OMB, 1996).

Perfect competition is a widely accepted economic practice for this type of analysis and only in rare cases are other approaches used (EPA 2000, p. 126). For the markets under consideration in this EIA, the perfect competition assumption is appropriate.

With regard to the fuel market, the Federal Trade Commission (FTC) has developed an approach to ensure competitiveness in this sector. The FTC reviews oil company mergers and frequently requires divestiture of refineries, terminals, and gas stations to maintain a minimum level of competition. This is discussed in more detail in the industry profile prepared for this proposal (RTI 2004b). Therefore, it is reasonable to assume a competitive market structure in this analysis.

With regard to the gas can market, the small number of firms in the market is offset by several features of this market. Because gas cans are compact and lightweight, they are easy to transport far from their place of manufacture. This means that production is not limited to local producers. Although they vary by size and material, consumers are likely to view all gas cans as good substitutes for one another. Because the products are similar enough to be considered homogeneous (e.g., perfectly substitutable), consumers can shift their purchases from one manufacturer to another. There are only minimal technical barriers to entry that would prevent new firms from freely entering the market, since manufacturing is based on well-known plastic processing methods. In addition, there is significant excess capacity, enabling competitors to respond quickly to changes in price. Excess production capacity in the general container manufacturing market also means that manufacturers could potentially switch their product lines to compete in this segment of the market, often without a significant investment. In addition, there is no evidence of high levels of strategic behavior in the price and quantity decisions of the firms. Finally, it should be noted that contestable market theory asserts that oligopolies and even monopolies will behave very much like firms in a competitive market if manufacturers have extra production capacity and this capacity could allow them to enter the market costlessly (i.e., there are no sunk costs associated with this kind of market entry or exit).[G] As a result of these conditions, producers and consumers in the gas can market take the market price as given when making their production and consumption choices. For all these reasons, the market can be modeled as a competitive market even though the number of producers is small.[H]

13.2.3.3 Intermediate-Run Model

In developing partial equilibrium models, the choices available to producers must be considered. For example, are producers able to increase their factors of production (e.g., increase production capacity) or alter their production mix (e.g., substitution between materials, labor, and capital)? These modeling issues are largely dependent on the time horizon for which the analysis is performed. Three benchmark time horizons are discussed below: the very short run, the long run, and the intermediate run. This discussion relies in large part on the material contained in the *OAQPS Economic Analysis Resource Guide* (U.S. EPA, 1999).

The EIM models market impacts in the intermediate run. The use of the intermediate run means that some factors of production are fixed and some are variable. This modeling period allows analysis of the economic effects of the rule’s compliance costs on current producers. As described below, a short-run analysis imposes all compliance costs on producers, while a long-run analysis imposes all costs on consumers. The use of the intermediate time frame is consistent with economic practices for this type of analysis.

In the very short run, all factors of production are assumed to be fixed, leaving the directly affected entity with no means to respond to increased costs associated with the regulation (e.g., they cannot adjust labor or capital inputs). Within a very short time horizon, regulated producers are constrained in their ability to adjust inputs or outputs due to contractual, institutional, or other factors and can be represented by a vertical supply curve, as shown in Figure 13.2-1. In essence, this is equivalent to the nonbehavioral model described earlier.

[G] A monopoly or firms in oligopoly may not behave as neoclassical economic theories of the firm predict because they may be concerned about new entrants to the market. If super-normal profits are earned, potential competitors may enter the market. To respond to this treat, existing firm(s) in the market will keep prices and output at a level where only normal profits are made, setting price and output levels at or close to the competitive price and output. (Baumol, Panzer, and Wilig, 1982; Baumol, 1982).

[H] More information about the structure of the gas can industry organization can be found in Section 3 of the industry characterization prepared for this proposal. See RTI 2004a.

Neither the price nor quantity changes and the manufacturer's compliance costs become fixed or sunk costs. Under this time horizon, the impacts of the regulation fall entirely on the regulated entity. Producers incur the entire regulatory burden as a one-to-one reduction in their profit. This is referred to as the "full-cost absorption" scenario and is equivalent to the engineering cost estimates. Although there is no hard and fast rule for determining what length of time constitutes the very short run, it is inappropriate to use this time horizon for this analysis because it assumes economic entities have no flexibility to adjust factors of production.

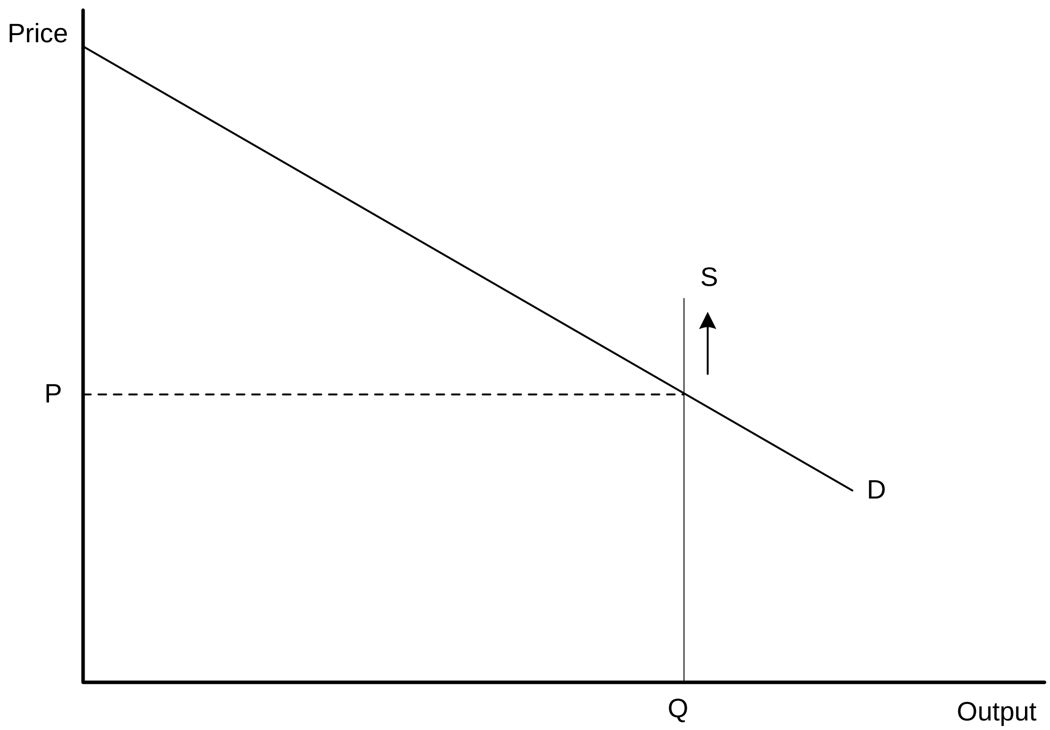


Figure 13.2-1. Short Run: All Costs Borne by Producers

In the long run, all factors of production are variable, and producers can be expected to adjust production plans in response to cost changes imposed by a regulation (e.g., using a different labor/capital mix). Figure 13.2-2 illustrates a typical, if somewhat simplified, long-run industry supply function. The function is horizontal, indicating that the marginal and average costs of production are constant with respect to output.[I] This horizontal slope reflects the fact that, under long-run constant returns to scale, technology and input prices ultimately determine the market price, not the level of output in the market.

Market demand is represented by the standard downward-sloping curve. The market is assumed here to be perfectly competitive; equilibrium is determined by the intersection of the supply and demand curves. In this case, the upward shift in the market supply curve represents

[I] The constancy of marginal costs reflects an underlying assumption of constant returns to scale of production, which may or may not apply in all cases.

the regulation's effect on production costs. The shift causes the market price to increase by the full amount of the per-unit control cost (i.e., from P to P′). With the quantity demanded sensitive to price, the increase in market price leads to a reduction in output in the new with-regulation equilibrium (i.e., Q to Q′). As a result, consumers incur the entire regulatory burden as represented by the loss in consumer surplus (i.e., the area P ac P′). In the nomenclature of EIAs, this long-run scenario is typically referred to as "full-cost pass-through" and is illustrated in Figure 13.2-2.

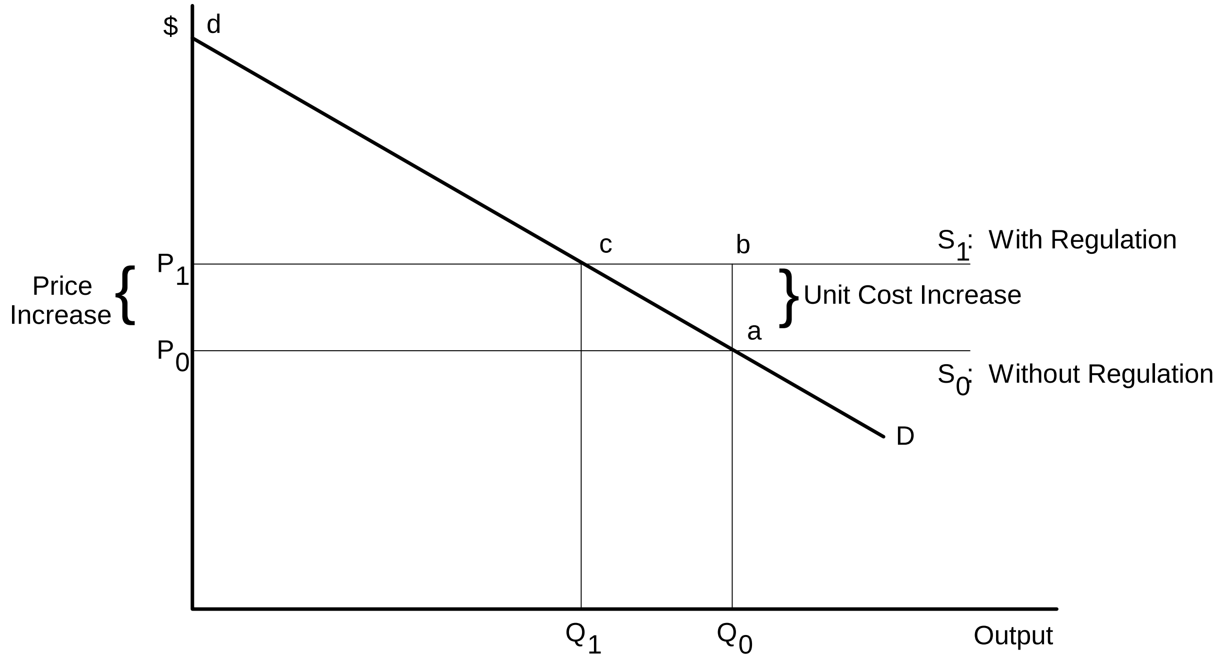


Figure 13.2-2. Long Run: Full Cost Pass Through

Taken together, impacts modeled under the long-run/full-cost-pass-through scenario reveal an important point: under fairly general economic conditions, a regulation's impact on producers is transitory. Ultimately, the costs are passed on to consumers in the form of higher prices. However, this does not mean that the impacts of a regulation will have no impact on producers of goods and services affected by a regulation. For example, the long run may cover the time taken to retire all of today's capital vintage, which could take decades. Therefore, transitory impacts could be protracted and could dominate long-run impacts in terms of present value. In addition, to evaluate impacts on current producers, the long-run approach is not appropriate. Consequently a time horizon that falls between the very short-run/full-cost-absorption case and the long-run/full-cost-pass-through case is most appropriate for this EIA.

The intermediate run time frame allows examination of impacts of a regulatory program during the transition between the short run and the long run. In the intermediate run, some factors are fixed; some are variable.[J] In other words, producers can adjust some, but not all, factors of production, meaning they will bear some portion of the costs of the regulatory program. The existence of fixed production factors generally leads to diminishing returns to those fixed factors. This typically manifests itself in the form of a marginal cost (supply)

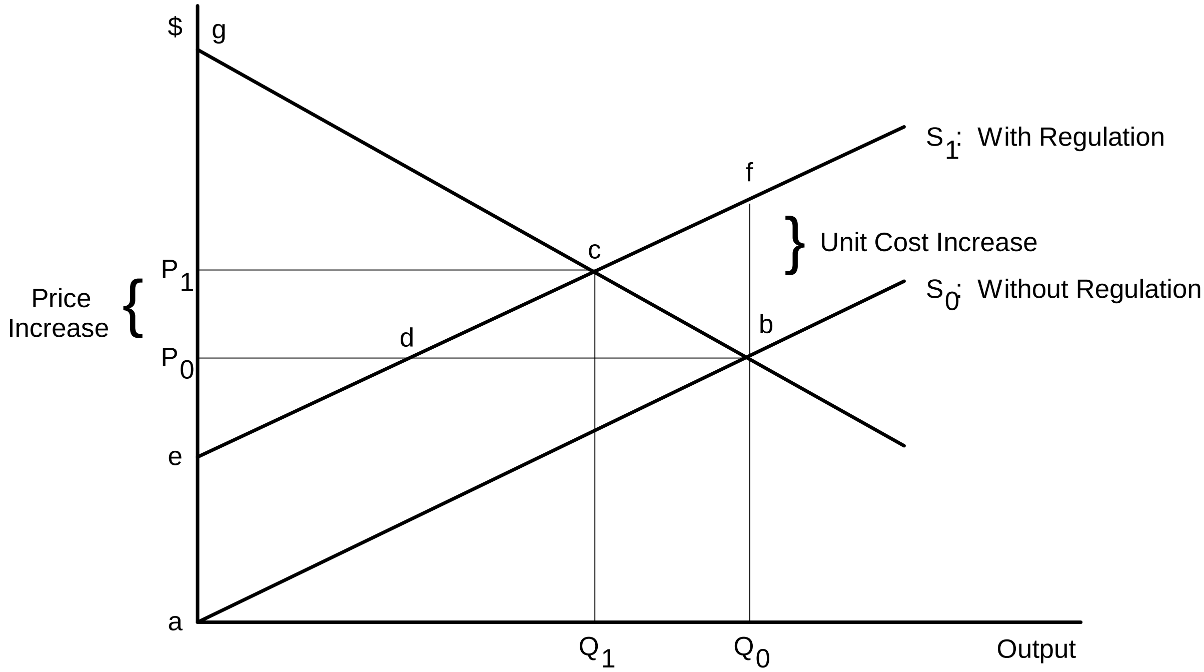


Figure 13.2-3. Intermediate Run: Partial Cost Pass Through

function that rises with the output rate, as shown in Figure 13.2-3.

Again, the regulation causes an upward shift in the supply function. The lack of resource mobility may cause producers to suffer profit (producer surplus) losses in the face of regulation; however, producers are able to pass through some of the associated costs to consumers, to the extent the market will allow. As shown, in this case, the market-clearing process generates an increase in price (from P to P′) that is less than the per-unit increase in costs, so that the regulatory burden is shared by producers (net reduction in profits) and consumers (rise in price). In other words, there is a loss of both producer and consumer surplus.

Consistent with other economic impact analyses performed by EPA, this EIM uses an intermediate run approach. This approach allows us to examine the market and social welfare impacts of the program as producers adjust their output and consumers adjust their consumption of affected products in response to the increased production costs. During this period, the distribution of the welfare losses between producer and consumer depends in large part on the

[J] As a semantical matter, the situation where some factors are variable and some are fixed is often referred to as the "short run" in economics, but the term "intermediate run" is used here to avoid any confusion with the term "very short run."

relative supply and demand elasticity parameters used in the model. For example, if demand for gas cans is relatively inelastic (i.e., demand does not decrease much as price increases), then most of the direct compliance cost on refiners will be passed along to gas can consumers in the form of higher prices.

13.2.3 How is the EIM Used to Estimate Economic Impacts?

13.2.3.1 Estimation of Market Impacts

A graphical representation of a general economic competitive model of price formation, as shown in Figure 13.2-4, posits that market prices and quantities are determined by the intersection of the market supply and market demand curves. Under the baseline scenario, a market price and quantity (p,Q) are determined by the intersection of the downward-sloping market demand curve (D^M) and the upward-sloping market supply curve (S^M). The market supply curve reflects the sum of the domestic (S_d) and import (S_i) supply curves.

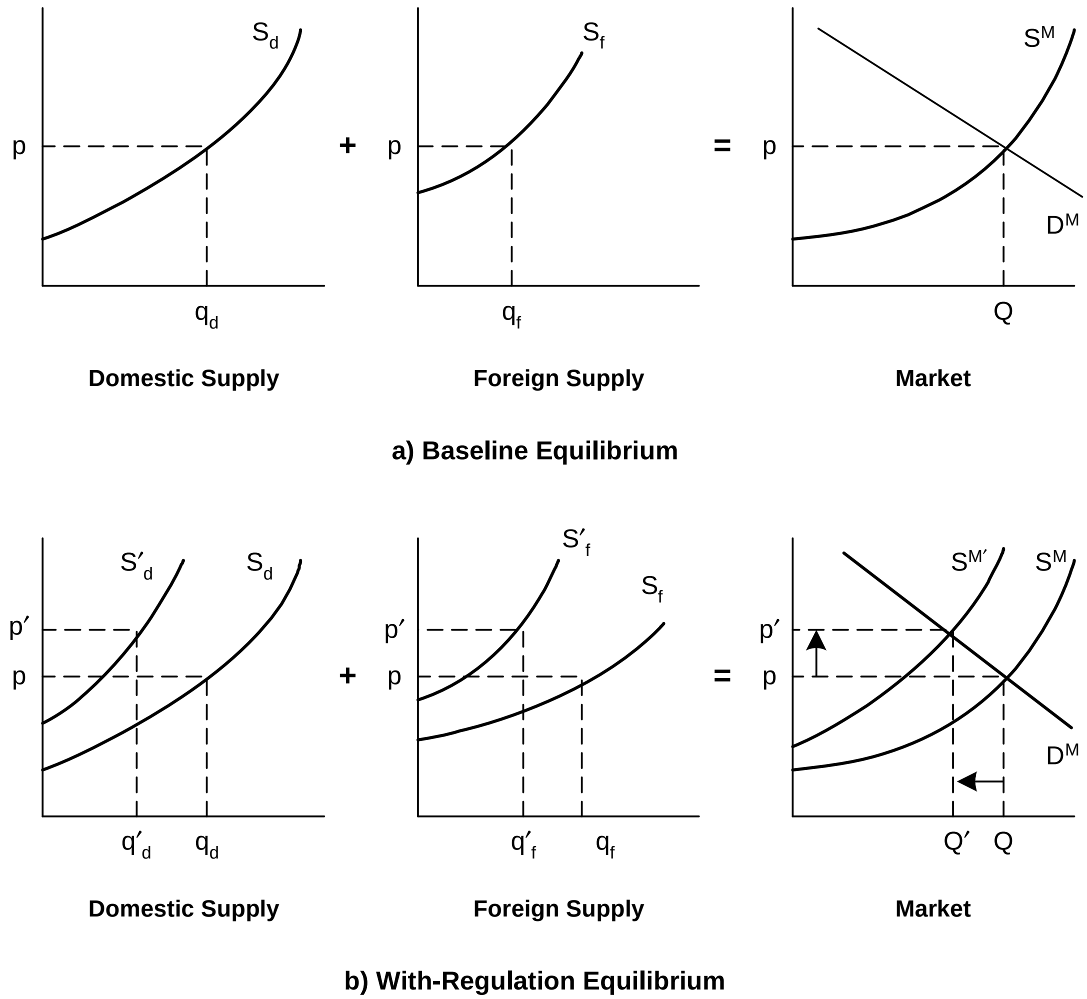


Figure 13.2-4. Market Equilibrium Without and With Regulation

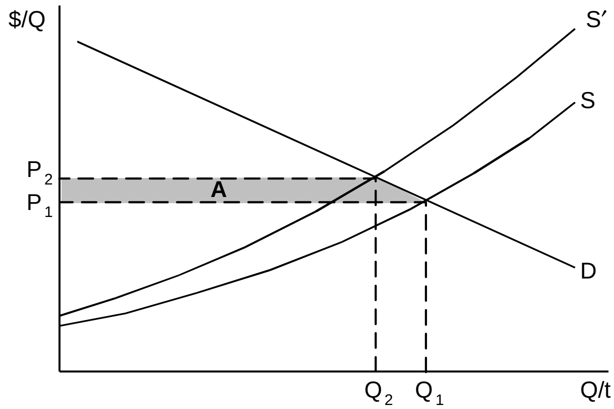
With the regulation, the costs of production increase for suppliers. The imposition of these regulatory control costs is represented as an upward shift in the supply curve for domestic and import supply by the estimated compliance costs. As a result of the upward shift in the supply curve, the market supply curve will also shift upward as shown in Figure 13.2-4(b) to reflect the increased costs of production.

At baseline without the proposed rule, the industry produces total output, Q, at price, p, with domestic producers supplying the amount q_d and imports accounting for Q minus q_d, or q_f. With the regulation, the market price increases from p to p′, and market output (as determined from the market demand curve) declines from Q to Q′. This reduction in market output is the net result of reductions in domestic and import supply

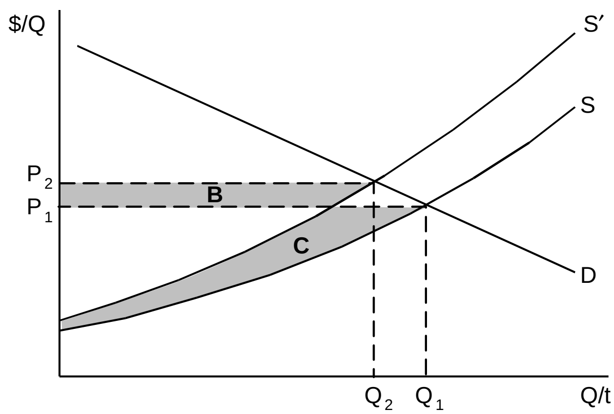
As indicated in Figure 13.2-3, when the proposed standards are applied the supply curve will shift upward by the amount of the estimated compliance costs. The demand curve, however, does not shift. This is because a shift in the demand curve is determined by changes in factors such as income, tastes, prices of substitute and complementary goods, expectations, and population. The standards under consideration do not affect these factors and so it is appropriate to assume all these factors remain constant.

13.2.3.2 Estimation of Social Costs

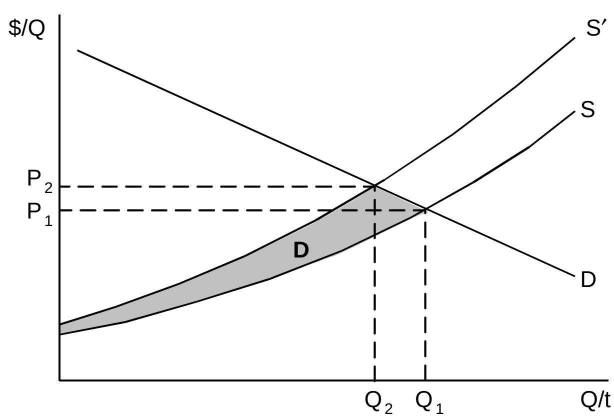
The economic welfare implications of the market price and output changes with the regulation can be examined by calculating consumer and producer net “surplus” changes associated with these adjustments. This is a measure of the negative impact of an environmental policy change and is commonly referred to as the “social cost” of a regulation. It is important to emphasize that this measure does not include the benefits that occur outside of the market, that is, the value of the reduced levels of air pollution with the regulation. Including this benefit will reduce the net cost of the regulation and even make it positive.



(a) Change in Consumer Surplus with Regulation



(b) Change in Producer Surplus with Regulation



(c) Net Change in Economic Welfare with Regulation

Figure 13.2-5. Market Surplus Changes with Regulations Consumer and Producer Surplus

The demand and supply curves that are used to project market price and quantity impacts can be used to estimate the change in consumer, producer, and total surplus or social cost of the regulation (see Figure 13.2-5a).

The difference between the maximum price consumers are willing to pay for a good and the price they actually pay is referred to as “consumer surplus.” Consumer surplus is measured as the area under the demand curve and above the price of the product. Similarly, the difference between the minimum price producers are willing to accept for a good and the price they actually receive is referred to as “producer surplus.” Producer surplus is measured as the area above the supply curve below the price of the product. These areas can be thought of as consumers’ net benefits of consumption and producers’ net benefits of production, respectively.

In Figure 13.2-5, baseline equilibrium occurs at the intersection of the demand curve, D, and supply curve, S. Price is P_l with quantity Q_l. The increased cost of production with the regulation will cause the market supply curve to shift upward to S′. The new equilibrium price of the product is P_2. With a higher price for the product there is less consumer welfare, all else being unchanged. In Figure 13.2-5a, area A represents the dollar value of the annual net loss in consumers’ welfare associated with the increased price. The rectangular portion represents the loss in consumer surplus on the quantity still consumed due to the price increase, Q_2, while the triangular area represents the foregone surplus resulting from the reduced quantity consumed, $Q_l – Q_2$.

In addition to the changes in consumers’ welfare, there are also changes in producers’ welfare with the regulatory action. With the increase in market price, producers receive higher revenues on the quantity still purchased, Q_2. In Figure 13.2-5b, area B represents the increase in revenues due to this increase in price. The difference in the area under the supply curve up to the original market price, area C, measures the loss in producer surplus, which includes the loss associated with the quantity no longer produced. The net change in producers’ welfare is represented by area B – C.

The change in economic welfare attributable to the compliance costs of the regulations is the sum of consumer and producer surplus changes, that is, –(A) + (B–C). Figure 13.2-5c shows the net (negative) change in economic welfare associated with the regulation as area D.

As explained in Section 13.1.3, the vehicle market is not included in the EIM. Instead, compliance costs are used as a proxy for the social welfare costs associated with that part of the proposed regulatory program. Vehicle compliance costs are likely to be absorbed by the manufacturers, thus increasing their surplus loss.

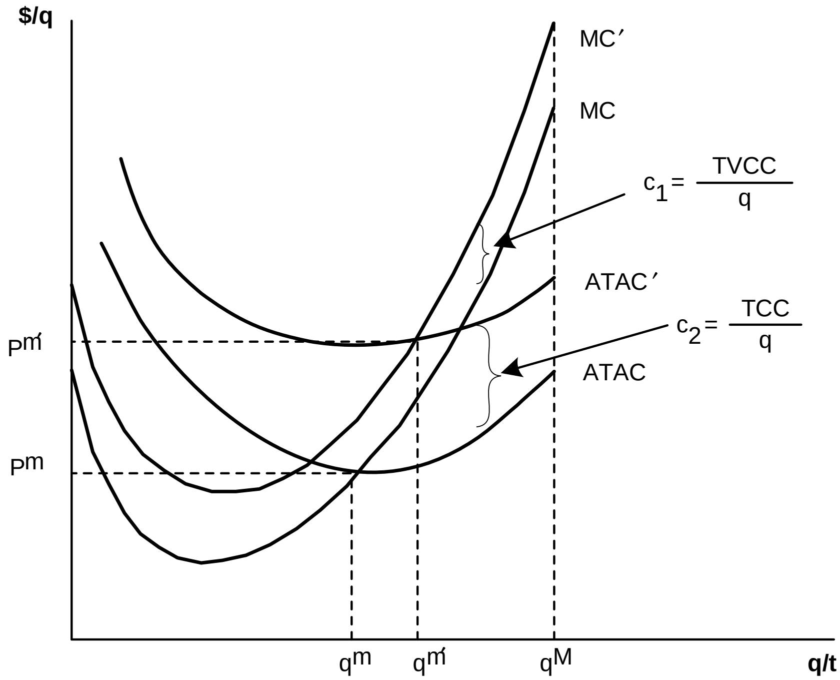
13.2.4. How Are Special Market Characteristics Addressed?

In addition to the general model features described in Section 13.2.2, there are several specific characteristics of the gas can and gasoline fuel markets that need to be addressed in the EIM. These are the treatment of fuel savings, fixed and variable costs, flexibility provisions, and substitution.

13.2.4.1 Fixed and Variable Costs

Related to short-run versus long-run modeling issues is the question of how fixed and variable costs are defined or treated by a specific industry or in the market analysis. The engineering estimates of fixed R&D and capital costs and variable material and operating and maintenance (O&M) costs provide an initial measure of total annual compliance costs without accounting for behavioral responses. The starting point for assessing the market impacts of a regulatory action is to incorporate the regulatory compliance costs into the production decision of the firm.

In general, shifting the supply curve by the total cost per unit implies that both capital and operating costs vary with output levels. At least in the case of capital, this raises some questions. In the long run, all inputs (and their costs) can be expected to vary with output. But a short(er)-run analysis typically holds some capital factors fixed. For instance, to the extent that a market supply function is tied to existing facilities, there is an element of fixed capital (or one-time R&D). As indicated above, the current market supply function might reflect these fixed factors with an upward slope. As shown in Figure 13.2-6, the marginal cost (MC) curve will only be affected, or shift upwards, by the per-unit variable compliance costs (c_1=TVCC/q), while the average total cost (ATAC) curve will shift up by the per-unit total compliance costs ($c_{2=}$TCC/q). Thus, the variable costs will directly affect the production decision (optimal output rate), and the fixed costs will affect the closure decision by establishing a new higher reservation price for the firm (i.e., $P^{m'}$). In other words, the fixed costs are important in determining whether the firm will stay in this line of business (i.e., produce anything at all), and the variable costs determine the level (quantity) of production.



(a) Upward-sloping supply function

Figure 13.2-6. Modeling Fixed Costs

Depending on the industry type, fixed costs associated with complying with a new regulation are generally treated differently in an analysis of market impacts. In a competitive market, the industry supply curve is generally based on the market's marginal cost curve; fixed costs do not influence production decisions at the margin. Therefore, the market analysis is based on variable costs only. This is the case with the vehicle controls in this analysis. The compliance costs for that program are fixed costs (R&D, test facilities) and do not affect marginal costs. As a result, this economic impact analysis does not include market impacts for the vehicle market. They are included in the social welfare analysis, however, since these compliance costs are a cost to society. By adding the vehicle program compliance costs to the social welfare costs we attribute all of the costs to the producers and assume that these costs do not change the quantities of affected vehicles produced or their prices.

The market analysis of the gas can market, however, is different and is based on total compliance costs (fixed + variable). The approach is appropriate even though this is a competitive market due to the nature of production practices in this market. Specifically, gas can manufacturers produce a product that changes very little over time. Gas cans are a fairly standard product and these manufacturers do not engage in research and development to improve their products on a continuous basis as is the case with highway vehicles or nonroad engines or equipment. A design change of nature that would be required by the proposed standards will require gas can manufacturers to devote new funds and resources to product redesign and facilities changes. Gas can manufacturers are expected to increase their prices by the full amount of the compliance costs to recover those costs.

Fixed costs required to comply with the proposed program on the refiner side are also treated differently, to reflect the refinery industry cost structure. Most of the petroleum refinery fixed costs used are for production hardware. The decision to invest to increase, maintain, or decrease production capacity may be made in response to anticipated or actual changes in price. To reflect the different ways in which refiners can pass costs through to consumers, three scenarios were run for the following supply curve shifts in the gasoline fuel markets:

- shift by average total (variable + fixed cost)
- shift by max total (variable + fixed cost)
- shift by max variable cost.

While it may seem reasonable to estimate costs based on maximum variable or maximum total costs, it should be noted that both of those scenarios assume that refiners with the highest benzene compliance costs are also the highest-cost gasoline producers absent benzene control. We do not have information on the highest gasoline cost producers to be able to examine whether these refineries are also expected to have the highest benzene control costs. However, we believe this is an extreme assumption.

We estimate the market and social welfare impacts of each of these scenarios. The first, shift by average total cost (variable + fixed), is the primary scenario and is included in the primary analysis. The other two are investigated using sensitivity analyses.

13.2.4.2 Fuel Savings and Fuel Taxes

If all the costs of the regulation are not reflected in the supply shift, then the producer and consumer surplus changes reflected in Figure 13.2-5a will not capture the total social costs of the regulation. This will be the case, for example, if there are cost savings attributable to a program that are not readily apparent to consumers. In this case, the proposed gas can controls are expected to reduce evaporative emissions from fuel storage, resulting in fuel savings for users of these containers. These fuel savings are not included in the market analysis for this EIA because these savings are not expected to affect consumer decisions with respect to the purchase of new containers. In other words, we assume people base their decision on whether to buy a new container on other needs (e.g., purchase of new equipment, replacement of a damaged container) and not on expected fuel savings that would accrue to them from using a compliant container. Fuel savings will be included in the social cost analysis, however, because they are a savings that accrues to society. They will be added into the estimated social costs as a separate line item.

The estimated fuel savings are estimated using the quantity of gasoline fuel saved through better evaporative controls and the post-tax price of gasoline (see Section 13.3.2.2). The post-tax price is used because this is the price consumers see at the fuel pump and is the price on which they base their purchasing decisions. In other words, consumers save the entire amount of the pump price. Also, in contrast to distillate diesel fuel used in nonroad equipment, gasoline fuel taxes are not typically rebated. This is because most gasoline fuel used in nonroad equipment is used by residential consumers and even those who could file for a tax rebate probably don't given the small amounts of fuel involved. As a result, the consumer would realize a savings equal to the pump price of gasoline for the fuel they save from evaporative controls (i.e., the full cost of the fuel and not just the pre-tax cost). At the same time, the tax savings realized on the fuel savings by consumers are reduced taxes revenues for local and federal governments. These revenue losses are estimated separately in the social welfare analysis, based on the gallons of fuel saved and the average national fuel tax (combined state and Federal government).

13.2.4.3 Flexibility Provisions

Consistent with the engineering cost estimates, the EIM does not include cost savings associated with compliance flexibility provisions or averaging, banking, and trading provisions. As a result, the results of this EIA can be viewed as somewhat conservative.

13.2.4.4 Substitution

This analysis assumes that there will be no substitution away from gasoline fuel. As explained in Section 13.2.3.3, the time horizon for this analysis is the intermediate run. In the intermediate run, economic actors can adjust some of their costs but others are fixed. So, for example, consumers can adjust the amount of gasoline they purchase but the type of vehicle or equipment they own (i.e., gasoline or diesel) is fixed. This analysis assumes that the relative proportions of gasoline to diesel vehicles and equipment are constant for the period of analysis. This assumption seems reasonable because the average cost increase for gasoline is estimated to be less than $0.01 per gallon. Gasoline prices vary considerably over time without provoking dramatic shifts in consumer behavior. Therefore, our assumption that consumers will not substitute away from gasoline vehicles and equipment in favor of diesels, or otherwise modify their behavior, is reasonable.

The analysis also assumes there will be no substitution away from affected gas cans. Consumers have only limited alternatives for safely storing gasoline: approved metal or plastic gas cans. Plastic gas cans account for the vast majority of gas cans sold due to their safety characteristics and ease of use. They are light-weight, are very durable, and do not rust. Plastic gas cans are also cheaper to manufacturer than their metal counterparts. Consequently, about 95 percent of the gas cans sold in the United States are plastic. While it may be the case that some consumers opt to use unapproved containers (e.g., milk jugs, glass jars, or diesel fuel containers), the extent to which they do this is not known. This rule will make approved plastic gasoline containers more expensive compared to unapproved containers, but we do not expect this rule to lead to more use of inappropriate containers by consumers than is already the case. Unapproved containers have serious defects. For example, it is difficult to pour fuel from containers such as plastic milk jugs, glass jars, and similar containers, especially into the small mouths of some lawn and garden equipment. In addition, these also are not long-term storage options as they may be damaged by the gasoline. Consumers are generally aware that gasoline must be transported and stored safely and are not likely to view these alternatives as safe relative to an approved gasoline container. Finally, it is illegal in most if not all states to dispense gasoline into unapproved containers, with this prohibition clearly marked on gas pumps.

The elasticity of demand for gas cans estimated for this EIM reflects this no-substitution assumption. As noted in Section 13.1.3 and explained in more detail in Section 13.3.5 and in Appendix E, this estimated elasticity is inelastic at -0.01. This means that a 100 percent increase in price is expected to result in a 1 percent decrease in demand. In acknowledgement of the concern about use of inappropriate containers, we also performed a sensitivity analysis for the elasticity of demand estimate relaxing the no-substitution assumption and using a rate of substitution of 10 percent. This is a fairly high rate of substitution and means that 10 percent of people who would otherwise buy a gas can find some other way to store gasoline (e.g., inappropriate containers) or opt not to purchase a gas can (for example, those with multiple containers will choose not to replace a container, giving up having multiple cans in multiple locations or the capability of filling multiple cans with a single trip to the gas station). Using a 10 percent rate of substitution we estimate a demand elasticity that is less inelastic, at -0.25. This means that a 100 percent increase in price results in a 25 percent decrease in demand. As described in Appendix G, this alternative demand elasticity has only a small impact on the results of the modeling. For 2015, the price impact is reduced by about 20 cents (decreasing from $1.52 to $1.31 in states that do not already have gas can requirements). In addition, producers are expected to bear more of the costs of the program (increasing from 0.7 percent to 15.1 percent). The emissions impacts of a 10 percent rate of substitution are small. If these purchasers exit the gas can market permanently (i.e., this is not a short-term adjustment with consumers only postponing their purchases), we would expect about 10 percent less emissions reductions from the gas can standards. Table 13.2-1 below provides a rough estimate of the losses in VOC emission reductions. It is important to note that the costs of the overall program would also be reduced by roughly the same 10 percent and so the overall cost per ton of emissions reduced would not significantly change. Also, in cases where the substitution occurs from consumers keeping their current gas cans for a longer period of time or by only leaving the market temporarily, the emissions reductions are only postponed to a future date. Therefore, the lost emissions reductions shown in the table below would represent a worst case for the 10 percent substitution scenario.

Table 13.2-1 - VOC Emissions Reductions from Gas Cans (tons)

	2015	2020	2030
Base Case	181,000	193,000	218,000
w/ 10 Percent Substitution	163,000	174,000	196,000
Difference	18,000	19,000	22,000

13.2.4.5 Market-Level Analysis

The EIM estimates the economic impacts of the proposal at the market level. It is not a firm-level analysis. The demand elasticity facing any particular manufacturer may be different from the demand elasticity of the market as a whole, and therefore the share of the compliance costs a particular firm may pass on to consumers may be smaller or larger than estimated by this model. This difference can be important, particularly where the rule affects different firms' costs over different volumes of production. However, to the extent there are differential effects, EPA believes that the flexibilities provided in this rule will be adequate to address any cost inequities that are likely to arise.

13.3 EIM Data Inputs and Model Solution

The EIM is a computer model comprised of a series of spreadsheet modules that simulate the supply and demand characteristics of the markets under consideration. The model equations, presented in Appendix D to this chapter, are based on the economic relationships described in Section 13.2. The EIM analysis consists of four basic steps:

- Define the initial market equilibrium conditions of the markets under consideration (equilibrium prices and quantities and behavioral parameters; these yield equilibrium supply and demand curves).
- Introduce a policy "shock" into the model based on estimated compliance costs that shift the supply functions.
- Use a solution algorithm to estimate a new, with-regulation equilibrium price and quantity for all markets.
- Estimate the change in producer and consumer surplus in all markets included in the model.

Supply responses and market adjustments can be conceptualized as an interactive process. Producers facing increased production costs due to compliance are willing to supply smaller quantities at the baseline price. This reduction in market supply leads to an increase in the market price that all producers and consumers face, which leads to further responses by producers and consumers and thus new market prices, and so on. The new with-regulation equilibrium reflects the new market prices where total market supply equals market demand.

The remainder of this section describes the data used to construct the EIM: initial equilibrium market conditions (equilibrium prices and quantities), compliance cost inputs, model elasticity parameters. Also included is a brief discussion of the analytical expression used to estimate with-regulation market conditions.

13.3.1 Description of Product Markets

There are six product markets included in this EIM: two gas can markets and four gasoline fuel markets. While the vehicle market will also be affected by the proposed standards, that market was not included in the EIM (see Section 13.1.3). Each of these markets is described below. More information can be found in the industry characterizations prepared for this proposal (RTI 2004a and RTI 2004b).

13.3.1.1 Gas Can Market

Gas cans allow people to refuel equipment in circumstances where refueling at a retail gasoline establishment is not convenient. Therefore, they support the use of a wide variety of small gasoline-powered equipment such as lawnmowers, chainsaws, string trimmers, and tractors. They are also used in recreational vehicles such as all-terrain vehicles, off-road motorcycles, and gasoline-powered golf carts. The demand for gas cans is directly linked to the demand for other household goods and services. Industry representatives suggest that sales of gas cans are influenced by trends in sales of power equipment (i.e., lawn and garden) and recreational vehicles As a result, factors that influence decisions to purchase these commodities (e.g., changes in the price of equipment, changes in personal income, population growth rates, home sales) will indirectly influence the decision to purchase gas cans. Economic theory for derived demand suggests that under some reasonable assumptions we can predict that an increase in the price of gas cans will have little impact on sales of gas cans both because gas cans represent a very small fraction of total expenditures and they are an essential input into household and business production functions (Hicks, 1961; Hicks, 1966; and Allen, 1938). In addition, there are only limited alternatives for storing gasoline.

There is little additional publicly available national data on the users of gas cans. However, a recent study by CARB (1999) found that 94 percent of portable fuel containers in California were used by residential households. Commercial businesses account for a remaining gas can use.

The vast majority of gas cans sold in the United States are plastic (about 98 percent). Gas can manufacturing is currently dominated by four firms (Blitz USA, Midwest Can, Scepter Manufacturing, Ltd., and Wedco Molded Products) and one firm accounts for about 70 percent of U.S. sales and 50 percent of North American sales. Other gas can manufacturers have very limited market share, are more geared for industrial use, and/or fill a niche specialty market. Manufacturing gas cans is not constrained geographically in that these containers are lightweight and fairly inexpensive to transport to distant markets.

Plastic gas cans are manufactured using well-known plastic processing methods to form plastic material into gas containers and spouts. The production process combines capital equipment, labor, and materials to produce portable fuel containers of desired size and technical standards. Therefore, only minimal technical barriers prevent new firms from freely entering the market, and there are many manufacturers of plastics and plastic containers who could join the market if it were profitable to do so.

California established an emissions control program for gas cans that began in 2001 (CARB 1999). Twelve other states (Delaware, Maine, Maryland, Pennsylvania, New York, Connecticut, Massachusetts, New Jersey, Rhode Island, Vermont, Virginia, and Texas) and the District of Columbia have adopted the California program in recent years. Because of these existing control measures, the costs of complying with the proposed standards is expected to be reduced for these states (fewer changes will be necessary for these gas cans). Consequently, the economic impact analysis differentiates between two markets: those states that have controls and those that do not.

13.3.1.2 Gasoline Fuel Market

Gasoline plays an important role in the American economy. The Federal Highway Administration (DoT 2002) reported that the United States consumed over 130 billion gallons of gasoline in 2002. The overwhelming majority of gasoline is consumed for highway uses. About 92% of gasoline consumption on a Btu basis was consumed by light-duty vehicles. Most people rely on gasoline for personal transportation, unlike the commercial transportation that relies mostly on diesel fuel. The remaining share of gasoline consumption is for nonhighway use (i.e., lawn and garden equipment and marine uses).

Consumers can respond to price changes in gasoline in two general ways. First, they may simply consider reducing the number of vehicle miles traveled or their use of nonroad equipment. If the relative price of gas remains higher for longer periods, consumers might also consider long-term adjustments to their capital stock to mitigate the effects of higher prices. For example, they may purchase vehicles with better fuel economy, buy a home closer to work or shopping, or purchase nonroad equipment that relies on electricity.

Refineries produce finished motor gasoline through a complex process that converts crude oil into several products. Finished gasoline product leaves the refinery and reaches consumers through one or more bulk transport services. Pipelines, tankers, or barges typically transport gasoline from refineries or ports to terminals that provide storage and dispensing facilities. A variety of downstream gasoline marketing arrangements (i.e. wholesale and retail) ultimately deliver gasoline to the consumer.

There are more than 100 refineries in the United States. Additional gasoline is obtained through imports, especially on the East Coast. However, production tends to be regional in nature. The Federal Trade Commission (FTC) has developed an approach to ensure competitiveness in gasoline fuel markets. It reviews oil company mergers and frequently requires divestiture of refineries, terminals, and gas stations to maintain a minimum level of competitiveness.

Given the existing region-specific gasoline performance standards and other physical and economic barriers, the national gasoline market is broken down into five for the purpose of the Economic Impact Analysis. These are the five Petroleum Administration for Defense Districts (PADDs) defined by the Department of Energy. This economic impact analysis distinguishes between these regions. For the purpose of this analysis, two PADDs are combined, giving four regional district fuel markets. These are:

- PADD 1 & 3
- PADD 2
- PADD 4
- PADD 5 (includes Alaska and Hawaii; California fuel treated separately).

PADD 1 and 3 are combined because of the high level of regional trade between these areas. Other regional trading is generally constrained due to inefficiencies in transporting gasoline between regions and so is not included in this analysis. Also not included in the analysis is inter-region trading on a consumer basis (drivers who cross state lines to purchase fuel). PADD 5 does not include California fuel in the market analysis since California already has similar although not identical fuel benzene controls and any additional refinery costs associated with the federal program for California fuel are expected to be small and not affect market prices or quantities in that state. However, because the estimated fuel program compliance costs include a small compliance cost for California, and this cost would be a cost to society, it is necessary to include those costs in the total economic welfare costs of the proposal.

This is done by including the estimated engineering compliance costs as a separate line item. Finally, consistent with the cost analysis, the EIM does not distinguish between conventional gasoline and reformulated gasoline (RFG).

13.3.2 Initial Market Conditions

The starting point for the economic impact analysis is initial market equilibrium conditions that exist prior to the implementation of new standards. At pre-control market equilibrium conditions, consumers are willing to purchase the same amount of a product that producers are willing to produce at the market price. This section describes the initial market equilibrium conditions (prices and quantities) for the gas can and gasoline markets.

13.3.2.1 Gas Can Market Quantities and Prices

The gas can market equilibrium sales and price data used in the EIM are contained in Tables 13.3-1 and 13.3-2. The data are based on information provided by industry (RTI 2004a, Section 4). Industry sales data from 2002 were grown for future years using a 2 percent growth rate. This growth rate is consistent with information obtained from industry representatives, who indicated that sales are expected to increase at the same pace as the retail market in general. The gas can prices from 2003 were obtained from industry. The prices in Table 3.3-2 are weighted averages of the observed prices of 3 sizes of gas cans (1 gallon, 2 gallon, and 5 gallon; 33 percent weight for each). Gas can prices are held fixed for all years included in the analysis reflecting an assumption of constant (real) price of goods and services over time (see Appendix F for an explanation of this assumption).

Table 13.3-1. Gas Can Sales Data

Year	States without Controls	States With Controls	Total
2009	15,415,362	9,855,723	25,271,085
2010	15,723,669	10,052,837	25,776,506
2011	16,038,142	10,253,894	26,292,037
2012	16,358,905	10,458,972	26,817,877
2013	16,686,083	10,668,152	27,354,235
2014	17,019,805	10,881,515	27,901,319
2015	17,360,201	11,099,145	28,459,346
2016	17,707,405	11,321,128	29,028,533
2017	18,061,553	11,547,550	29,609,103
2018	18,422,784	11,778,501	30,201,286
2019	18,791,240	12,014,071	30,805,311
2020	19,167,065	12,254,353	31,421,417
2021	19,550,406	12,499,440	32,049,846
2022	19,941,414	12,749,429	32,690,843
2023	20,340,242	13,004,417	33,344,660
2024	20,747,047	13,264,506	34,011,553
2025	21,161,988	13,529,796	34,691,784

Year	States without Controls	States With Controls	Total
2026	21,585,228	13,800,392	35,385,619
2027	22,016,932	14,076,399	36,093,332
2028	22,457,271	14,357,927	36,815,199
2029	22,906,417	14,645,086	37,551,502
2030	23,364,545	14,937,988	38,302,533
2031	23,831,836	15,236,747	39,068,583
2032	24,308,472	15,541,482	39,849,955
2033	24,794,642	15,852,312	40,646,954
2034	25,290,535	16,169,358	41,459,893
2035	25,796,345	16,492,745	42,289,091

Table 13.3-2. Gas Can Price Data (2003$)

States Without Controls	States With Controls
$4.66	$11.05

13.3.2.2 Gasoline Fuel Market Quantities and Prices

The gasoline fuel market equilibrium sales and price data used in the EIM are contained in Tables 13.3-3 and 13.3-4. It should be noted that the sales data is for all gasoline and that this analysis does not differentiate between reformulated and conventional gasoline. This is consistent with the cost analysis performed for this proposal.[K] Also, California gasoline is considered separately from PADD 5 because, as explained above, California has a state-level program that controls fuel benzene.

The sales data is Energy Information Administration data, based on the Energy Information Administration's Petroleum Market Annual fuel consumption data for 2003 (DoE 2003, Table 48). This data was adjusted using the growth rates from the Energy Information Administration's Annual Energy Outlook 2005 (DoE 2005). The gasoline volumes used in this economic impact analysis are consumption volumes, which include imported gasoline as well as gasoline produced in the United States for domestic purposes. Consumption volumes are used because the market equilibrium price is determined by all the gasoline supplied and purchased in the market and not just the gasoline produced in the U.S. for that market.

Gasoline retail prices were estimated using the following approach (see RTI 2005 for more information). First, the average price of motor gasoline by PADD (all grades, sales to end users, excluding taxes) was obtained from the Energy Information Administrations 2003 Petroleum Marketing Annual (DoE 2003, Table 31). Next, state and federal motor gasoline taxes data were obtained from the Department of Transportation's *2003 Highway Statistics* to

[K] See Note B, above.

create an average state tax per model region (DoT 2003, Table MF-121T). State and federal taxes were added to the price data obtained from the Energy Information Administration. Since EIM model combines PADDs 1 and 3, the retail price for this market is an average price for the region. Each PADD's price is weighted by the gasoline consumption data used in the market model.

Table 13.3-3. Gasoline Fuel Sales Data, by Region (MM gallons)

Year	PADD 1 & 3	PADD 2	PADD 4	PADD 5 w/out CA	California	Total
2009	77,221	42,908	5,025	8,759	16,411	150,324
2010	78,764	43,766	5,125	8,934	16,739	153,328
2011	80,147	44,534	5,215	9,091	17,033	156,020
2012	81,520	45,298	5,305	9,247	17,325	158,695
2013	82,886	46,056	5,393	9,402	17,615	161,352
2014	84,282	46,832	5,484	9,560	17,911	164,069
2015	85,654	47,595	5,574	9,716	18,203	166,742
2016	86,933	48,305	5,657	9,861	18,475	169,231
2017	88,216	49,018	5,740	10,006	18,747	171,727
2018	89,449	49,703	5,820	10,146	19,010	174,128
2019	90,662	50,377	5,899	10,284	19,267	176,489
2020	91,842	51,033	5,976	10,418	19,518	178,787
2021	93,095	51,729	6,058	10,560	19,784	181,226
2022	94,407	52,458	6,143	10,709	20,063	183,780
2023	95,807	53,236	6,234	10,867	20,361	186,505
2024	97,366	54,102	6,336	11,044	20,692	189,540
2025	98,957	54,987	6,439	11,225	21,030	192,638
2026	100,575	55,885	6,544	11,408	21,374	195,786
2027	102,219	56,799	6,651	11,595	21,723	198,987
2028	103,889	57,727	6,760	11,784	22,078	202,238
2029	105,588	58,671	6,871	11,977	22,439	205,546
2030	107,313	59,630	6,983	12,173	22,806	208,905
2031	109,067	60,604	7,097	12,372	23,179	212,319
2032	110,850	61,595	7,213	12,574	23,558	215,790
2033	112,662	62,602	7,331	12,779	23,943	219,317
2034	114,503	63,625	7,451	12,988	24,334	222,901
2035	116,375	64,665	7,573	13,200	24,732	226,545

Table 13.3-4. Gasoline Fuel Prices (2003$; includes fuel taxes)

PADD 1 & 3	PADD 2	PADD 4	PADD 5 w/out CA	California
$1.48	$1.51	$1.57	$1.67	$1.69

Gasoline fuel prices are held fixed for all years included in the analysis reflecting an assumption of constant (real) price of goods and services over time (see Appendix F for an explanation of this assumption). We also performed a sensitivity analysis using gasoline fuel prices projected by the Energy Information Agency. The results of that sensitivity analysis can be found in Appendix G.

13.3.3 Compliance Costs

The social costs of the proposed standards are estimated by shocking the initial market equilibrium conditions by the amount of the compliance costs. The compliance costs used in this analysis are the engineering compliance costs described in Chapters 9 and 10 of this RIA and are summarized in this section.

13.3.3.1 Gas Can Compliance Costs

The economic impacts of the proposed gas can controls are estimated based on the estimated engineering compliance costs described in Chapter 10. The compliance costs used in the EIA are summarized in Table 13.3-5.

Even though this is a competitive market, the gas can market is shocked by the sum of the fixed and variable compliance costs in the initial years of the program. The fixed costs are included for the first five years of the program, which represents the capital recovery period for the initial R&D and tooling costs. As explained in Section 13.2.4.1, in a competitive market the industry supply curve is based on its marginal cost curve and therefore the market shock should reflect only variable costs. However, as explained in that section, gas can manufacturing sector is structured such that these manufacturers are expected to pass along the full amount of the compliance costs, fixed and variable costs, to consumers in the form of higher prices.

In the engineering cost analysis, fixed costs are applied equally over the five-year recovery period. For the purpose of the EIA, a simplified constant fixed cost approach was used to allocate the fixed costs to a per-unit basis. Because the number of units produced is expected to increase every year, this approach means that the model anticipates that engine manufacturers would recover slightly more than the estimated fixed costs, and the supply curve shift would be slightly more than of another method of allocating fixed costs were used. While the resulting estimated social welfare costs of the program are slightly higher, this difference is not expected to change the overall results of the analysis.

As reflected in Table 13.3-5, variable and fixed costs are different for gas cans in states with or without existing controls. The estimated costs are expected to be less in states with existing programs because manufacturers will incur fewer costs to bring their gas cans into compliance with the standards.

Table 13.3-5. Gas Can Compliance Costs, Per Unit

Year	States without State Program			States with State Program		
	Fixed Costs	Variable Costs	Total Costs	Fixed Costs	Variable Costs	Total Costs
2009	$1.17	$1.53	$2.70	$0.56	$0.21	$0.77
2010	$1.17	$1.53	$2.70	$0.56	$0.21	$0.77
2011	$1.17	$1.53	$2.70	$0.56	$0.21	$0.77
2012	$1.17	$1.53	$2.70	$0.56	$0.21	$0.77
2013	$1.17	$1.53	$2.70	$0.56	$0.21	$0.77
2014		$1.53	$1.53		$0.21	$0.21
2015		$1.53	$1.53		$0.21	$0.21
2016		$1.53	$1.53		$0.21	$0.21
2017		$1.53	$1.53		$0.21	$0.21
2018		$1.53	$1.53		$0.21	$0.21
2019		$1.53	$1.53		$0.21	$0.21
2020		$1.53	$1.53		$0.21	$0.21
2021		$1.53	$1.53		$0.21	$0.21
2022		$1.53	$1.53		$0.21	$0.21
2023		$1.53	$1.53		$0.21	$0.21
2024		$1.53	$1.53		$0.21	$0.21
2025		$1.53	$1.53		$0.21	$0.21
2026		$1.53	$1.53		$0.21	$0.21
2027		$1.53	$1.53		$0.21	$0.21
2028		$1.53	$1.53		$0.21	$0.21
2029		$1.53	$1.53		$0.21	$0.21
2030		$1.53	$1.53		$0.21	$0.21
2031		$1.53	$1.53		$0.21	$0.21
2032		$1.53	$1.53		$0.21	$0.21
2033		$1.53	$1.53		$0.21	$0.21
2034		$1.53	$1.53		$0.21	$0.21
2035		$1.53	$1.53		$0.21	$0.21

13.3.3.2 Gasoline Fuel Compliance Costs

The EIM uses the estimated gasoline fuel compliance costs described in Chapter 9. These costs are summarized in Table 13.3-6. The gasoline compliance costs are different across regions, reflecting different refinery production practices. Compliance costs are treated the same for domestically produced fuel and imports for each PADD. This approach is reasonable because many areas (e.g., Europe, Japan, and Australia) already have benzene standards. In addition, although foreign refiners may face a compliance situation different from domestic producers in a particular PADD, they can select fuel streams for export that require less benzene removal, thereby keeping their costs low.

Unlike gas can compliance costs, gasoline fuel compliance costs are constant for all years. This is because each regional supply curve is shifted by the average total (variable + fixed) regional cost of the regulation. This approach is used for the fuel market because most of the petroleum refinery fixed costs are used for production hardware which is required by the proposed standards. This new capital investment (fixed costs) will be amortized each year and will be replaced after a certain period. Therefore, the fixed costs required by this rule are expected to be constant for all years included in the analysis.

As explained in Section 13.2.4.1, above, we investigate three compliance cost scenarios. In the primary analysis, fuel compliance costs are based on the average variable compliance costs for the industry. However, if refiners' investment in benzene control capacity is very close to that needed to satisfy the fuel demand for the proposed benzene control program, then economic theory suggests that the last or highest increment of control in that market would determine the gasoline price. Two max cost scenarios are explored in the sensitivity analysis presented in Appendix G: one in which the high-cost refinery's total (variable + fixed) compliance costs determine price, and a second in which only the high-cost refinery's variable compliance costs determine price. It should be noted, however, that both of these maximum cost scenarios assume that refiners with the highest benzene compliance costs are also the highest-cost gasoline producers absent benzene control. This is an extreme assumption.

Table 13.3-6. Gasoline Fuel Compliance Costs by Region (¢/gallon, 2003$)

Scenario	PADD 1 & 3	PADD 2	PADD 4	PADD 5 (w/out California)	California
Total Average (Fixed + Variable) Cost – Primary Analysis	0.049¢	0.202¢	0.358¢	0.391¢	0.010¢
Maximum Total (Fixed + Variable) Cost	0.606¢	1.154¢	1.459¢	1.142¢	0.148¢
Maximum Variable Cost	0.537¢	1.067¢	1.459¢	1.142¢	0.077¢

13.3.3.3 Vehicle Compliance Costs

The market impacts of the proposed vehicle control program are not modeled because they are fixed costs (primarily R&D and facility costs) and are therefore not included in the market analysis (see Section 13.2.4.1, above). However, these compliance costs are costs to society and should be included in the social cost analysis. We use the vehicle compliance costs as a proxy for the social welfare costs associated with those controls. These are added to the social costs for the gasoline fuel and gas can controls to obtain the total social costs of the program.

For this analysis, we used the vehicle compliance costs described in Chapter 8. These are summarized in Table 13.3-7. These costs are primarily for R&D, tooling, certification, and facilities. Because these costs are so small on a per vehicle basis, this analysis assumes that they will be absorbed by the manufacturers.

Table 13.3-7. Vehicle Compliance Costs (2003$)

Year	Compliance Costs ($Million)
2010	$11.1
2011	$11.8
2012	$12.5
2013	$13.3
2014	$13.4
2015	$12.9
2016	$12.2
2017	$11.4
2018	$10.7
2019	$10.6
2020 and subsequent years	$0

13.3.4 Fuel Savings

As noted in section 13.2.4.1, there are fuel savings attributable to the gas can program, reflecting the reduction in evaporative emissions. As explained in that section, these savings are included in the economic welfare analysis as a separate line item. Consumers of gas cans will realize an increase in their welfare equivalent to the amount of gallons of gasoline saved multiplied by the retail price of the gasoline (post-tax price). In the engineering cost analysis the fuel savings are estimated in this manner. However, in the context of the social welfare analysis, some of this increase in consumer welfare is offset by lost tax revenues to local, state, and federal governments. These welfare losses must be accounted for as well. Therefore, the net change in social welfare is the difference between the increase in consumer welfare and the lost tax revenues. This is equivalent to using the pre-tax price of gasoline to estimate the fuel savings for the social welfare analysis.

The amount of gallons of gasoline fuel saved is estimated based on the VOC reductions attributable to gas can controls. California fuel is not included in this estimate because there are no emission reductions attributable to the proposed program for that state. Tons of annual VOC reductions are translated to gallons of gasoline saved using a fuel density of 6 lbs per gallon (for lighter hydrocarbons which evaporate first).

Because the gallons of gasoline saved are based on national VOC reductions and were not estimated by PADD, we estimated a national average retail gasoline price. This estimate is the sum of the weighted average of pre-tax gasoline prices by PADD and the weighted average gasoline tax by PADD, using data from the *2003 Petroleum Marketing Annual* (DoE 2003, Table 31). The results of this analysis are shown in Tables 13.3-8 and 13.3-9.

Table 13.3-8. Estimated National Average Fuel Prices (2003$)

PADD	Weight	Pre-tax Price/Gallon	Average State Taxes	Federal Tax	Post-Tax Price/Gallon
PADD 1 & 3	0.58	$1.099	$0.201	$0.184	$1.484
PADD 2	0.32	$1.117	$0.208	$0.184	$1.509
PADD 4	0.04	$1.165	$0.225	$0.184	$1.574
PADD 5	0.06	$1.272	$0.200	$0.184	$1.663
Total		$1.118			$1.506

Source: *2003 Petroleum Marketing Annual* (Table 31). U.S. Department of Energy, Energy Information Administration (DoE 2004).

From 2009 until 2016 the estimated consumer savings associated with reduced gasoline consumption from the gas can controls increases sharply, from $14.3 million to $93.1 million. After 2016 the savings continue to accrue, but at a reduced rate as the gas can population turns over and fuel savings are due to the continuing benefits of using compliant gas cans. Similarly, the tax revenue losses are expected to increase from $3.7 million in 2009 to $24 million in 2016, but only $6 million more, to $30 million, by 2035.

Table 13.3-9. Estimated Fuel Savings and Tax Revenue Impacts (2003$)

Year	Gallons	Consumer Fuel Savings ($Million)	Tax revenue Impacts ($Million)	Net Fuel Savings ($Million)
2009	9,461,282	$14.3	-$3.7	$10.6
2010	19,602,073	$29.6	-$7.6	$21.9
2011	29,742,864	$44.8	-$11.5	$33.3
2012	39,883,656	$60.1	-$15.5	$44.6
2013	50,024,447	$75.4	-$19.4	$56.0
2014	60,165,238	$90.7	-$23.4	$67.3
2015	60,977,696	$91.9	-$23.7	$68.3
2016	61,790,154	$93.1	-$24.0	$69.2
2017	62,602,611	$94.4	-$24.3	$70.1
2018	63,415,069	$96.5	-$24.6	$71.0
2019	64,227,527	$96.8	-$24.9	$71.9
2020	65,039,985	$98.0	-$25.2	$72.8
2021	65,852,443	$99.3	-$25.6	$73.7
2022	66,664,901	$100.5	-$25.9	$74.6
2023	67,477,359	$101.7	-$26.2	$75.5
2024	68,289,817	$102.9	-$26.5	$76.4
2025	69,102,275	$104.2	-$26.8	$77.3
2026	69,914,732	$105.4	-$27.1	$78.3
2027	70,727,190	$106.6	-$27.5	$79.2
2028	71,539,648	$107.8	-$27.8	$80.1
2029	72,352,106	$109.1	-$28.1	$81.0
2030	73,164,564	$110.3	-$28.4	$81.9
2031	73,977,022	$111.5	-$28.7	$82.8
2032	74,789,480	$112.7	-$29.0	$83.7
2033	75,601,938	$114.0	-$29.3	$84.6
2034	76,414,396	$115.2	-$29.7	$85.5
2035	77,226,853	$116.4	-$30.0	$86.4

13.3.5 Supply and Demand Elasticity Estimates

The estimated market impacts and economic welfare costs of this emission control program are a function of the ways in which producers and consumers of the gas can and gasoline fuel affected by the standards change their behavior in response to the costs incurred in complying with the standards. These behavioral responses are incorporated in the EIM through the price elasticity of supply and demand (reflected in the slope of the supply and demand curves), which measure the price sensitivity of consumers and producers.

Table 13.3-10 provides a summary of the demand and supply elasticities used to estimate the economic impact of the proposed rule. More detailed information is provided in Appendix E. The gasoline elasticities were obtained from the literature. Because we were unable to find published supply and demand elasticities for the gas can market, we estimated these parameters using the procedures described in Appendix E. These methods are well-documented and are consistent with generally accepted econometric practice. It should be noted that these elasticities reflect intermediate run behavioral changes. In the long run supply and demand are expected to be more elastic.

The price elasticity parameters for gasoline fuel used in this analysis are -0.2 for demand and 0.2 for supply. This means that both the quantity supplied and demanded are expected to be fairly insensitive to price changes and that increases in prices are not expected to cause sales to fall or production to increase by very much. The inelastic supply elasticity for the gasoline fuel market reflects the fact that most refineries operate near capacity and are therefore less responsive to fluctuations in market prices. Note that these elasticities reflect intermediate run behavioral changes. In the long run, supply and demand are expected to be more elastic since more substitutes may become available.

The price elasticity parameters for gas cans used in this analysis are -0.01 for demand) and 1.5 for supply. The estimated demand elasticity is nearly perfectly inelastic (equal to zero). This means that a change in price is expected to have very little effect on the quantity of gas cans demanded. This makes intuitive sense since if households need to store gasoline for convenient use they do not have many alternatives. However, supply is fairly elastic, meaning producers are expected to respond to a change in price. This also makes intuitive sense since it is fairly easy for these producers to store finished gas cans and it is inexpensive for them to increase output. Therefore, consumers are expected to bear more of the burden of gas can regulatory control costs.

Because the elasticity estimates are a key input to the model, a sensitivity analysis for supply and demand elasticity parameters was performed as part of this analysis. The results are presented in Appendix E.

Table 13.3-10. Summary of Elasticities Used in the EIM

Market	Estimate	Source	Method	Input Data Summary
Supply Elasticities				
Gasoline Fuel	0.24	Considine (2002)	Literature estimate	NA
Gas Can	1.50	EPA econometric estimate (see Appendix C)	Cobb-Douglas production function	Bartlesman et al. (2000); 1980–1996; SIC 3089
Demand Elasticities				
Gasoline Fuel	–0.20	FTC (2001)	Literature estimate	NA
Gas Can	–0.01	EPA numerical simulation (see Appendix D)	Hicks-Allen derived demand	Described in Appendix D

13.3.6 Economic Impact Model Structure

The EIM developed for this analysis is a spreadsheet model that estimates changes in price and quantity in a market that are expected to occur as a result of an increase in producer costs in the amount of the compliance costs associated with the proposed standards. The impacts on the gasoline and gas can markets are modeled separately, and there is no feedback between the two models. The model for each of these two markets consists of one demand curve and one supply curve, reflecting the fact that the standards affect only one group of producers (gas can manufacturers, gasoline fuel refiners) and one group of consumers (residential gas can users, residential gasoline fuel users). There are no intermediate levels in the market since there are no intermediate producers and consumers affected by the standards.

This structure makes the model relatively simple to construct and solve. Specifically, the EIM's partial equilibrium models use a commonly used analytical expression used in the analysis of supply and demand in a single market (Berck and Hoffmann, 2002; Fullerton and Metcalfe, 2002). Appendix D explains in detail how this expression is derived using the following steps:

1. *Specify* a set of supply and demand relationships for each market.
2. *Simplify* the equations by transforming them into a set of linear equations.
3. *Solve* the equilibrium system of equations.

Using this expression, we can estimate the market price change in terms of the market's supply and elasticity parameters and the regulatory program's per unit cost (Equation D.5 in Appendix D).

$$\Delta\text{price} = \frac{\text{Supply Elasticity}}{(\text{Supply Elasticity - Demand Elasticity})} \times \text{per - unit cost}$$

Given the market price change due to increased cost required by the proposed rule and the demand elasticity for each market, we can also estimate the market quantity change.

$$\Delta \text{quantity} = \Delta \text{price} \times \text{ Demand Elasticity}$$

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Appendix 13A: Impacts on Gas Can Markets

This appendix provides the time series of impacts from 2009 through 2035 for the gas can markets. Two separate markets were modeled and segmented by existence of a state regulatory program.

Table 13A-1 provides the time series of impacts for each market and includes the following:

- average engineering costs (variable and fixed) per can
- absolute change in the market price ($)
- relative change in market price (%)
- absolute change in market quantity (%)
- relative change in market quantity (%)
- consumer, producer, and total surplus losses

All prices and costs are presented in 2003$ and real gas can prices are assumed to be constant during the period of analysis.

Table 13A-1. Regional Impacts: Gas Can Markets

	Without State Program (Average price $4.66)							
Year	**Average Total Cost ($/can)**	**Change in Price ($/can)**	**Change in Price (%)**	**Change in Quantity (thousand cans)**	**Change in Quantity (%)**	**CS Loss (million $)**	**PS Loss (million $)**	**Total Social Cost (million $)**
2009	$2.70	$2.68	57.4%	-88.5	-0.57%	-$41.18	-$0.28	-$41.46
2010	$2.70	$2.68	57.4%	-90.3	-0.57%	-$42.01	-$0.28	-$42.29
2011	$2.70	$2.68	57.4%	-92.1	-0.57%	-$42.85	-$0.29	-$43.13
2012	$2.70	$2.68	57.4%	-94.0	-0.57%	-$43.70	-$0.29	-$44.00
2013	$2.70	$2.68	57.4%	-95.8	-0.57%	-$44.58	-$0.30	-$44.88
2014	$1.53	$1.52	32.5%	-55.3	-0.32%	-$25.75	-$0.17	-$25.92
2015	$1.53	$1.52	32.5%	-56.4	-0.32%	-$26.27	-$0.18	-$26.44
2016	$1.53	$1.52	32.5%	-57.5	-0.32%	-$26.79	-$0.18	-$26.97
2017	$1.53	$1.52	32.5%	-58.7	-0.32%	-$27.33	-$0.18	-$27.51
2018	$1.53	$1.52	32.5%	-59.9	-0.32%	-$27.87	-$0.19	-$28.06
2019	$1.53	$1.52	32.5%	-61.1	-0.32%	-$28.43	-$0.19	-$28.62
2020	$1.53	$1.52	32.5%	-62.3	-0.32%	-$29.00	-$0.19	-$29.19
2021	$1.53	$1.52	32.5%	-63.5	-0.32%	-$29.58	-$0.20	-$29.78
2022	$1.53	$1.52	32.5%	-64.8	-0.32%	-$30.17	-$0.20	-$30.37
2023	$1.53	$1.52	32.5%	-66.1	-0.32%	-$30.78	-$0.21	-$30.98
2024	$1.53	$1.52	32.5%	-67.4	-0.32%	-$31.39	-$0.21	-$31.60
2025	$1.53	$1.52	32.5%	-68.8	-0.32%	-$32.02	-$0.21	-$32.23
2026	$1.53	$1.52	32.5%	-70.1	-0.32%	-$32.66	-$0.22	-$32.88
2027	$1.53	$1.52	32.5%	-71.5	-0.32%	-$33.31	-$0.22	-$33.54
2028	$1.53	$1.52	32.5%	-73.0	-0.32%	-$33.98	-$0.23	-$34.21
2029	$1.53	$1.52	32.5%	-74.4	-0.32%	-$34.66	-$0.23	-$34.89
2030	$1.53	$1.52	32.5%	-75.9	-0.32%	-$35.35	-$0.24	-$35.59
2031	$1.53	$1.52	32.5%	-77.4	-0.32%	-$36.06	-$0.24	-$36.30
2032	$1.53	$1.52	32.5%	-79.0	-0.32%	-$36.78	-$0.25	-$37.03
2033	$1.53	$1.52	32.5%	-80.6	-0.32%	-$37.52	-$0.25	-$37.77
2034	$1.53	$1.52	32.5%	-82.2	-0.32%	-$38.27	-$0.26	-$38.52
2035	$1.53	$1.52	32.5%	-83.8	-0.32%	-$39.03	-$0.26	-$39.29
NPV 3%						-$572.11	-$3.84	-$575.94
NPV 7%						-$338.24	-$2.27	-$340.50

(continued)

Table 13A-1. Regional Impacts: Gas Can Markets (continued)

Year	With State Program (Average price $11.05) Average Total Cost ($/can)	Change in Price ($/can)	Change in Price (%)	Change in Quantity (thousand cans)	Change in Quantity (%)	CS Loss (million $)	PS Loss (million $)	Total Social Cost (million $)
2009	$0.77	$0.76	6.89%	-6.8	-0.07%	-$7.49	-$0.05	-$7.54
2010	$0.77	$0.76	6.89%	-6.9	-0.07%	-$7.64	-$0.05	-$7.69
2011	$0.77	$0.76	6.89%	-7.1	-0.07%	-$7.80	-$0.05	-$7.85
2012	$0.77	$0.76	6.89%	-7.2	-0.07%	-$7.95	-$0.05	-$8.01
2013	$0.77	$0.76	6.89%	-7.3	-0.07%	-$8.11	-$0.05	-$8.17
2014	$0.21	$0.20	1.85%	-2.0	-0.02%	-$2.23	-$0.01	-$2.24
2015	$0.21	$0.20	1.85%	-2.1	-0.02%	-$2.27	-$0.02	-$2.29
2016	$0.21	$0.20	1.85%	-2.1	-0.02%	-$2.32	-$0.02	-$2.33
2017	$0.21	$0.20	1.85%	-2.1	-0.02%	-$2.36	-$0.02	-$2.38
2018	$0.21	$0.20	1.85%	-2.2	-0.02%	-$2.41	-$0.02	-$2.43
2019	$0.21	$0.20	1.85%	-2.2	-0.02%	-$2.46	-$0.02	-$2.48
2020	$0.21	$0.20	1.85%	-2.3	-0.02%	-$2.51	-$0.02	-$2.52
2021	$0.21	$0.20	1.85%	-2.3	-0.02%	-$2.56	-$0.02	-$2.58
2022	$0.21	$0.20	1.85%	-2.4	-0.02%	-$2.61	-$0.02	-$2.63
2023	$0.21	$0.20	1.85%	-2.4	-0.02%	-$2.66	-$0.02	-$2.68
2024	$0.21	$0.20	1.85%	-2.5	-0.02%	-$2.72	-$0.02	-$2.73
2025	$0.21	$0.20	1.85%	-2.5	-0.02%	-$2.77	-$0.02	-$2.79
2026	$0.21	$0.20	1.85%	-2.6	-0.02%	-$2.82	-$0.02	-$2.84
2027	$0.21	$0.20	1.85%	-2.6	-0.02%	-$2.88	-$0.02	-$2.90
2028	$0.21	$0.20	1.85%	-2.7	-0.02%	-$2.94	-$0.02	-$2.96
2029	$0.21	$0.20	1.85%	-2.7	-0.02%	-$3.00	-$0.02	-$3.02
2030	$0.21	$0.20	1.85%	-2.8	-0.02%	-$3.06	-$0.02	-$3.08
2031	$0.21	$0.20	1.85%	-2.8	-0.02%	-$3.12	-$0.02	-$3.14
2032	$0.21	$0.20	1.85%	-2.9	-0.02%	-$3.18	-$0.02	-$3.20
2033	$0.21	$0.20	1.85%	-2.9	-0.02%	-$3.24	-$0.02	-$3.27
2034	$0.21	$0.20	1.85%	-3.0	-0.02%	-$3.31	-$0.02	-$3.33
2035	$0.21	$0.20	1.85%	-3.1	-0.02%	-$3.38	-$0.02	-$3.40
NPV 3%						-$66.61	-$0.45	-$67.07
NPV 7%						-$42.91	-$0.29	-$43.20

Appendix 13B: Impacts on Gasoline Fuel Markets

This appendix provides the time series of impacts from 2009 through 2035 for the gasoline markets. Four gasoline markets were modeled: Four PADDs (PADDs 1 & 3, PADD 2, PADD 4, and PADD 5). Note that PADD 5 includes Alaska and Hawaii but excludes California fuel volumes that are not affected by the program because they are covered by separate California standards.

Table 13B-1 provides the time series of impacts for each market and includes the following:

- average engineering costs (variable and fixed) per gallon
- absolute change in the market price ($)
- relative change in market price (%)
- absolute change in market quantity (%)
- relative change in market quantity (%)
- consumer, producer, and total surplus losses

All prices and costs are presented in 2003$ and real gasoline prices are assumed to be constant during the period of analysis. A sensitivity analysis of the constant price assumption is provided in Appendix G.

Table 13B-1. Regional Impacts: Gasoline Markets

	PADD I & III (Average price $1.45)							
Year	Average Total Cost (cents/ gallon)	Change in Price (cents/ gallon)	Change in Price (%)	Change in Quantity (Absolute)	Change in Quantity (%)	CS Loss (million $)	PS Loss (million $)	Total Social Cost (million $)
2009	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2010	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2011	0.0495	0.0270	0.019%	–3	–0.0037%	–$21.630	–$18.020	–$39.650
2012	0.0495	0.0270	0.019%	–3	–0.0037%	–$22.000	–$18.330	–$40.330
2013	0.0495	0.0270	0.019%	–3	–0.0037%	–$22.370	–$18.640	–$41.010
2014	0.0495	0.0270	0.019%	–3	–0.0037%	–$22.740	–$18.950	–$41.700
2015	0.0495	0.0270	0.019%	–3	–0.0037%	–$23.120	–$19.260	–$42.380
2016	0.0495	0.0270	0.019%	–3	–0.0037%	–$23.460	–$19.550	–$43.010
2017	0.0495	0.0270	0.019%	–3	–0.0037%	–$23.810	–$19.840	–$43.650
2018	0.0495	0.0270	0.019%	–3	–0.0037%	–$24.140	–$20.120	–$44.260
2019	0.0495	0.0270	0.019%	–3	–0.0037%	–$24.470	–$20.390	–$44.860
2020	0.0495	0.0270	0.019%	–3	–0.0037%	–$24.790	–$20.660	–$45.440
2021	0.0495	0.0270	0.019%	–3	–0.0037%	–$25.120	–$20.940	–$46.060
2022	0.0495	0.0270	0.019%	–3	–0.0037%	–$25.480	–$21.230	–$46.710
2023	0.0495	0.0270	0.019%	–4	–0.0037%	–$25.860	–$21.550	–$47.400
2024	0.0495	0.0270	0.019%	–4	–0.0037%	–$26.280	–$21.900	–$48.170
2025	0.0495	0.0270	0.019%	–4	–0.0037%	–$26.710	–$22.260	–$48.960
2026	0.0495	0.0270	0.019%	–4	–0.0037%	–$27.140	–$22.620	–$49.760
2027	0.0495	0.0270	0.019%	–4	–0.0037%	–$27.590	–$22.990	–$50.570
2028	0.0495	0.0270	0.019%	–4	–0.0037%	–$28.040	–$23.360	–$51.400
2029	0.0495	0.0270	0.019%	–4	–0.0037%	–$28.490	–$23.750	–$52.240
2030	0.0495	0.0270	0.019%	–4	–0.0037%	–$28.960	–$24.130	–$53.090
2031	0.0495	0.0270	0.019%	–4	–0.0037%	–$29.430	–$24.530	–$53.960
2032	0.0495	0.0270	0.019%	–4	–0.0037%	–$29.910	–$24.930	–$54.840
2033	0.0495	0.0270	0.019%	–4	–0.0037%	–$30.400	–$25.340	–$55.740
2034	0.0495	0.0270	0.019%	–4	–0.0037%	–$30.900	–$25.750	–$56.650
2035	0.0495	0.0270	0.019%	–4	–0.0037%	–$31.410	–$26.170	–$57.580
NPV 3%						–$384.00	–$320.00	–$703.97
NPV 7%						–$206.43	–$172.02	–$378.45

(continued)

Table 13B-1. Regional Impacts: Gasoline Markets (continued)

	PADD II (Average price $1.50)							
Year	**Average Total Cost (cents/ gallon)**	**Change in Price (cents/ gallon)**	**Change in Price (%)**	**Change in Quantity (Absolute)**	**Change in Quantity (%)**	**CS Loss (million $)**	**PS Loss (million $)**	**Total Social Cost (million $)**
2009	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2010	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2011	0.2020	0.1102	0.073%	–7	–0.0146%	–$49.070	–$40.890	–$89.960
2012	0.2020	0.1102	0.073%	–7	–0.0146%	–$49.910	–$41.590	–$91.500
2013	0.2020	0.1102	0.073%	–7	–0.0146%	–$50.740	–$42.290	–$93.030
2014	0.2020	0.1102	0.073%	–7	–0.0146%	–$51.600	–$43.000	–$94.600
2015	0.2020	0.1102	0.073%	–7	–0.0146%	–$52.440	–$43.700	–$96.140
2016	0.2020	0.1102	0.073%	–7	–0.0146%	–$53.220	–$44.360	–$97.580
2017	0.2020	0.1102	0.073%	–7	–0.0146%	–$54.000	–$45.010	–$99.020
2018	0.2020	0.1102	0.073%	–7	–0.0146%	–$54.760	–$45.640	–$100.400
2019	0.2020	0.1102	0.073%	–7	–0.0146%	–$55.500	–$46.260	–$101.760
2020	0.2020	0.1102	0.073%	–7	–0.0146%	–$56.220	–$46.860	–$103.090
2021	0.2020	0.1102	0.073%	–8	–0.0146%	–$56.990	–$47.500	–$104.490
2022	0.2020	0.1102	0.073%	–8	–0.0146%	–$57.800	–$48.170	–$105.960
2023	0.2020	0.1102	0.073%	–8	–0.0146%	–$58.650	–$48.880	–$107.540
2024	0.2020	0.1102	0.073%	–8	–0.0146%	–$59.610	–$49.680	–$109.290
2025	0.2020	0.1102	0.073%	–8	–0.0146%	–$60.580	–$50.490	–$111.070
2026	0.2020	0.1102	0.073%	–8	–0.0146%	–$61.570	–$51.320	–$112.890
2027	0.2020	0.1102	0.073%	–8	–0.0146%	–$62.580	–$52.160	–$114.730
2028	0.2020	0.1102	0.073%	–8	–0.0146%	–$63.600	–$53.010	–$116.610
2029	0.2020	0.1102	0.073%	–9	–0.0146%	–$64.640	–$53.870	–$118.510
2030	0.2020	0.1102	0.073%	–9	–0.0146%	–$65.700	–$54.750	–$120.450
2031	0.2020	0.1102	0.073%	–9	–0.0146%	–$66.770	–$55.650	–$122.420
2032	0.2020	0.1102	0.073%	–9	–0.0146%	–$67.860	–$56.560	–$124.420
2033	0.2020	0.1102	0.073%	–9	–0.0146%	–$68.970	–$57.480	–$126.450
2034	0.2020	0.1102	0.073%	–9	–0.0146%	–$70.100	–$58.420	–$128.520
2035	0.2020	0.1102	0.073%	–9	–0.0146%	–$71.240	–$59.380	–$130.620
NPV 3%						–$871.07	–$725.98	–$1,597.06
NPV 7%						–$468.28	–$390.27	–$858.56

(continued)

Table 13B-1. Regional Impacts: Gasoline Markets (continued)

	PADD IV (Average price $1.57)							
Year	Average Total Cost (cents/ gallon)	Change in Price (cents/ gallon)	Change in Price (%)	Change in Quantity (Absolute)	Change in Quantity (%)	CS Loss (million $)	PS Loss (million $)	Total Social Cost (million $)
2009	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2010	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2011	0.3580	0.1953	0.124%	–1	–0.0248%	–$10.180	–$8.490	–$18.670
2012	0.3580	0.1953	0.124%	–1	–0.0248%	–$10.360	–$8.630	–$18.990
2013	0.3580	0.1953	0.124%	–1	–0.0248%	–$10.530	–$8.780	–$19.310
2014	0.3580	0.1953	0.124%	–1	–0.0248%	–$10.710	–$8.930	–$19.630
2015	0.3580	0.1953	0.124%	–1	–0.0248%	–$10.880	–$9.070	–$19.950
2016	0.3580	0.1953	0.124%	–1	–0.0248%	–$11.040	–$9.210	–$20.250
2017	0.3580	0.1953	0.124%	–1	–0.0248%	–$11.210	–$9.340	–$20.550
2018	0.3580	0.1953	0.124%	–1	–0.0248%	–$11.360	–$9.470	–$20.840
2019	0.3580	0.1953	0.124%	–1	–0.0248%	–$11.520	–$9.600	–$21.120
2020	0.3580	0.1953	0.124%	–1	–0.0248%	–$11.670	–$9.730	–$21.390
2021	0.3580	0.1953	0.124%	–2	–0.0248%	–$11.830	–$9.860	–$21.690
2022	0.3580	0.1953	0.124%	–2	–0.0248%	–$11.990	–$10.000	–$21.990
2023	0.3580	0.1953	0.124%	–2	–0.0248%	–$12.170	–$10.150	–$22.320
2024	0.3580	0.1953	0.124%	–2	–0.0248%	–$12.370	–$10.310	–$22.680
2025	0.3580	0.1953	0.124%	–2	–0.0248%	–$12.570	–$10.480	–$23.050
2026	0.3580	0.1953	0.124%	–2	–0.0248%	–$12.780	–$10.650	–$23.430
2027	0.3580	0.1953	0.124%	–2	–0.0248%	–$12.990	–$10.830	–$23.810
2028	0.3580	0.1953	0.124%	–2	–0.0248%	–$13.200	–$11.000	–$24.200
2029	0.3580	0.1953	0.124%	–2	–0.0248%	–$13.410	–$11.180	–$24.600
2030	0.3580	0.1953	0.124%	–2	–0.0248%	–$13.630	–$11.360	–$25.000
2031	0.3580	0.1953	0.124%	–2	–0.0248%	–$13.860	–$11.550	–$25.410
2032	0.3580	0.1953	0.124%	–2	–0.0248%	–$14.080	–$11.740	–$25.820
2033	0.3580	0.1953	0.124%	–2	–0.0248%	–$14.310	–$11.930	–$26.240
2034	0.3580	0.1953	0.124%	–2	–0.0248%	–$14.550	–$12.130	–$26.670
2035	0.3580	0.1953	0.124%	–2	–0.0248%	–$14.790	–$12.320	–$27.110
NPV 3%						–$180.77	–$150.69	–$331.45
NPV 7%						–$97.18	–$81.01	–$178.18

(continued

Table 13B-1. Regional Impacts: Gasoline Markets (continued)

Year	PADD V (excluding California) (Average price $1.69)							
	Average Total Cost (cents/ gallon)	Change in Price (cents/ gallon)	Change in Price (%)	Change in Quantity (Absolute)	Change in Quantity (%)	CS Loss (million $)	PS Loss (million $)	Total Social Cost (million $)
2009	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2010	0.0000	0.0000	0.000%	0	0.0000%	$0.000	$0.000	$0.000
2011	0.3910	0.2133	0.126%	–2	–0.0252%	–$19.390	–$16.160	–$35.550
2012	0.3910	0.2133	0.126%	–2	–0.0252%	–$19.720	–$16.440	–$36.150
2013	0.3910	0.2133	0.126%	–2	–0.0252%	–$20.050	–$16.710	–$36.760
2014	0.3910	0.2133	0.126%	–2	–0.0252%	–$20.390	–$16.990	–$37.380
2015	0.3910	0.2133	0.126%	–2	–0.0252%	–$20.720	–$17.270	–$37.990
2016	0.3910	0.2133	0.126%	–2	–0.0252%	–$21.030	–$17.530	–$38.560
2017	0.3910	0.2133	0.126%	–3	–0.0252%	–$21.340	–$17.790	–$39.120
2018	0.3910	0.2133	0.126%	–3	–0.0252%	–$21.640	–$18.030	–$39.670
2019	0.3910	0.2133	0.126%	–3	–0.0252%	–$21.930	–$18.280	–$40.210
2020	0.3910	0.2133	0.126%	–3	–0.0252%	–$22.220	–$18.520	–$40.730
2021	0.3910	0.2133	0.126%	–3	–0.0252%	–$22.520	–$18.770	–$41.290
2022	0.3910	0.2133	0.126%	–3	–0.0252%	–$22.840	–$19.030	–$41.870
2023	0.3910	0.2133	0.126%	–3	–0.0252%	–$23.170	–$19.320	–$42.490
2024	0.3910	0.2133	0.126%	–3	–0.0252%	–$23.550	–$19.630	–$43.180
2025	0.3910	0.2133	0.126%	–3	–0.0252%	–$23.940	–$19.950	–$43.890
2026	0.3910	0.2133	0.126%	–3	–0.0252%	–$24.330	–$20.280	–$44.610
2027	0.3910	0.2133	0.126%	–3	–0.0252%	–$24.730	–$20.610	–$45.330
2028	0.3910	0.2133	0.126%	–3	–0.0252%	–$25.130	–$20.950	–$46.080
2029	0.3910	0.2133	0.126%	–3	–0.0252%	–$25.540	–$21.290	–$46.830
2030	0.3910	0.2133	0.126%	–3	–0.0252%	–$25.960	–$21.640	–$47.590
2031	0.3910	0.2133	0.126%	–3	–0.0252%	–$26.380	–$21.990	–$48.370
2032	0.3910	0.2133	0.126%	–3	–0.0252%	–$26.810	–$22.350	–$49.160
2033	0.3910	0.2133	0.126%	–3	–0.0252%	–$27.250	–$22.720	–$49.970
2034	0.3910	0.2133	0.126%	–3	–0.0252%	–$27.700	–$23.090	–$50.780
2035	0.3910	0.2133	0.126%	–3	–0.0252%	–$28.150	–$23.460	–$51.610
NPV 3%						–$344.19	–$286.89	–$631.05
NPV 7%						–$185.04	–$154.23	–$339.24

Appendix 13C: Time Series of Social Costs

This appendix provides a time series of the rule's estimated social costs from 2009 through 2035. Costs are presented in 2003 dollars.

Table 13C-1. Time Series of Social Costs

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Consumer Surplus Change, Total	**-$48.7**	**-$49.7**	**-$150.9**	**-$153.6**	**-$156.4**	**-$133.4**	**-$135.7**	**-$137.9**	**-$140.1**
Gasoline, U.S.	$0.0	$0.0	-$100.3	-$102.0	-$103.7	-$105.4	-$107.2	-$108.8	-$110.4
PADD I & III	$0.0	$0.0	-$21.6	-$22.0	-$22.4	-$22.7	-$23.1	-$23.5	-$23.8
PADD II	$0.0	$0.0	-$49.1	-$49.9	-$50.7	-$51.6	-$52.4	-$53.2	-$54.0
PADD IV	$0.0	$0.0	-$10.2	-$10.4	-$10.5	-$10.7	-$10.9	-$11.0	-$11.2
PADD V (excludes California)	$0.0	$0.0	-$19.4	-$19.7	-$20.1	-$20.4	-$20.7	-$21.0	-$21.3
Gas Cans, U.S.	-$48.7	-$49.7	-$50.7	-$51.7	-$52.7	-$28.0	-$28.5	-$29.1	-$29.7
States With State Regulatory Programs	-$7.5	-$7.6	-$7.8	-$8.0	-$8.1	-$2.2	-$2.3	-$2.3	-$2.4
States Without State Regulatory Programs	-$41.2	-$42.0	-$42.9	-$43.7	-$44.6	-$25.8	-$26.3	-$26.8	-$27.3
Producer Surplus Change, Total	**-$0.3**	**-$0.3**	**-$85.6**	**-$87.1**	**-$88.5**	**-$89.8**	**-$91.3**	**-$92.7**	**-$94.1**
Gasoline, U.S.	$0.0	$0.0	-$85.3	-$86.7	-$88.2	-$89.7	-$91.1	-$92.5	-$93.9
PADD I & III	$0.0	$0.0	-$18.0	-$18.3	-$18.6	-$19.0	-$19.3	-$19.6	-$19.8
PADD II	$0.0	$0.0	-$40.9	-$41.6	-$42.3	-$43.0	-$43.7	-$44.4	-$45.0
PADD IV	$0.0	$0.0	-$8.5	-$8.6	-$8.8	-$8.9	-$9.1	-$9.2	-$9.3
PADD V (excludes California)	$0.0	$0.0	-$16.2	-$16.4	-$16.7	-$17.0	-$17.3	-$17.5	-$17.8
PADD V (California)	$0.0	$0.0	-$1.7	-$1.7	-$1.8	-$1.8	-$1.8	-$1.8	-$1.9
Gas Cans, U.S.	-$0.3	-$0.3	-$0.3	-$0.3	-$0.4	-$0.2	-$0.2	-$0.2	-$0.2
States With State Regulatory Programs	-$0.1	-$0.1	-$0.1	-$0.1	-$0.1	$0.0	$0.0	$0.0	$0.0
States Without State Regulatory Programs	-$0.3	-$0.3	-$0.3	-$0.3	-$0.3	-$0.2	-$0.2	-$0.2	-$0.2
Fuel Savings	**$10.6**	**$21.9**	**$33.3**	**$44.6**	**$56.0**	**$67.3**	**$68.3**	**$69.2**	**$70.1**
Consumer Savings	$14.3	$29.6	$44.8	$60.1	$75.4	$90.7	$91.9	$93.1	$94.4
Fuel	$10.6	$21.9	$33.3	$44.6	$56.0	$67.3	$68.3	$69.2	$70.1
Tax	$3.7	$7.6	$11.5	$15.5	$19.4	$23.4	$23.7	$24.0	$24.3
Government Revenue	-$3.7	-$7.6	-$11.5	-$15.5	-$19.4	-$23.4	-$23.7	-$24.0	-$24.3
Vehicle Program	**$0.0**	**-$11.1**	**-$11.8**	**-$12.5**	**-$13.3**	**-$13.4**	**-$12.9**	**-$12.2**	**-$11.4**
Total Surplus Change	**-$38.4**	**-$39.2**	**-$215.0**	**-$208.6**	**-$202.2**	**-$169.3**	**-$171.6**	**-$173.6**	**-$175.5**

(continued)

Table 13C-1. Time Series of Social Costs (continued)

	2018	2019	2020	2021	2022	2023	2024	2025	2026
Consumer Surplus Change, Total	**-$142.2**	**-$144.3**	**-$146.4**	**-$148.6**	**-$150.9**	**-$153.3**	**-$155.9**	**-$158.6**	**-$161.3**
Gasoline, U.S.	-$111.9	-$113.4	-$114.9	-$116.5	-$118.1	-$119.9	-$121.8	-$123.8	-$125.8
PADD I & III	-$24.1	-$24.5	-$24.8	-$25.1	-$25.5	-$25.9	-$26.3	-$26.7	-$27.1
PADD II	-$54.8	-$55.5	-$56.2	-$57.0	-$57.8	-$58.7	-$59.6	-$60.6	-$61.6
PADD IV	-$11.4	-$11.5	-$11.7	-$11.8	-$12.0	-$12.2	-$12.4	-$12.6	-$12.8
PADD V (excludes California)	-$21.6	-$21.9	-$22.2	-$22.5	-$22.8	-$23.2	-$23.6	-$23.9	-$24.3
Gas Cans, U.S.	-$30.3	-$30.9	-$31.5	-$32.1	-$32.8	-$33.4	-$34.1	-$34.8	-$35.5
States With State Regulatory Programs	-$2.4	-$2.5	-$2.5	-$2.6	-$2.6	-$2.7	-$2.7	-$2.8	-$2.8
States Without State Regulatory Programs	-$27.9	-$28.4	-$29.0	-$29.6	-$30.2	-$30.8	-$31.4	-$32.0	-$32.7
Producer Surplus Change, Total	**-$95.4**	**-$96.7**	**-$97.9**	**-$99.3**	**-$100.7**	**-$102.2**	**-$103.8**	**-$105.5**	**-$107.2**
Gasoline, U.S.	-$95.2	-$96.5	-$97.7	-$99.0	-$100.4	-$101.9	-$103.6	-$105.3	-$107.0
PADD I & III	-$20.1	-$20.4	-$20.7	-$20.9	-$21.2	-$21.6	-$21.9	-$22.3	-$22.6
PADD II	-$45.6	-$46.3	-$46.9	-$47.5	-$48.2	-$48.9	-$49.7	-$50.5	-$51.3
PADD IV	-$9.5	-$9.6	-$9.7	-$9.9	-$10.0	-$10.2	-$10.3	-$10.5	-$10.7
PADD V (excludes California)	-$18.0	-$18.3	-$18.5	-$18.8	-$19.0	-$19.3	-$19.6	-$20.0	-$20.3
PADD V (California)	-$1.9	-$1.9	-$2.0	-$2.0	-$2.0	-$2.0	-$2.1	-$2.1	-$2.1
Gas Cans, U.S.	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2
States With State Regulatory Programs	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
States Without State Regulatory Programs	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2
Fuel Savings	**$71.0**	**$71.9**	**$72.8**	**$73.7**	**$74.6**	**$75.5**	**$76.4**	**$77.3**	**$78.3**
Consumer Savings	$95.6	$96.8	$98.0	$99.3	$100.5	$101.7	$102.9	$104.2	$105.4
Fuel	$71.0	$71.9	$72.8	$73.7	$74.6	$75.5	$76.4	$77.3	$78.3
Tax	$24.6	$24.9	$25.2	$25.6	$25.9	$26.2	$26.5	$26.8	$27.1
Government Revenue	-$24.6	-$24.9	-$25.2	-$25.6	-$25.9	-$26.2	-$26.5	-$26.8	-$27.1
Vehicle Program	**-$10.7**	**-$10.6**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**
Total Surplus Change	**-$177.3**	**-$179.7**	**-$171.5**	**-$174.2**	**-$176.9**	**-$179.9**	**-$183.3**	**-$186.8**	**-$190.3**

(continued)

Table 13C-1. Time Series of Social Costs (continued)

	2027	2028	2029	2030	2031	2032	2033	2034	2035
Consumer Surplus Change, Total	**-$164.1**	**-$166.9**	**-$169.7**	**-$172.7**	**-$175.6**	**-$178.6**	**-$181.7**	**-$184.8**	**-$188.0**
Gasoline, U.S.	-$127.9	-$130.0	-$132.1	-$134.3	-$136.4	-$138.7	-$140.9	-$143.3	-$145.6
PADD I & III	-$27.6	-$28.0	-$28.5	-$29.0	-$29.4	-$29.9	-$30.4	-$30.9	-$31.4
PADD II	-$62.6	-$63.6	-$64.6	-$65.7	-$66.8	-$67.9	-$69.0	-$70.1	-$71.2
PADD IV	-$13.0	-$13.2	-$13.4	-$13.6	-$13.9	-$14.1	-$14.3	-$14.6	-$14.8
PADD V (excludes California)	-$24.7	-$25.1	-$25.5	-$26.0	-$26.4	-$26.8	-$27.3	-$27.7	-$28.2
Gas Cans, U.S.	-$36.2	-$36.9	-$37.7	-$38.4	-$39.2	-$40.0	-$40.8	-$41.6	-$42.4
States With State Regulatory Programs	-$2.9	-$2.9	-$3.0	-$3.1	-$3.1	-$3.2	-$3.2	-$3.3	-$3.4
States Without State Regulatory Programs	-$33.3	-$34.0	-$34.7	-$35.4	-$36.1	-$36.8	-$37.5	-$38.3	-$39.0
Producer Surplus Change, Total	**-$109.0**	**-$110.8**	**-$112.6**	**-$114.4**	**-$116.3**	**-$118.2**	**-$120.1**	**-$122.1**	**-$124.1**
Gasoline, U.S.	-$108.8	-$110.5	-$112.3	-$114.2	-$116.0	-$117.9	-$119.9	-$121.8	-$123.8
PADD I & III	-$23.0	-$23.4	-$23.8	-$24.1	-$24.5	-$24.9	-$25.3	-$25.8	-$26.2
PADD II	-$52.2	-$53.0	-$53.9	-$54.8	-$55.7	-$56.6	-$57.5	-$58.4	-$59.4
PADD IV	-$10.8	-$11.0	-$11.2	-$11.4	-$11.6	-$11.7	-$11.9	-$12.1	-$12.3
PADD V (excludes California)	-$20.6	-$21.0	-$21.3	-$21.6	-$22.0	-$22.4	-$22.7	-$23.1	-$23.5
PADD V (California)	-$2.2	-$2.2	-$2.2	-$2.3	-$2.3	-$2.4	-$2.4	-$2.4	-$2.5
Gas Cans, U.S.	-$0.2	-$0.3	-$0.3	-$0.3	-$0.3	-$0.3	-$0.3	-$0.3	-$0.3
States With State Regulatory Programs	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
States Without State Regulatory Programs	-$0.2	-$0.2	-$0.2	-$0.2	-$0.2	-$0.3	-$0.3	-$0.3	-$0.3
Fuel Savings	**$79.2**	**$80.1**	**$81.0**	**$81.9**	**$82.8**	**$83.7**	**$84.6**	**$85.5**	**$86.4**
Consumer Savings	$106.6	$107.8	$109.1	$110.3	$111.5	$112.7	$114.0	$115.2	$116.4
Fuel	$79.2	$80.1	$81.0	$81.9	$82.8	$83.7	$84.6	$85.5	$86.4
Tax	$27.5	$27.8	$28.1	$28.4	$28.7	$29.0	$29.3	$29.7	$30.0
Government Revenue	-$27.5	-$27.8	-$28.1	-$28.4	-$28.7	-$29.0	-$29.3	-$29.7	-$30.0
Vehicle Program	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**
Total Surplus Change	**-$193.9**	**-$197.6**	**-$201.3**	**-$205.2**	**-$209.1**	**-$213.1**	**-$217.2**	**-$221.4**	**-$225.6**

Appendix 13D: Overview of Economic Model Equations

We illustrate our approach for addressing conceptual questions of market-level impacts using a numerical simulation model. Our method involves specifying a set of nonlinear supply and demand relationships for the affected markets, simplifying the equations by transforming them into a set of linear equations, and then solving the equilibrium system of equations (see, for example, Fullerton and Metcalfe [2002]).

13D.1 Discussion and Specification of Model Equations

First, we consider the formal definition of the elasticity of supply with respect to changes in own price:

$$\varepsilon_S \equiv \frac{dQ_S / Q_S}{dp / p} \qquad \text{(D.1)}$$

Next, we can use "hat" notation to transform Eq. (D.1) to proportional changes and rearrange terms:

$$\hat{Q}_S = \varepsilon_S \hat{p} \qquad \text{(D.1a)}$$

$\hat{Q}_S$ = percentage change in the quantity of market supply,

ε_S = market elasticity of supply, and

$\hat{p}$ = percentage change in market price.

As Fullerton and Metcalfe (2002) note, we have taken the elasticity definition and turned it into a linear *behavioral* equation for our market. Similarly, we can specify a demand equation as follows:

$$\hat{Q}_d = \eta_d \hat{p} \qquad \text{(D.2)}$$

$\hat{Q}_d$ = percentage change in the quantity of market demand,

η_d = market elasticity of demand, and

$\hat{p}$ = percentage change in market price.

To introduce the direct impact of the regulatory program, we assume the per-unit cost (c) leads to a proportional shift in the marginal cost of production. Under the assumption of perfect competition (price equals marginal cost), we can approximate this shift at the initial equilibrium point as follows:

$$\hat{MC} = \frac{c}{MC_o} = \frac{c}{p_o} \qquad \text{(D.3)}$$

Finally, we specify the market equilibrium conditions in the affected markets. In response to the exogenous increase in production costs, producer and consumer behaviors are represented in Eq. (D.1a) and Eq. (D.2), and the new equilibrium satisfies the condition that the change in supply equals the change in demand:

$$\hat{Q}_s = \hat{Q}_d \tag{D.4}$$

We now have three linear equations in three unknowns ($\hat{p}$, $\hat{Q}_d$, and $\hat{Q}_s$) and we can solve for the proportional price change in terms of the elasticity parameters(ε_s and η_d) and the proportional change in marginal cost:

$$\hat{p} = \frac{\varepsilon_s}{\varepsilon_s - \eta_d} \bullet \hat{MC} \tag{D.5}$$

Given this solution, we can solve for the proportional change in market quantity using Eq. (D.2).

13D.2 Consumer and Producer Welfare Calculations

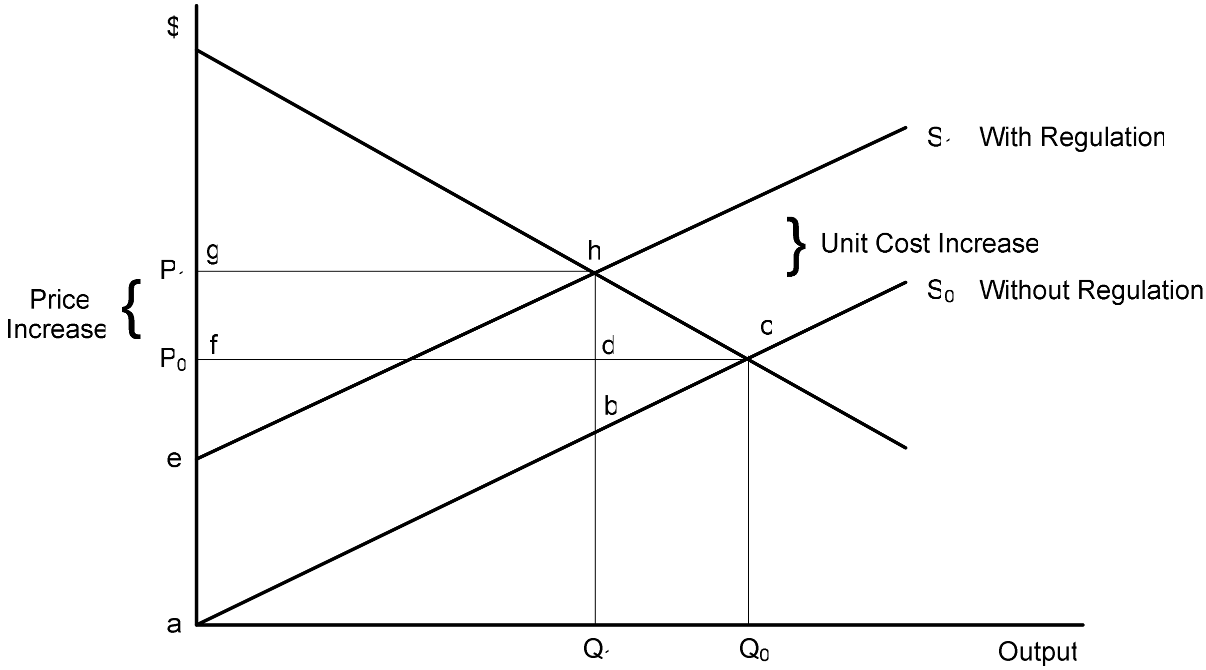
The change in consumer surplus in the affected markets can be estimated using the following linear approximation method:

$$\Delta CS = - Q_1 \bullet \Delta p + 0.5 \bullet \Delta Q \bullet \Delta p. \tag{D.6}$$

As shown, higher market prices and reduced consumption lead to welfare losses for consumers. A geometric representation of this calculation is illustrated in Figure D-1.

For affected supply, the change in producer surplus can be estimated with the following equation:

$$\Delta PS = Q_1 \bullet (\Delta p - c) - 0.5 \bullet \Delta Q \bullet (\Delta p - c). \tag{D.7}$$



Δ consumer surplus = –[fghd + dhc]

Δ producer surplus = [fghd – aehb] – bdc

Δ total surplus = –[aehb + dhc + bdc]

Figure D-1. Welfare Calculations

Increased regulatory costs and output declines have a negative effect on producer surplus, because the net price change (Δp – c) is negative. However, these losses are mitigated, to some degree, as a result of higher market prices. A geometric representation of this calculation is illustrated in Figure D-1.

Appendix 13E: Elasticity Parameters

To estimate market equilibrium price and quantity, supply and demand elasticities are needed to represent the behavior adjustments that are likely to be made by market participants.[L] Tables 13E-1 and 13E-2 provide a summary of the supply and demand elasticities used to estimate the economic impact of the rule.

Table 13E-1. Summary of Supply Elasticities Used in the EIA Model

Markets	Estimate	Source	Method	Input Data Summary
All Gasoline Markets	0.24	Considine (2002)	Literature estimate	NA
Gas Can Markets	1.50	EPA econometric estimate (see Section 13E.4)	Cobb-Douglas production function	Bartlesman et al. (2000); 1980–1996; SIC 3089

Table E-2. Summary of Demand Elasticities Used in EIA Model

Market	Estimate	Source	Method	Input Data Summary
All Gasoline Markets	–0.20	FTC (2001)	Literature estimate	NA
Gas Can Markets	–0.01	EPA numerical simulation (see Section 13E.3)	Hicks-Allen derived demand	Described in Section 13E.3

13E.1 Gasoline Market Parameters

Very few studies have attempted to quantify supply responsiveness for individual refined products, such as gasoline fuel. For example, a study for the California Energy Commission stated “There do not seem to be credible estimates of gasoline supply elasticity” (Finizza, 2002). However, sources agree that refineries have little or no ability to change output in response to price: high fixed costs compel them to operate as close to their capacity limit as possible. The Federal Trade Commission (FTC) analysis made this point explicitly (FTC, 2001).

Greene and Tishchishyna (2000) reviewed supply elasticity estimates available in the literature. The supply elasticity values cited in most of these studies were for “petroleum” or “oil” production in the United States, which includes exploration, distribution and refining activities. The lowest short-term numbers cited were 0.02 to 0.05, with long-run values ranging from 0.4 to 1.0. It seems likely that these extremely low numbers are influenced by the limited domestic supply of crude petroleum and the difficulty of extraction.

[L] The models equations are described in Appendix A.

A recent paper by Considine (2002) provides one of the few supply elasticity estimates for refining production (excluding extraction and distribution) based on historical price and quantity data. In this study, Considine estimates a refining production supply elasticity of 0.24. This estimate is for aggregate refinery production and includes distillate and nondistillate fuels. Because petroleum products are made in strict proportion and refineries have limited ability to adjust output mix in the short to medium run, it is reasonable to assume that supply is relatively inelastic and similar across refinery products. This value of 0.24 was used for the supply elasticity for this market. This estimated elasticity is inelastic, which means that the quantity of goods and services supplied is expected to be fairly insensitive to price changes.

For demand elasticity estimates, EPA's NESHAP analysis of refinery markets included the development of a price elasticity of demand elasticity for several refined petroleum products (EPA, 1997, page 3-19[M]). To compute this elasticity, EPA reviewed the economic literature and found estimated for the following petroleum products:

- Motor gasoline: −0.55 to − 0.82.
- Jet fuel: −0.15.
- Residual fuel oil: −0.61 to −0.74.
- Distillate fuel oil: −0.50 to −0.99.
- Liquefied petroleum gas: −0.60 to −1.00

EPA developed a weighted average elasticity for petroleum products using the midpoints of the elasticity estimates and production data for 1995. The use of the average value of –0.69 is more consistent with long-run estimates of the gasoline price elasticity of demand.

However, a better choice for the primary analysis in this EIM is a short- to midterm-run elasticity of -0.2 used by other Federal government analysis (FTC, 2001). This value is consistent with recent surveys of the gasoline demand literature (Graham and Glaister, 2002; Espey, 1998). In addition, recent applied work on the incidence of gas taxes (Chouinard and Perloff, 2004) suggests that the national demand elasticity should approximately equal the negative of the national supply elasticity (see page 57). Given that the supply elasticity we are using in the economic model is 0.24, this implies a national gasoline demand elasticity of approximately -0.2.

13E.2 Gas Can Market Parameters

[M] Industry Profile for the Petroleum Refinery NESHAP, Draft for EPA, by Methtech and Pechan & Associates, Feb 1997, EPA Contract No. 68-D4-0107, WA No. II-17.
Source:
http://www.epa.gov/ttnecas1/regdata/IPs/Petroleum%20Refinery%20(Sulfur%20Recovery%20Units,%20Catalytic%20Crackin.pdf

There are no estimated gas can demand elasticities from current economic literature. As a result, we estimated this parameter numerically using a Hicks-Allen derived demand approach (see Section E.3 for discussion) for a class of products that use similar production technologies (SIC 3089, Plastic Products, Not Elsewhere Classified). Our Monte Carlo simulation and generated a mean value of –0.01 for the derived demand elasticity estimate for gas cans. Using this value, a 1 percent change in the price of gas cans would lead to approximately a 0.014 percent reduction in the quantity of gas cans demanded by consumers.

There are also no estimated gas can supply elasticities from the economic literature. As a result, we estimated this parameter econometrically using a production function cost minimization approach (see Section E.4 for discussion) for a class of products that use similar production technologies (SIC 3089, Plastic Products, Not Elsewhere Classified). This category includes manufacturers engaged in manufacturing plastic products not elsewhere classified and includes such products as plastic containers and plastics drums. Using this approach, we found the elasticity supply for these products is approximately 1.5, which means a 1 percent change in the price of gas cans would lead to a 1.5 percent increase in the quantity of gas cans manufacturers would be willing to sell in the market.

13E.3 Gas Can Demand Elasticity Estimation Procedure

Gas cans are an integral component of any activity involving small gasoline engines. These activities range from lawn and garden work to recreation use. The behavioral change in gas can consumption is expected to be quite small in response to an increased price because gas cans represent a small fraction of overall lawn and garden or recreation expenditures. In addition, because gas cans are in many cases a necessity for small engine use, households have limited ability to substitute away from gas cans as their price increases.

However, it is probably not appropriate to assume that the demand elasticity for gas cans is zero. There will likely be some behavior response to the increased price of gas cans—even though it is anticipated to be small. Unfortunately, an elasticity of demand for gas cans is not available in the literature. Nor does the historical price and quantity data exist that would be required to empirically estimate a demand elasticity for cans.

An alternative approach is to model gas cans as an input in the household production function for household lawn and garden activities and develop a derived demand for gas cans through changes in the household for lawn and garden products and services market. Because over 90 percent of gas cans are used to support lawn and garden activities, we use the lawn and garden market to derive a demand elasticity for gas cans.

The demand for gas cans is directly linked to the demand for lawn and garden products and services. When the price of gas cans increases, the cost of the bundled commodity, lawn and garden products services, also increases. This is illustrated in the supply curve's upward shift in Figure E-1. This results in a reduced equilibrium quantity in the household lawn and garden services market. Then, this reduced quantity feeds back into a reduced demand in the gas can market. For example, if households reduce their purchases by X percent in the lawn and garden service market, this translates into the same X percent decrease in gas can purchases, which in turn determines the derived demand point d_1 in Figure E-1.[N]

13E.3.1 Numerical Example: Base Case

Because gas cans represent such as small fraction of household expenditures in the lawn and garden services market, the resulting derived elasticity of demand is very small. As illustrated below, with average annual household expenditures on lawn and garden services of $500 to $2,500, and a $5 increase in the price of gas cans because of the regulation, the resulting shift in the supply function is 1.0 percent to 0.2 percent.

Economic theory states that the elasticity of the derived demand for an input is a function of the following (Hicks, 1961, 1966; Allen, 1938):

- demand elasticity for the final good it will be used to produce,
- the elasticity of supply of other inputs,
- the cost share of the input in total production cost, and
- the elasticity of substitution between this input and other inputs in production.

Using Hicks' formula,

$$E_{dc} = [\ \alpha*(E_{df} + E_{si}) + C*E_{si}*(E_{df} - \alpha)] \,/\, [(E_{df} + E_{si}) - C*(E_{df} - \alpha)] \qquad \text{(E.1)}$$

where

E_{dc} = price elasticity of demand for the cans,

E_{df} = price elasticity of demand for final product,

E_{si} = price elasticity of supply of other inputs,

C = cost share of cans in total production cost, and

α = elasticity of substitution between cans and all other inputs.

[N]This assumes that gas cans are a fixed proportion input into the lawn and garden services market.

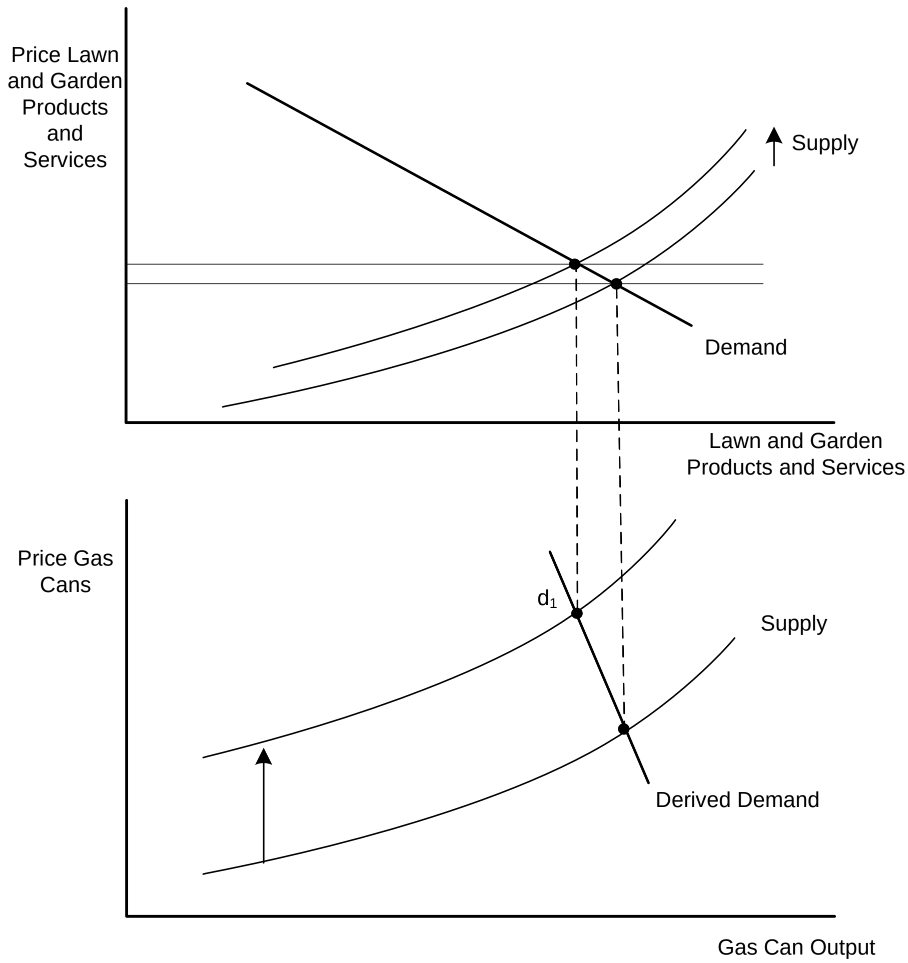


Figure 13E-1. Derived Demand for Gas Cans

Using the parameter values in Table E-3, we conducted a Monte Carlo simulation and generated the following derived demand elasticity estimate for gas cans:

Mean Value = –0.01

Standard Deviation = 0.004

Using the mean value, a 100 percent change in the price of gas cans would lead to approximately a 1.0 percent reduction in the quantity of gas cans demanded by consumers.

13E.3.2 Numerical Example: Sensitivity

In the baseline analysis for the EIA, we propose to use a zero elasticity of substitution between gas cans and all other inputs. This implies that consumers do not substitute away from gas cans as the price increases. However, we acknowledge that there is a potential for households with more than one gas can to reduce the number of multiple can purchases as the price increases (i.e., they may choose to reduce the number of cans they purchase, giving up the "luxury" of

Table 13E-3. Assumed Parameter Values Used to Generate Derived Demand Elasticity for Gas Cans

Parameter	Type of Distribution	Values (range)	Comments
E_{df}	Normal	Mean = –1.2 StDev = 0.64	EPA econometric estimate for consumer walk behind mowers
E_{si}	Uniform	Min = 0.5 Max = 2.0	Assumed range
C	Uniform	Min = 0.20% Max = 1.0%	Example: $5 increase in cost for gas can, with household lawn and garden expenditures of $500 to $2,500
α		0	Assume fixed proportions technology

having multiple cans in multiple locations, or the capability of filling multiple cans with a single trip to the gas station). These decisions in effect substitute additional household labor for the convenience of having more than one gas can.

To investigate the potential impact of substitution in the gas can market, we conducted a sensitivity analysis. Unfortunately, neither a literature estimate of substitution elasticity for gas cans nor the data to estimate such an elasticity exist. Thus, a substitution elasticity value of α = 0.1 was used in the sensitivity analysis (see Table E-4). Using this value yields a demand elasticity for cans with a mean value = –0.25 and a standard deviation = 0.45. This implies that a 100 percent change in the price of gas cans would lead to approximately a 25 percent reduction in the quantity of gas cans demanded by consumers. Specific impact estimates were estimated with engineering cost data.

13E.4 Gas Can Supply Elasticity Estimation

Our approach assumes that firms minimize costs subject to production technology constraints. To characterize these constraints, we use a "production function" that describes the relationship between inputs and outputs of the production process. The functional form (Cobb-Douglas) of the production function is specified as

$$Q_t = A\,(K_t)^{\alpha_K}\,(L_t)^{\alpha_L}\,(M_t)^{\alpha_M}\,t^{\lambda} \qquad \text{(E.2)}$$

Table 13E-4. Assumed Parameter Values Used to Generate Derived Demand Elasticity for Gas Cans

Parameter	Type of Distribution	Values (range)	Comments
E_{df}	Normal	Mean = –1.2 StDev = 0.64	EPA econometric estimate for consumer walk behind mowers
E_{si}	Uniform	Min = 0.5 Max = 2.0	Assumed range
C	Uniform	Min = 0.20% Max = 1.0%	Example: $5 increase in cost for gas can, with household expenditures of $500 to $2,500 on lawn and garden services
α		0.1	Used a single value

where

Q_t = output in year t,

K_t = real capital consumed in production in year t,

L_t = quantity of labor used in year t,

M_t = material inputs in year t, and

t = a time trend variable to reflect technology changes.

This equation can be written in linear form by taking the natural logarithms of each side of the equation. The parameters of this model, α_K, α_L, α_M, can then be estimated using linear regression techniques:

$$\ln Q_t = \ln A + \alpha_K \ln K_t + \alpha_L \ln L_t + \alpha_M \ln M_t + \lambda \ln t. \qquad \text{(E.3)}$$

Under the assumptions of a competitive market and perfect competition, the elasticity of supply with respect to the price of the final product can be expressed in terms of the parameters of the production function:

$$\text{Supply Elasticity} = (\alpha_L + \alpha_M) / (1 - \alpha_L - \alpha_M). \qquad \text{(E.4)}$$

To maintain the desired properties of the Cobb-Douglas production function, it is necessary to place restrictions on the estimated coefficients. For example, if $\alpha_L + \alpha_M = 1$, then the supply elasticity will be undefined. Alternatively, if $\alpha_L + \alpha_M > 1$, this yields a negative supply elasticity. Thus, a common assumption is that $\alpha_K + \alpha_L + \alpha_M = 1$. This implies constant returns to scale, which is consistent with most empirical studies.

13E.4.1 Data Sets

The National Bureau of Economic Research-Center for Economic Studies (Bartlesman, Becker, and Gray, 2000) publishes industry-level data used for the analysis (years 1958 to 1996). In cases where a price index was not available, we used the most recent implicit gross domestic product (GDP) price deflator reported by the U.S. Bureau of Economic Analysis (BEA, 2004)[O]. The following variables were used:

- value of shipments (NBER-CES),
- price index of value shipments (NBER-CES),
- production worker wages (NBER-CES),
- GDP deflator (BEA),
- cost of materials (NBER-CES),
- price index for materials (NBER-CES), and
- value added (NBER-CES).

To provide a measure of capital consumed, a capital variable is calculated as follows:

Capital = (Value added – Production worker wages)/GDP deflator.

The NBER data set is restricted to four-digit SIC codes for the manufacturing industries. As a result, we selected a class of products that use similar production technologies (SIC 3089, Plastic Products, Not Elsewhere Classified). This category includes manufacturers engaged in manufacturing plastic products not elsewhere classified and includes such products as plastic containers and plastics drums. We also restricted our analysis to years after 1980, the time period the Consumer Products Safety Commission (CPSC, 2003) identified plastic cans were introduced. The data covers the period 1980 through 1996.

13E.4.2 Results of Supply Elasticity Estimation

We used an autoregressive error model to estimate Eq. (E.3). SAS procedure PROC AUTOREG was used to compute a linear regression corrected for auto correlation. We assume the error term is AR(2). This approach is identical to the one used successfully for the Nonroad CI Engines and Equipment EIA completed in 2003 (EPA, 2004), with some of the independent variables updated with the most recent data. In addition, we also tested the assumption of constant error variance using a Goldfeld-Quandt test and could not reject the hypothesis of

[O] "Table 1.1.9, Implicit Price deflator for Gross Domestic Product", BEA, Quarterly, from 2002 to 2004, Source: http://www.bea.gov/bea/dn/nipaweb/SelectTable.asp. All values are expressed in $1987. Note the GDP deflators have been updated since the previous estimation of engine and lawn and garden supply elasticities for the nonroad rule (See Chapter 10 of the Final Regulatory Analysis for the Clean Air Nonroad Diesel Rule, EPA 420-R-04-007, May 2004; http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf) As a result, the supply elasticity estimates are the same; however, the coefficient estimates may vary slightly.

homoskedasticity. Using this model, we estimate a supply elasticity of 1.5 for this industry (see Table E-5).

Table 13E-5. Supply Elasticity Estimate for SIC 3089, Plastic Products, Not Elsewhere Classified: 1980–1996

Supply elasticity =	1.5		
Number of observations =	17		
R-squared =	99.79		
Goldfeld-Quandt F(4,4) =	2.62 (p-value = 0.187)		
d_{DW} =	1.40		
d_l =	0.90		
d_u =	1.71		
Variable	**Estimate**	**t-value**	**p-value**
Intercept	–0.3544		
ln K	0.4048	4.07	0.0019
ln L	0.4404	3.21	0.0083
ln M	0.1548	1.26	0.2339
ln T	0.5087	7.27	<0.0001

Appendix 13F: Initial Market Equilibrium - Price Forecasts

The EIM analysis begins with current market conditions: equilibrium supply and demand. To estimate the economic impact of a regulation, standard practice uses projected market equilibrium (time series of prices and quantities) as the baseline and evaluates market changes from this projected baseline. Consequently, it is necessary to forecast equilibrium prices and quantities for future years.

Equilibrium quantity forecasts are driven by projected activity factors and this approach implicitly incorporates changes in production capacity during the period of analysis into the baseline.

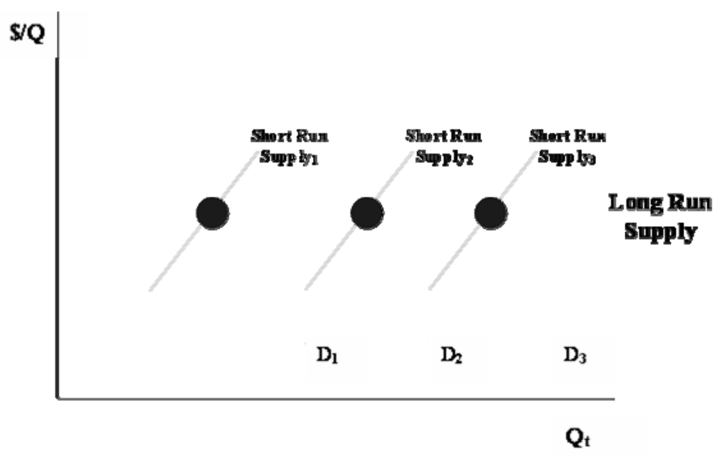


Figure 13.3-1. Prices and Quantities in Long Run Market Equilibrium

Equilibrium price forecasts typically use one of two approaches (see EPA 1999, p. 5-25). The first assumes a constant (real) price of goods and services over time. The second models a specific time series where prices may change over time due to exogenous factors.

In the absence of shocks to the economy or the supply of raw materials, economic theory suggests that the equilibrium market price for goods and services should remain constant over time. As shown in Figure 13.3-1, demand grows over time, in the long run, capacity will also grow as existing firms expand or new firms enter the market and eliminate any excess profits. This produces a flat long run supply curve. Note that in the short to medium run time frame the supply curve has a positive slope due to limitations in how quickly firms can react.

If capacity is constrained (preventing the outward shift of the baseline supply curve) or if the price of production inputs increase (shifting the baseline supply curve upward over time), then prices may trend upward reflecting that either the growth in demand is exceeding supply or the commodity is becoming more expensive to produce.

It is very difficult to develop forecasts events (such as those mentioned above) that influence long run prices. As a result, the approach used in this analysis is to use a constant 2003 observed price for gas cans and gasoline prices.

Nevertheless, there are forecasts of future gasoline prices, such as those provided by the Annual Energy Outlook. To take these forecasts into account we performed a sensitivity analysis using AEO forecasted prices for gasoline markets (see Appendix 13G).

Appendix 13G: Sensitivity Analyses

The economic impact analysis presented in this Chapter 13 is based on an economic impact mode (EIM) developed specifically for this analysis. This EIM reflects certain assumptions about behavioral responses (modeled by supply and demand elasticities), how compliance costs are treated by refiners, and how prices will behave in the future. This Appendix presents several sensitivity analyses in which various model parameters are varied to examine how different values for these parameters would affect model results. Four parameters are examined:

- Scenario 1: alternative market supply and demand elasticity parameters
- Scenario 2: alternative ways to treat fuel market compliance costs
- Scenario 3: alternative ways to project future gasoline prices
- Scenario 4: alternative social discount rates

The results of these sensitivity analyses are presented below. The results for the first two scenarios are presented for 2015. The results for the other two scenarios are presented for 2009 through 2035.

In general, varying the model parameters does not significantly change the estimated net impacts on economic welfare, with net surplus losses (consumer plus producer) remaining the same across the sensitivity analysis scenarios at about $171.6 million. The sole exception is the Maximum Total Cost alternative for Scenario 3. In this case, net welfare losses are about $133 million, as much of the consumer surplus loss is captured by refiners in the form of excess profits and resulting in a net gain for producers.

However, even if net surplus losses are the same across most scenarios, varying the model parameters has an impact on how costs are distributed between producers and consumers. In some scenarios consumers bear more of the burden than in others. Varying the supply elasticity in Scenario 1, for example, results in the consumer share of the gasoline fuel program varying from $32.7 million to $178.6 million, compared to $107.2 for the primary analysis. Similarly, as noted above, the Maximum Total Cost fuel example in Scenario 2 shows a much higher loss of consumer surplus, $1,259 million, compared to the primary analysis estimate of $107 million. The alternative gasoline prices in Scenario 3 do not substantially affect the distribution of costs between consumers and producers.

13G.1 Scenario 1: Model Elasticity Parameters

The supply and demand price elasticities are key parameters in the EIM. They characterize the behavioral responses of producers and consumers in the gasoline fuel and gas can markets. Demand and supply elasticities measure the responsiveness of producers and consumers to a change in price: how much the quantity demanded or supplied is expected to change. A detailed discussion regarding the estimation and selection of the elasticities used in the EIM is provided in Appendix 13E. In this section we examine the impact of changes in the selected values of the elasticity parameters, holding other parameters constant. The goal is to determine whether alternative elasticity values significant alter the conclusions of the primary analysis.

13G.1.1 Alternative Demand and Supply Elasticities

The values of the demand and supply elasticities for the gasoline fuel and gas can markets is important because the distribution of regulatory costs depends on the relative supply and demand elasticities used in the analysis. For example, consumers will bear less of the regulatory burden of a program if they are more responsive to prices than producers (demand is relatively more elastic). Similarly, producers will bear less of the regulatory burden if they are more responsive (supply is relatively more elastic).

Table 13G.1-1 reports the upper- and lower-bound values of the values of the elasticity parameters (supply and demand) used in this sensitivity analysis.

Table 13G.1-1. Sensitivity Analysis of the Supply and Demand Elasticities for the Application Markets

Market/Parameter	Elasticity Source	Lower Bound	Base Case	Upper Bound
Gasoline Market				
Supply	Literature estimate (EPA 2004 – NRT4)	0.04	0.24	2.0
Demand	Literature estimate (FTC 2001	-0.10	-0.20	-0.40
Gas Can Market				
Supply	EPA estimate	0.7	1.5	3.9
Demand	EPA estimate	N/A	-0.01	-0.25

For the gasoline market, the upper- and lower-bounds of the demand and supply elasticities are those reported in the literature. It should be noted that these are these ranges do not include long-run elasticity estimates. As explained in Section 13.2.3, the EIM uses an intermediate time frame, during which producers have some resource immobility which may cause them to suffer producer surplus losses. In the long run, in contrast, all factors of production are variable and producers can adjust production in response to cost changes. This allows them to shift more of the burden of the rule to consumers.

The elasticites for the gas can market are estimated econometrically. The sensitivity ranges are derived by estimating a 90 percent confidence interval around the estimated elasticities, using the coefficient and standard error values from the econometric analysis (See Appendix 13E). Because gas can expenditures are only such a small portion of total household production inputs, households are not expected to switch their preferences for gas cans due to the proposed standards. The sensitivity analysis reflects a hypothetical assumption that 10 percent of demand is substituted away from gas cans, a fairly large assumption since it is not clear what consumers would use instead of gas cans for such a significant share of their consumption. This forms the upper bound of the sensitivity analysis. Such a household behavioral change would increase the demand elasticity for gas cans to -0.25 from -0.01. In other words, a 1.0 percent increase in the price of gas cans will result in a 0.25 percent decrease in the quantity demanded.

13G.1.2 Results

The results of the sensitivity analysis for the demand and supply elasticities are reported in Tables 13G.1-2 and 13G.1-3. According to these results, market prices are relatively stable across the upper- and lower-bound sensitivity scenarios.

In the gasoline fuel case, price increases are the highest for the upper-bound supply elasticity and lower-bound demand elasticity. In other words, when producers are more able to respond to cost increases (more elastic supply elasticity) they can adjust their production and pass more of the costs on to producers. Similarly, when consumers are less able to respond to price increases (less elastic demand elasticity) they cannot reduce their demand and must accommodate higher prices, resulting in their bearing more of the costs of the program. It is important to note, however, that none of these estimated price increases are very large, with the smallest being about 0.01 cent per gallon and the largest about 0.36 cent per gallon, as compared to 0.3 to 0.21 cent per gallon in the primary case.

In the gas can case, changes in the elasticity parameters have no impacts on the price of gas cans. This is not surprising given that the alternative elasticities are perfectly inelastic (elasticity of zero) or very inelastic (elasticity of -0.25), meaning that consumers are not expected to alter their purchases very much, if at all, in response to a change in price.

With regard to how the compliance costs of the program are distributed among producers and consumers in the gasoline fuel market, producers bear a larger portion of the burden when supply elasticity is less elastic (producers are less responsive to price changes) or the demand elasticity is more elastic (consumers are more responsive to price changes), ranging from about 62 percent to 83 percent compared to the primary analysis of 45 percent. Similarly, consumers bear a larger portion of the burden when the supply elasticity is more elastic (producers are more responsive to price changes) or the demand elasticity is less elastic (consumers are less responsive to price changes), ranging from 71 percent to 91 percent compared to the primary analysis of about 55 percent.

In the gas can case, however, varying the demand and supply parameters does not vary the results, with consumers expected to bear most of the burden across all cases. The sole exception is the demand upper-bound, in which the consumer burden decreases from 99 percent in the primary case to 85 percent. Again, this is because the alternative elasticities are also highly inelastic.

Finally, the overall expected social costs of the program across scenarios do not change, and are always about $171 million.

Table 13G.1-2. Application Market Sensitivity Analysis for Supply Elasticities[a, b]

	Supply Lower Bound		Base Case		Supply Upper Bound	
Scenario	**Absolute**	**Relative [c]**	**Absolute**	**Relative [c]**	**Absolute**	**Relative [c]**
Gasoline Fuel						
Price (¢/q)						
PADD I+III	0.01¢	0.01%	0.03¢	0.02%	0.04¢	0.03%
PADD II	0.03¢	0.02%	0.11¢	0.07%	0.18¢	0.12%
PADD IV	0.06¢	0.04%	0.20¢	0.12%	0.33¢	0.21%
PADD V (w/out CA)	0.07¢	0.04%	0.21¢	0.13%	0.36¢	0.21%
Change in Consumer Surplus ($\$10^6$/yr)	–$32.7	*16.7%*	–$107.2	*54.5%*	–$178.6	*90.9%*
Change in Producer Surplus ($\$10^6$/yr)	–$163.7	*83.3%*	–$89.3	*45.5%*	–$17.9	*9.1%*
Gas Cans						
Price ($/q)						
States w/Programs	$0.20	1.8%	$0.20	2.0%	$0.20	2.0%
States w/out Programs	$1.50	32.2%	$1.52	32.0%	$1.48	32.0%
Change in Consumer Surplus ($\$10^6$/yr)	–$28.3	*98.6%*	–$28.5	*99.4%*	–$28.0	*99.7%*
Change in Producer Surplus ($\$10^6$/yr)	–$0.4	*1.4%*	–$0.2	*0.6%*	–$0.1	*0.3%*
Subtotal Social Costs	–$225.2		–$225.2		–$225.2	
Fuel Savings	$68.3		$68.3		$68.3	
Vehicle Program	–$12.9		–$12.9		–$12.9	
California Fuel	–$1.8		–$1.8		–$1.8	
Total Social Costs ($\$10^6$/yr)	**–$171.6**		**–$171.6**		**–$171.6**	

[a] Sensitivity analysis is presented for 2015.

[b] Figures are in 2003 dollars.

[c] For “prices” rows the “relative” column refers to the relative change in price (with regulation) from the baseline price. For “Surplus” rows, the “relative” column contains the percent distribution between consumer and producer surplus.

Table 13G.1-3. Application Market Sensitivity Analysis for Demand Elasticities[a, b]

Scenario	Demand Lower Bound		Base Case		Demand Upper Bound	
	Absolute	**Relative [c]**	**Absolute**	**Relative [c]**	**Absolute**	**Relative [c]**
Gasoline Fuel						
Price (¢/q)						
PADD I+III	0.03¢	0.02%	0.03¢	0.02%	0.02¢	0.01%
PADD II	0.14¢	0.09%	0.11¢	0.07%	0.08¢	0.05%
PADD IV	0.25¢	0.16%	0.20¢	0.12%	0.13¢	0.09%
PADD V (w/out CA)	0.28¢	0.17%	0.21¢	0.13%	0.15¢	0.09%
Change in Consumer Surplus ($\$10^6$/yr)	–$138.7	*70.6%*	–$107.2	*54.5%*	–$73.7	*37.5%*
Change in Producer Surplus ($\$10^6$/yr)	–$57.8	*29.4%*	–$89.3	*45.5%*	–$122.8	*62.5%*
Gas Cans						
Price ($/q)						
States w/Programs	$0.21	1.9%	$0.20	1.9%	$0.18	1.6%
States w/out Programs	$1.53	32.7%	$1.52	32.5%	$1.31	28.0%
Change in Consumer Surplus ($\$10^6$/yr)	–$28.8	*100.0%*	–$28.5	*99.3%*	–$23.9	*84.9%*
Change in Producer Surplus ($\$10^6$/yr)	$0.0	*0.0%*	–$0.2	*0.7%*	–$4.3	*15.1%*
Subtotal Social Costs	–$225.2		–$225.2		–$224.6	
Fuel Savings	$68.3		$68.3		$68.3	
Vehicle Program	–$12.9		–$12.9		–$12.9	
California Fuel	–$1.8		–$1.8		–$1.8	
Total Social Costs ($\$10^6$/yr)	**–$171.7**		**–$171.6**		**–$170.0**	

[a] Sensitivity analysis is presented for 2015.

[b] Figures are in 2003 dollars.

[c] For "prices" rows the "relative" column refers to the relative change in price (with regulation) from the baseline price. For "Surplus" rows, the "relative" column contains the percent distribution between consumer and producer surplus.

13G.2 Scenario 2: Fuel Market Compliance Costs

13G.2.1 Scenarios Modeled

Section 13.2 discusses alternative approaches to shifting the supply curve in the market model. Three alternatives for the fuel market supply shift are investigated in this sensitivity analysis:

- Total average (variable + fixed) cost shift—the results presented in Section 13.1 and the appendices are generated using this cost shift.
- Total maximum (variable + fixed) cost shift
- Variable maximum cost shift

While it may seem reasonable to estimate costs based on maximum variable or maximum total costs, it should be noted that both of those scenarios assume that refiners with the highest benzene compliance costs are also the highest-cost gasoline producers absent benzene control. We do not have information on the highest gasoline cost producers to be able to examine whether these refineries are also expected to have the highest benzene control costs. However, we believe this is an extreme assumption.

To model the total and variable maximum cost scenarios, the high-cost producer is represented by a separate supply curve as shown in Figure 13G-1. The remainder of the market is represented as a single aggregate supplier. The high-cost producer's supply curve is then shifted by Cmax (either total or variable), and the aggregate supply curve is shifted by Cagg. Using this structure, the high-cost producer will determine price as long as

- the decrease in market quantity does not shut down the high-cost producer, and
- the supply from aggregate producers is highly inelastic (i.e., remaining producers are operating close to capacity); thus, the aggregate producers cannot expand output in response to the price increase.

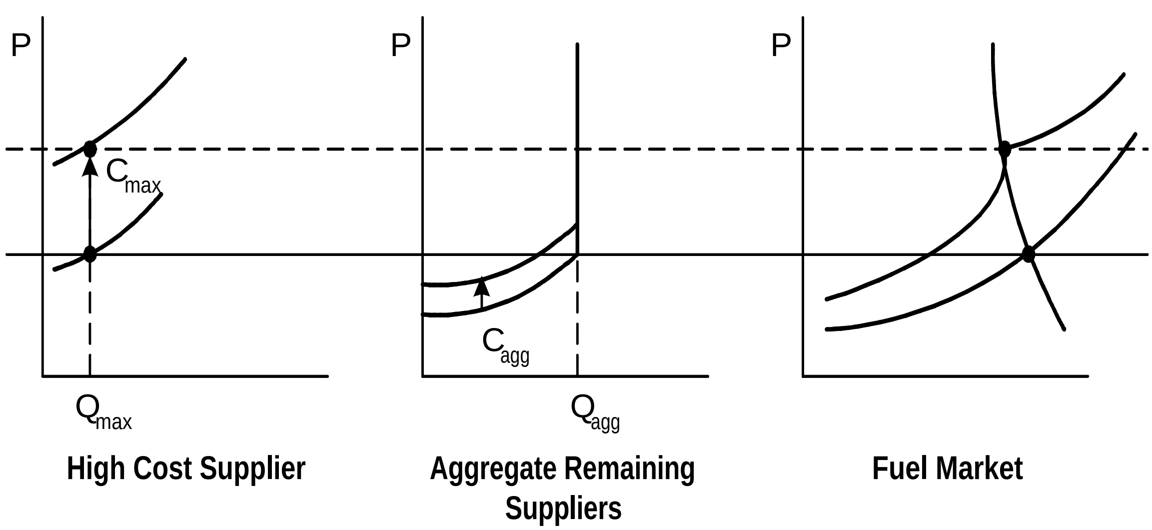


Figure 13G2-1. High Cost Producer Drives Price Increases

Note that the aggregate supply curve is no longer shifted by the average compliance costs but slightly less than the average because the high-cost producer has been removed. The adjusted average aggregate cost shift (Cagg) is calculated from the following:

$$C_{ave}*Q_{tot} = C_{max} * Q_{max} + C_{agg} * Q_{agg} \qquad (13G.1)$$

where C_{ave} is the average control cost for the total population; Q_{max}, C_{max}, and Q_{agg}, C_{agg} are the baseline output and cost shift for the maximum cost producer; and the baseline output and cost shift for the remaining aggregate producers, respectively.

13G.2.2 Results

The results of the sensitivity analysis for the fuel compliance scenarios reported in Table 13G.2-1. According to these results, market prices are sensitive to changes in assumptions about compliance costs. The way in which the cost burden is shared across producers and consumers is also sensitive to changes in these assumptions.

With regard to prices, the Maximum Total Cost and Maximum Variable Cost scenarios both lead to larger estimated price increases. In the primary case (Total Average Cost scenario), prices are expected to increase between 0.03 to 0.21 cents per gallon, depending on the PADD. In the Maximum Total Cost scenario, prices are expected to increase from 0.61 to 1.46 cents per gallon. In the Maximum Variable Cost scenario, the estimated prices increases range from 0.54 to 1.46 cents per gallon.

With regard to how the burden is shared, both the Maximum Total Cost and Maximum Variable Cost scenarios lead to a significant outcome: producers are expected to benefit from the regulations, with an increase in producer surplus of about $1,101 million. Consumers, on the other hand, will bear a much larger share of the burden: $1,259 million in surplus loss compared to $107 million in the primary case.

Table 13G.2-1. Sensitivity Analysis to Cost Shifts in the Gasoline Fuel Market (2015)[a,b]

Scenario	Total Average Scenario		Maximum Total Scenario		Maximum Variable Scenario	
	Absolute	Relative[c]	Absolute	Relative[c]	Absolute	Relative[c]
Gasoline Fuel						
Price (¢/q)						
PADD I+III	0.03¢	0.02%	0.61¢	0.41%	0.54¢	0.36%
PADD II	0.11¢	0.07%	1.15¢	0.76%	1.07¢	0.71%
PADD IV	0.20¢	0.12%	1.46¢	0.93%	1.46¢	0.93%
PADD V (w/out CA)	0.21¢	0.13%	1.14¢	0.69%	1.14¢	0.69%

Scenario	Total Average Scenario		Maximum Total Scenario		Maximum Variable Scenario	
	Absolute	Relative[c]	Absolute	Relative[c]	Absolute	Relative[c]
Change in Consumer Surplus ($\$10^6$/yr)	**–**$107.2		–$1,259.3		–$1,159.7	
Change in Producer Surplus ($\$10^6$/yr)	–$89.3		$1,101.1		$963.9	
Gas Cans						
Price ($/q)						
States w/Programs	$0.20	1.9%	$0.20	1.9%	$0.20	2.0%
States w/out Programs	$1.52	32.5%	$1.52	32.5%	$1.52	32.0%
Change in Consumer Surplus ($\$10^6$/yr)	–$28.5	*99.3%*	–$28.5	*99.3%*	–$28.5	*99.4%*
Change in Producer Surplus ($\$10^6$/yr)	–$0.2	*0.7%*	–$0.2	*0.7%*	–$0.2	*0.7%*
Subtotal Social Costs	–$225.2		-$187.0		-$224.5	
Fuel Savings	$68.3		$68.3		$68.3	
Vehicle Program	–$12.9		–$12.9		-$12.9	
California Fuel	–$1.8		–$1.8		-$1.8	
Total Social Costs ($\$10^6$/yr)	**–$171.6**		**–$133.4**		**-$171.0**	

a Sensitivity analysis is presented for 2015.

b Figures are in 2003 dollars.

c For “prices” rows the “relative” column refers to the relative change in price (with regulation) from the baseline price. For “Surplus” rows, the “relative” column contains the percent distribution between consumer and producer surplus

Under the base case (Total Average Cost scenario), refiners are expected to pass more than half of the average compliance costs on to consumers, and the net decrease in producer surplus for refiners is about $89.3 million, or 45 percent of total social costs. Under this scenario, prices are expected to increase about 0.01 percent. Note that these are industry averages, and individual refiners will gain or lose because compliance costs vary across individual refineries.

In the Total Maximum Cost scenario, the highest operating cost refinery determines the new market price through the impacts on both fixed and variable costs. This refinery has the highest per-unit supply shift, which leads to a higher price increase relative to the Total Average Cost scenario. As a result, all refiners except the highest cost refiner are expected to benefit from the rule, with an increase in producer surplus of about $1,101 million. This would occur because the change in market price exceeds the additional per-unit compliance costs for most of the refineries (i.e., most refiners have costs less than the costs for the highest operating cost refinery). Consequently, in this scenario gasoline fuel consumers are expected to bear a larger share of the total cost of the program: $1,259 million compared to $107 million in the base case.

The Variable Maximum Cost scenario is similar to the Total Maximum Cost scenario in that the highest cost refinery determines the with-regulation market price. However, the Variable Maximum Cost scenario leads to an expected price increase that is smaller than the Total Maximum Cost scenario because the refiner supply shift includes only variable compliance costs. In other words, the refiners do not pass along any fixed costs; they absorb the fixed costs. Refiners also experience a net surplus gain in this scenario, about $964 million, because the change in market price (driven by the Maximum Variable Cost supply curve shift) exceeds the additional per-unit compliance costs for many refineries (i.e., many refiners still have total costs less than the costs for the highest operating cost refinery in this scenario). The net surplus gain for refiners is smaller than the Total Maximum Cost scenario ($964 million compared to $1,101 million) because refiners absorb fixed costs, and the projected market price increase is smaller. Again, gasoline fuel consumers are expected to bear a larger share of the total cost of the program, about $1,159 million.

The results of this sensitivity analysis suggest that the expected impacts on producers and consumers are affected by how refinery costs are modeled. In the EIM these costs are modeled based on the Average Total Cost scenario (variable + fixed), reflecting a competitive market situation in all regional markets. However, if the highest cost refinery drives the new market price, then prices are expected to increase more (up to 0.93 percent in PADD 4) and output is expected to contract more. In both of the maximum cost scenarios, gasoline fuel consumers are expected to bear more than the cost of the rule and refiners will bear less than in the base case.

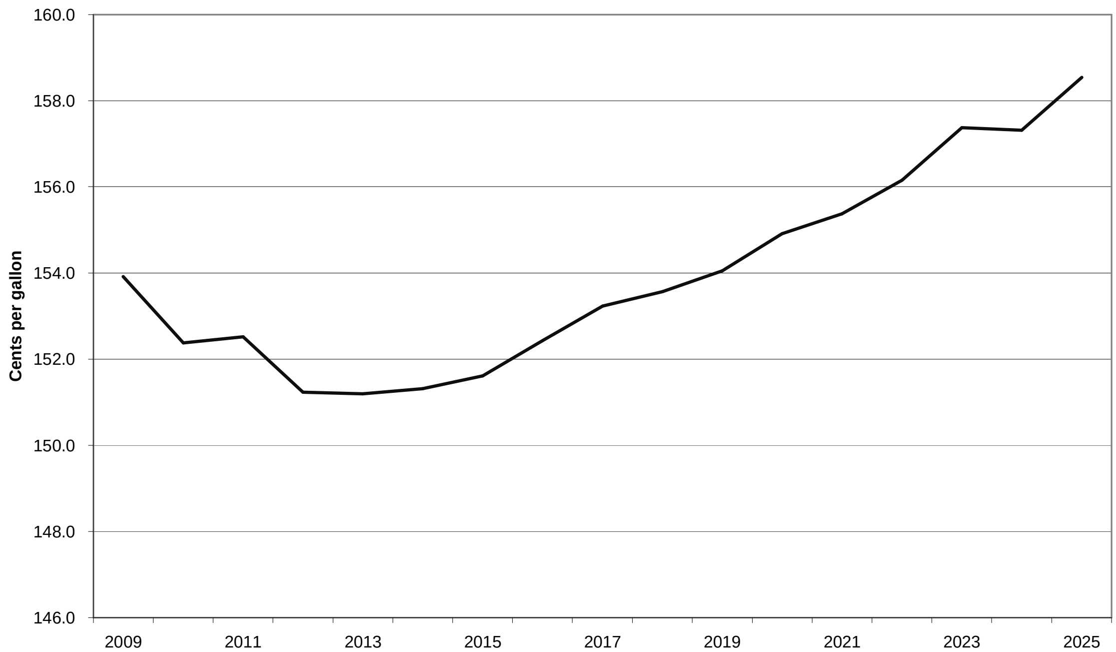
13G.3 Scenario 3: Alternative Gasoline Price

Appendix F discusses two ways to handle future prices in the Economic Impact Analysis. The first assumes a constant (real) price of goods and services over time. The second approach allows prices change over time.

The primary analysis reflects the first alternative, and prices are held constant. As explained in Appendix F, this is a reasonable assumption because in a competitive market as demand grows over time production capacity will also grow as existing firms expand or new firms enter the market and eliminate any excess profit. If, however, capacity is constrained or if the price of inputs increases, then prices may change over time. In this sensitivity analysis we relax the constant price assumption and allow prices to change over time.

This sensitivity analysis examines the constant price assumption for the gasoline fuel market. We do not examine the impacts of relaxing the constant price assumption for the gas can market because there are no publicly available price forecasts for that market. Gasoline price forecasts are available through the Annual Energy Outlook (DoE 2005, Appendix A). Gasoline fuel forecast prices are presented in Figure 13G-2. This graph shows that prices are initially expected to decrease from 2009 to about 2013, and then gradually increase after 2013.

Figure 13G-2. AEO 2005 Motor Fuel Forecast Prices
(Includes Federal, State, and Local Taxes)



The AEO price forecasts are national averages. To estimate forecast prices by PADD, an adjustment factor was calculated for each year based on the percent difference between the AEO national price forecast for that year and the 2003 national price. Because the final year of the AEO projections is 2025, it is necessary to estimate projected prices through 2035. This was done by applying a linear growth rate based on the average annual growth Rate between 2021 and 2025. The resulting adjustment factors were applied to the individual PADD prices presented in Table 13.3-4 (2003 price multiplied by one plus the adjustment factor). The resulting price forecasts by PADD are presented in Table 13G.3-1.

Table 13G.3-1. Forecast Gasoline Prices

Year	Change from 2003	PADD 1 & 3	PADD 2	PADD 4	PADD 5
Constant Price (Primary Case)		$1.48	$1.51	$1.67	$1.69
		Forecast Prices			
2009	-0.0374	$1.43	$1.45	$1.52	$1.60
2010	-0.0469	$1.41	$1.44	$1.50	$1.58
2011	-0.0460	$1.42	$1.44	$1.50	$1.59
2012	-0.0541	$1.40	$1.43	$1.49	$1.57
2013	-0.0545	$1.40	$1.43	$1.49	$1.57
2014	-0.0538	$1.40	$1.43	$1.49	$1.57
2015	-0.0518	$1.41	$1.43	$1.49	$1.58
2016	-0.0470	$1.41	$1.44	$1.50	$1.58
2017	-0.0419	$1.42	$1.45	$1.51	$1.59
2018	-0.0399	$1.43	$1.45	$1.51	$1.60
2019	-0.0369	$1.43	$1.45	$1.52	$1.60
2020	-0.0315	$1.44	$1.46	$1.52	$1.61
2021	-0.0286	$1.44	$1.47	$1.53	$1.62
2022	-0.0237	$1.45	$1.47	$1.54	$1.62
2023	-0.0161	$1.46	$1.48	$1.55	$1.64
2024	-0.0165	$1.46	$1.48	$1.55	$1.64
2025	-0.0089	$1.47	$1.50	$1.56	$1.65
2026	-0.0048	$1.48	$1.50	$1.57	$1.65
2027	-0.0008	$1.48	$1.51	$1.57	$1.66
2028	0.0033	$1.49	$1.51	$1.58	$1.67
2029	0.0074	$1.50	$1.52	$1.59	$1.67
2030	0.0115	$1.50	$1.53	$1.59	$1.68
2031	0.0156	$1.51	$1.53	$1.60	$1.69
2032	0.0197	$1.51	$1.54	$1.61	$1.70
2033	0.0239	$1.52	$1.55	$1.61	$1.70
2034	0.0281	$1.53	$1.55	$1.62	$1.71

2035	0.0323	$1.53	$1.56	$1.62	$1.72

The results of this sensitivity analysis are presented in Table 13G.3-2. Results are reported for 2015, 2020, and 2030, for each PADD. These results suggest there is no measurable difference between holding the price of gasoline constant or allowing it to vary in terms of the impact of the proposed standard on gasoline prices or in the distribution of social welfare costs among producers and consumers of gasoline fuel. This is not surprising, since the estimated compliance costs are the same for both the constant price and variable price scenarios and are small, and the difference in fuel prices between the two scenarios is small, less than five cents per gallon for all PADDs.

Table 13G3.2. Sensitivity Analysis Constant and Variable Prices

	2015				2020				2030			
	Constant Price		Variable Price		Constant Price		Variable Price		Constant Price		Variable Price	
Scenario	**Absolute**	**Relative**	**Absolute**	**Relative**	**Absolute**	**Relative**	**Relative**	**Relative**	**Absolute**	**Relative**	**Absolute**	**Relative**
Gasoline Fuel												
Price (¢/q)												
PADD I+III	$0.03	0.02%	$0.03	0.02%	$0.03	0.02%	$0.03	0.02%	$0.03	0.02%	$0.03	0.02%
PADD II	$0.11	0.07%	$0.11	0.08%	$0.11	0.07%	$0.11	0.08%	$0.11	0.07%	$0.11	0.07%
PADD IV	$0.20	0.12%	$0.20	0.13%	$0.20	0.12%	$0.20	0.13%	$0.20	0.12%	$0.20	0.13%
PADD V (w/out CA)	$0.21	0.13%	$0.21	0.14%	$0.21	0.13%	$0.21	0.13%	$0.2	0.13%	$0.21	0.13%
Change in Consumer Surplus ($\$10^6$/yr)												
PADD I+III	–$23.1	11.8%	–$23.1	11.8%	–$24.8	11.8%	–$24.8	11.8%	–$29.0	11.8%	–$29.0	11.8%
PADD II	–$52.4	26.7%	–$52.4	26.7%	–$56.2	26.7%	–$56.2	26.7%	–$65.7	26.7%	–$65.7	26.7%
PADD IV	–$10.9	5.5%	–$10.9	5.5%	–$11.7	5.5%	–$11.7	5.5%	–$13.6	5.5%	–$13.6	5.5%
PADD V (w/out CA)	–$20.7	10.5%	–$20.7	10.5%	–$22.2	10.5%	–$22.2	10.5%	–$26.0	10.5%	–$26.0	10.5%
Change in Producer Surplus ($\$10^6$/yr)												
PADD I+III	–$19.3	9.8%	–$19.3	9.8%	–$20.7	9.8%	–$20.7	9.8%	–$24.1	9.8%	–$24.1	9.8%
PADD II	–$43.7	22.2%	–$43.7	22.2%	–$46.9	22.2%	–$46.9	22.2%	–$54.8	22.2%	–$54.8	22.2%
PADD IV	–$9.1	4.6%	–$9.1	4.6%	–$9.7	4.6%	–$9.7	4.6%	–$11.4	4.6%	–$11.4	4.6%
PADD V (w/out CA)	–$17.3	8.8%	–$17.3	8.8%	–$18.5	8.8%	–$18.5	8.8%	–$21.6	8.8%	–$21.6	8.8%
Total Gasoline Fuel Social Costs	–$196.5	100.0%	–$196.5	100.0%	–$210.7	100.0%	–$210.7	100.0%	–$246.1	100.0%	–$246.1	100.0%

13G.4 Scenario 4: Alternative Social Discount Rates

Future benefits and costs are commonly discounted to account for the time value of money. The market and economic impact estimates presented in Section 13.1 calculate the present value of economic impacts using a social discount rate of 3 percent, yielding a total social cost of $2,937.3 billion from 2009 to 2035. The 3 percent discount rate reflects the commonly used substitution rate of consumption over time. An alternative is the OMB-recommended discount rate of 7 percent that reflects the commonly used real private rate of investment. Table 13G.4-1 shows the present value calculated over 2009 to 2035 using both the 3 and 7 percent social discount rates. With the 7 percent social discount rate, the present value of total social costs decreases to $1,633 billion.[P]

Table 13G.4-1. Summary of NPV Net Social Costs Estimates Associated with Primary Program (3%, 2009 to 2035) (2003$, $million)

Market	Change in Consumer Surplus	Change in Producer Surplus	Total	Change in Consumer Surplus	Change in Producer Surplus	Total
	Net Present Value 3%			Net Present Value 7%		
Gasoline, U.S.						
PADD 1 & 3	-$384.0	-$320.0	-$704.0	-$206.4	-$172.0	-$378.4
PADD 2	-$871.1	-$726.0	-$1,597.1	-$468.3	-$290.3	-$858.6
PADD 4	-$180.8	-$150.7	-$331.4	-$97.2	-$81.0	-$178.2
PADD 5 (w/out CA)	-$344.2	-$286.9	-$631.0	-$185.0	-$154.2	-$339.2
Gas Cans US						
States with existing programs	-$66.3	-$0.5	-$67.1	-$42.9	-$0.3	-$43.2
States without existing programs	-$572.1	-$3.8	-$575.9	-$338.2	-$2.3	-$340.5
Subtotal	-$2,418.8 *61.9%*	-$1,487.8 *38.1%*	-$3,906.5	-$1,338.1 *62.6%*	-$800.1 *37.4%*	-$2,126.9
Fuel Savings			$1,090.5			$585.9
Vehicle Program			-$91.1			-$64.6
California fuel[a]			-$30.2			-$16.3
Total			-$2,937.3			-$1,633.0

[a]California fuel costs are considered separately. See Section 13.1.3 of the RIA.

[P] EPA has historically presented the present value of cost and benefits estimates using both a 3 percent and a 7 percent social discount rate. The 3 percent rate represents a demand-side approach and reflects the time preference of consumption (the rate at which society is willing to trade current consumption for future consumption). The 7 percent rate is a cost-side approach and reflects the shadow price of capital.