Control of Emissions from Marine SI and Small SI Engines, Vessels, and Equipment

Draft Regulatory Impact Analysis

Chapter 9
Economic Impact Analysis

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

EPA United States Environmental Protection Agency

EPA420-D-07-004
April 2007

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We prepared a draft Economic Impact Analysis (EIA) to estimate the economic impacts of the proposed emission control program on the Small SI and Marine SI engine and equipment markets. In this chapter we describe the Economic Impact Model (EIM) developed to estimate the market-level changes in price and outputs for affected markets and the social costs of the program as well as the expected distribution of those costs across affected economic sectors. We also present the results of our analysis.

We estimate the net social costs of the proposed program to be about $241 million in 2030.[1, 2] This estimate reflects the estimated compliance costs associated with the Small SI and Marine SI engine standards and the expected fuel savings from improved evaporative controls. When the fuel savings are not taken into account, the results of the economic impact modeling suggest that the social costs of these programs are expected to be about $569 million in 2030. Consumers of Small SI and Marine products are expected to bear about 75 percent of these costs. Small SI engine and equipment manufacturers are expected to bear 6 percent and 19 percent, respectively. We estimate fuel savings of about $327 million in 2030, which will accrue to consumers.

With regard to market-level impacts in 2030, the average price increase for Small SI engines is expected to be about 9.1 percent ($17 per unit). The average price increase for Marine SI engines is expected to be about 1.7 percent ($195 per unit). The largest average price increase for Small SI equipment is expected to be about 5.6 percent ($15 per unit) for Class I equipment. The largest average price increase for Marine SI vessels is expected to be about 2.1 percent ($178 per unit) for Personal Watercraft.

9.1 Overview and Results

9.1.1 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 8). As defined in EPA's *Guidelines for Preparing Economic Analyses* (EPA 2000, p

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[1] All estimates presented in this section are in 2005$.

[2] This analysis is based on an earlier version of the engineering costs developed for this rule. The net present value of the engineering costs used in this analysis (without taking the fuel savings into account, at a 3 percent discount rate over the period of the analysis) is $10.0 billion, which is about $100 million less than the net present value of the final estimated engineering costs, $10.1 billion. We do not expect that a difference of this magnitude would change the overall results of this economic impact analysis, in terms of market impacts and how the costs are expected to be shared among stakeholders.

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.

9.1.2 What Methodology Did EPA Use in this Economic Impact Assessment?

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 9.2.

The EIM is designed to estimate the economic impacts of the proposed program by simulating economic behavior. This is done by creating a model of the initial, pre-control market for a product, shocking it by the estimated compliance costs, and observing the impacts on the market. At the initial, pre-control market equilibrium, a market is characterized by a price and quantity combination at which consumers are willing to purchase the same amount of a product that producers are willing to produce at that price (demand is equal to supply). The control program under consideration would increase the production costs of affected goods by the amount of the compliance costs. This generates a "shock" to the initial 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 decrease their demand for the affected goods. Producers will react to the decrease in quantity demanded by decreasing the quantity they produce; the market will react by setting a higher price for those fewer units. 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).

The EIM is a behavioral model. The estimated social costs of this emission control program are a function of the ways in which producers and consumers of the engines and equipment 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. An "inelastic" price elasticity (less than one) means that supply or demand is not very responsive to price changes (a one percent change in price leads to less than one percent change in demand). An "elastic" price elasticity (more than one) means that supply or demand is sensitive to price changes (a one percent change in price leads to more than one percent change in demand). A price elasticity of one is unit elastic, meaning there is a one-to-one correspondence between a change in price and change in demand. The price elasticities used in this analysis are described in Section 9.3 andwere estimated using well-established econometric methods. It should be noted that demand in the engine markets is internally derived from the Small SI equipment and Marine SI vessel markets as part of the process of running the model. This is an important feature of the EIM, which allows it to link the engine and equipment components of each model and simulate how compliance costs can be expected to ripple through the affected market.

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

There are two broad economic sectors affected by the emission control program described in this proposal: (1) Small SI engines and equipment, and (2) Marine SI engines and equipment. For Small SI engines and equipment we model one integrated handheld engine and equipment category. On the nonhandheld side, the model distinguishes between 6 engine categories, depending on engine class and useful life (Class I: UL125, UL250, and UL500; Class II: UL250, UL500, UL1000), and 8 nonhandheld equipment categories (agriculture/construction/ general industrial; utility and recreational vehicles; lawn mowers; tractors; other lawn and garden; gensets/welders; pumps/compressors/pressure washers; and snowblowers). For Marine SI engines and equipment, the model distinguishes between sterndrives and inboards (SD/I), outboards (OB), and personal watercraft (PWC); SD/I and OB are further classified by whether they are luxury or not. These markets are described in Section 9.3 and in more detail in the industry characterizations prepared for this proposal.

This analysis assumes that the all of these products are purchased and used by residential households. This means that to model the behavior change associated with proposed standards we model all uses as residential lawn and garden care, power generation (Small SI) or personal recreation (Marine SI). We do not explicitly model commercial uses (how the costs of complying with the proposed programs may affect the production of goods and services that use Small SI or Marine SI engines or equipment as production inputs); we treat all commercial uses as if they were residential uses. We believe this approach is reasonable because the commercial share of the end use markets for both Small SI and Marine SI equipment is very small (see Section 9.3.1.1). In addition, for any commercial uses of these products the share of the cost of these products to total production costs is also small (e.g., the cost of a Small SI generator is only a very small part of the total production costs for a 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 or services produced using Small SI or Marine SI equipment as inputs (e.g., commercial turf care, construction, or fishing).

In the EIM the Small SI and Marine SI markets are not linked (there is no feedback mechanism between the Small SI and Marine SI market segments). This is appropriate because the affected equipment is not interchangeable and because there is very little overlap between the engine producers in each market. These two sectors represent different aspects of economic activity (lawn and garden care and power generation as opposed to recreational marine) and production and consumption of one product is not affected by the other. In other words, an increase in the price of lawnmowers is not expected to have an impact on the production and supply of personal watercraft, and vice versa. Production and consumption of each of these products are the results of other factors that have little crossover impacts (the need for residential garden upkeep or power generation; the desire for personal recreation).

Consistent with the proposed emission controls, this Economic Impact Analysis covers engines sold in 49 states. California engines are not included because California has its own state-level controls for Small SI and Marine SI engines. The sole exceptions are Small SI engines used in agriculture and construction applications in California: these engines are included in the control program of this analysis because the Clean Air Act preempts California from setting standards for those engines.

Table 9.1-1 summarizes the markets included in this Economic Impact Analysis. More detailed information on the markets and model data inputs is provided in Section 9.3.3, and in the industry profiles prepared for this proposal (See Chapter 1, & RTI, 2006).

In the EIM, the Small SI and Marine SI markets are not linked (there is no feedback mechanism between the Small SI and Marine SI market segments). This is appropriate because the affected equipment is not interchangeable and because there is very little overlap between the engine producers in each market. These two sectors represent different aspects of economic activity (lawn and garden care and power generation as opposed to recreational marine) and production and consumption of one product is not affected by the other. In other words, an increase in the price of lawnmowers is not expected to have an impact on the production and supply of personal watercraft, and vice versa. Production and consumption of each of these productions are the results of other factors that have little cross-over impacts (the need for residential garden upkeep or power generation; the desire for personal recreation).

Table 9.1-1: Summary of Markets in Economic Impact Model

Model Dimension	**Small SI**	**Marine SI**
Description of Markets	HANDHELD No distinction between engine and equipment types for this analysis NONHANDHELD Engine types Class I (125, 250, 500 hours) Class II (250, 500, 1000 hours) Equipment types Lawn mowers Lawn and garden tractors Pumps/compressors/pressure washers Agriculture/construction/industrial Other lawn and garden Gensets/welders Snowblowers Utility and recreational vehicles	Engine and equipment types SD/I recreational (runabouts, airboats, jetboats) SD/I luxury (yachts, cruisers, offshore) OB recreational (runabouts, pontoons, fishing) OB luxury (yacht, cruiser, express fish) Personal watercraft (PWC) Engine sizes Less than 25 hp 26 to 50 hp 51 to 100 hp 101 to 175 hp 176 to 300 hp Greater than 300 hp
Geographic scope	49 state, plus agriculture and construction for California	49 state (no California engines or equipment)
Market structure	Perfectly competitive	Perfectly competitive
Baseline population	EPA certification database PSR OE Link sales database	EPA and CARB certification database NMMA published statistical data
Growth projections	EPA's 2005 Nonroad model	EPA's 2005 Nonroad model
Supply elasticity	Econometric estimate (elastic)	Econometric estimate (elastic)
Demand elasticity	Econometric estimate Gensets, all handheld: elastic Lawn mowers: inelastic All others: unit elastic	Econometric estimate (elastic)
Regulatory shock	**Handheld (integrated market):** direct compliance costs (fixed + variable) cause shift in supply function **Nonhandheld:** Engine: direct compliance costs cause shift in supply function Equipment (Class I): no direct compliance costs but higher engine prices cause shift in supply function Equipment (Class II): direct compliance costs plus higher engine prices cause shift in supply function	**PWC (integrated):** direct compliance costs (fixed + variable) cause shift in supply function **SD/I and Outboard luxury:** Engine: direct compliance costs cause shift in supply function Vessel: direct compliance costs plus higher engine prices cause shift in supply function **Outboard recreational:** Engine: direct compliance costs cause shift in supply function Vessel: direct compliance costs cause shift in supply function

9.1.4 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.

We performed a market analysis for all years and all engines and equipment markets. In this section we present summarized results for selected markets and years. More detail can be found in the appendices to this chapter and in the docket for this rule (Li, 2007). Also included in Appendix 9H are sensitivity analyses for several key inputs.

In this analysis, initial market equilibrium conditions are shocked by the sum of fixed and variable costs. For the market analysis, this leads to a small increase in estimated price impacts for the years 2011 through 2016, the period during which fixed costs are recovered. The increase is small because, for many elements of the program, annual per unit fixed costs are smaller than annual per unit variable costs. For the welfare analysis, applying both fixed and variable costs means that the burden of the social costs attributable to producers and consumers remains fixed throughout the period of analysis. This is because producers pass the fixed costs to consumers at the same rate as the variable costs instead of having to absorb them internally.

9.1.4.1 Market Analysis Results

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. The analysis relies on the initial market equilibrium prices and quantities for each type of equipment and the price elasticity of supply and demand. It predicts market reactions to the increase in production costs due to the new compliance costs (variable and fixed). It should be noted that this analysis does not allow any other factors of production to vary. In other words, it does not consider that manufacturers may adjust their production processes or marketing strategies in response to the control program. Also, as explained above, while the markets are shocked by both fixed and variable costs, the market shock is not offset by fuel savings.

A summary of the estimated market impacts is presented in Table 9.1-2 for 2013, 2018, and 2030. These years were chosen because 2013 is the year of highest compliance; after 2018, the fixed costs are recovered and the market impacts reflect variable costs as well as growth in equipment population; and 2030 illustrates the long-term impacts of the program.

Market level impacts are reported for the engine and equipment markets separately. This is because the EIM is a two-level model that treats these markets separately. However, changes in equipment prices and quantities are due to impacts of both direct equipment compliance costs and indirect engine compliance costs that are passed through to the equipment market from the engine market through higher engine prices.

The average market-level impacts presented in this section are designed to provide a broad overview of the expected market impacts that is useful when considering the impacts of the rule on the economy as a whole. The average price impacts are product-weighted averages of the results for the individual engine and equipment categories included in that sub-sector (e.g., the estimated Marine SI engine price and quantity changes are weighted averages of the estimated results for all of the Marine SI engine markets). The average quantity impacts are the sum of the decrease in units produced units across sub-markets. Price increases and quantity decreases for specific types of engines and equipment are likely to be different.

Although each of the affected equipment in this analysis generally require one engine (the exception being Marine SI sterndrive/inboards), the estimated decrease in the number of engines produced in Table 9.1-2 is less than the estimated decrease in the number of equipment produced. At first glance, this result seems counterintuitive because it does not reflect the approximate one-to-one correspondence between engines and equipment. This discrepancy occurs because the engine market-level analysis examines only output changes for engines that are produced by independent engine manufacturers and subsequently sold to independent equipment manufacturers. Engines produced and consumed by vertically integrated equipment/engine manufactures are not explicitly modeled. Therefore, the market-level analysis only reflects engines sold on the "open market," and estimates of output changes for engines consumed internally are not reflected in this number.[3] Despite the fact that changes in consumption of internally consumed engines in not directly reported in the market-level analysis results, the costs associated with these engines are included in the market-level analysis (as supply shift for the equipment markets). In addition, the cost and welfare analyses include the compliance costs associated with internally consumed engines.

9.1.4.1.1 Marine SI Market Analysis

The average price increase for Marine SI engines in 2013, the high cost year, is estimated to be about 2.3 percent, or $257. By 2018, this average price increase is expected to decline to about 1.7 percent, or $196, and remain at that level for later years. The market impact analysis predicts that with these increases in engine prices the expected average decrease in total sales in 2013 is about 2.0 percent, or 8,800 engines. This decreases to about 1.6 percent in 2018, or about 7,000 engines.

On the vessel side, the average price change reflects the direct equipment compliance costs plus the portion of the engine costs that are passed on to the equipment purchaser (via higher engine prices). The average price increase in 2013 is expected to be about 1.3 percent, or $232. By 2018, this average price increase is expected to decline to about 1 percent, or $178. These price increases are expected to vary across vessel categories. The category with the largest price increase in 2013 is expected to be personal watercraft engines, with an estimated price increase of about 2.8 percent in 2013; this is expected to decrease to 2.1 percent in 2018.

[3]For example, PWC and handheld equipment producers generally integrate equipment and engine manufacturing processes and are included in the EIM as one-level equipment markets. Since there is no engine market for these engines, the EIM does not include PWC and handheld engine consumption changes in engine market-level results.

The smallest expected change in 2013 is expected to be for sterndrive/inboards and outboard recreational vessels, which are expected to see price increases of about 0.7 percent. The market impact analysis predicts that with these increases in vessel prices the expected average decrease in quantity produced in 2013 is about 2.7 percent, or 11,000 vessels. This is expected to decrease to about 2.0 percent in 2018, or about 8,600 vessels. The personal watercraft category is expected to experience the largest decline in 2013, about 5.6 percent (4,800 vessels). The smallest percentage decrease in production is expected for sterndrive/inboards at 1.4 percent (1,300 vessels); the smallest absolute decrease in quantity is expected for outboard recreational vessels, at 113 vessels (1.5 percent).

9.1.4.1.2 Small SI Market Analysis

The average price increase for Small SI engines in 2013, the high cost year, is estimated to be about 11.7 percent, or $22. By 2018, this average price increase is expected to decline to about 9.1 percent, or $17, and remain at that level for later years. The market impact analysis predicts that with these increases in engine prices the expected average decrease in total sales in 2013 is expected to be about 2.3 percent, or 371,000 engines. This is expected to decrease to about 1.7 percent in 2018, or about 299,000 engines.

On the equipment side, the average price change reflects the direct equipment compliance costs plus the portion of the engine costs that are passed on to the equipment purchaser (via higher engine prices). The average price increase for all Small SI equipment in 2013 is expected to be about 3.1 percent, or $14. By 2018, this average price increase is expected to decline to about 2.4 percent, or $10. The average price increase and quantity decrease differs by category of equipment. As shown in Table XII.F-2, the price increase for Class I equipment is estimated to be about 6.9 percent ($19) in 2013, decreasing to 5.5 percent ($15) in 2018. The market impact analysis predicts that with these increases in equipment prices the expected average decrease in the quantity of Class I equipment produced in 2013 is about 2.2 percent, or 219,400 units. This is expected to decrease to about 1.8 percent in 2018, or about 189,700 units. For Class II equipment, a higher price increase is expected, about 3.9 percent ($41) in 2013, decreasing to 2.6 percent ($25) in 2018. The expected average decrease in the quantity of Class II equipment produced in 2013 is about 4.3 percent, or 157,300 units, decreasing to 2.8 percent, or about 114,000 units, in 2018.

For the handheld equipment market, prices are expected to increase about 0.3 percent for all years, and quantities are expected to decrease about 0.6 percent.

Table 9.1-2: Summary of Estimated Market Impacts for 2013, 2018, 2030 (2005$)

Market	Change in Price		Change in Quantity	
	Absolute	Percent	Absolute	Percent
2013				
Marine				
Engines	*$257*	*2.3%*	*-8,846*	*-2.0%*
Equipment	*$232*	*1.3%*	*-10,847*	*-2.7%*
SD/I	*$252*	*0.7%*	*-1,336*	*-1.4%*
OB Recreational	*$638*	*0.7%*	*-113*	*-1.5%*
OB Luxury	*$206*	*1.1%*	*-4,579*	*-2.1%*
PWC	*$237*	*2.8%*	*-4,819*	*-5.6%*
Small SI				
Engines	*$22*	*11.7%*	*-371,097*	*-2.3%*
Equipment	*$14*	*3.1%*	*-482,942*	*-1.9%*
Class I	*$19*	*6.9%*	*-219,400*	*-2.2%*
Class II	*$41*	*3.9%*	*-157,306*	*-4.3%*
HH	*$0.3*	*0.3%*	*-106,236*	*-0.6%*
2018				
Marine				
Engines	*$196*	*1.7%*	*-7,002*	*-1.6%*
Equipment	*$178*	*1.0%*	*-8,563*	*-2.0%*
SD/I	*$195*	*0.5%*	*-1,072*	*-1.1%*
OB Recreational	*$496*	*0.6%*	*-91*	*-1.1%*
OB Luxury	*$160*	*0.8%*	*-3,634*	*-1.6%*
PWC	*$178*	*2.1%*	*-3,766*	*-4.2%*
Small SI				
Engines	*$17*	*9.1%*	*-298,988*	*-1.7%*
Equipment	*$10*	*2.4%*	*-401,025*	*-1.4%*
Class I	*$15*	*5.5%*	*-189,771*	*-1.8%*
Class II	*$25*	*2.6%*	*-113,999*	*-2.8%*
HH	*$0.2*	*0.3%*	*-97,255*	*-0.5%*
2030				
Marine				
Engines	*$195*	*1.7%*	*-7,728*	*-1.6%*
Equipment	*$179*	*1.0%*	*-9,333*	*-2.0%*
SD/I	*$195*	*0.5%*	*-1,161*	*-1.1%*
OB Recreational	*$496*	*0.6%*	*-98*	*-1.1%*
OB Luxury	*$160*	*0.8%*	*-3,998*	*-1.7%*
PWC	*$178*	*2.1%*	*-4,076*	*-4.2%*
Small SI				
Engines	*$17*	*9.1%*	*-354,915*	*-1.7%*
Equipment	*$10*	*2.4%*	*-475,825*	*-1.4%*
Class I	*$15*	*5.6%*	*-225,168*	*-1.8%*
Class II	*$25*	*2.6%*	*-135,400*	*-2.8%*
HH	*$0.2*	*0.3%*	*-115,257*	*-0.5%*

9.1.4.2 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 fuel savings to estimate the net economic welfare impacts of the program. Estimated annual net social costs for selected years are presented in Table 9.1-3. This table shows that total social costs for each year are slightly less than the total engineering costs. This is because the total engineering costs do not reflect the decreased sales of engines and equipment that are incorporated in the total social costs.

Table 9.1-3: Estimated Annual Engineering and Social Costs Through 2038 (2005$, $million)

Year	Total Engineering Costs	Total Social Costs	Fuel Savings	Net Engineering Costs (including fuel savings)	Net Social Costs (including fuel savings)
2008	$9.5	$9.5	$3.1	$6.4	$6.4
2009	$171.7	$168.8	$13.7	$157.9	$155.1
2010	$191.1	$188.0	$25.4	$165.7	$162.6
2011	$470.5	$463.4	$64.9	$405.7	$398.5
2012	$647.3	$638.2	$103.5	$543.8	$534.7
2013	$652.5	$643.4	$136.5	$516.0	$506.9
2014	$621.1	$613.1	$161.2	$459.9	$451.9
2015	$627.0	$619.0	$182.3	$444.7	$436.7
2016	$520.9	$515.2	$200.9	$320.0	$314.2
2017	$492.6	$487.5	$216.2	$276.4	$271.3
2018	$497.2	$492.0	$229.9	$267.3	$262.1
2019	$503.6	$498.4	$242.1	$261.5	$256.2
2020	$510.0	$504.7	$253.1	$256.9	$251.6
2021	$516.4	$511.0	$263.3	$253.1	$247.8
2022	$522.7	$517.3	$272.9	$249.8	$244.4
2023	$529.1	$523.7	$281.4	$247.7	$242.3
2024	$535.8	$530.3	$289.3	$246.5	$241.0
2025	$542.3	$536.7	$296.6	$245.6	$240.0
2026	$548.7	$543.1	$303.6	$245.1	$239.5
2027	$555.2	$549.4	$310.1	$245.1	$239.3
2028	$561.6	$555.8	$316.3	$245.3	$239.5
2029	$568.0	$562.2	$322.0	$246.1	$240.2
2030	$574.5	$568.6	$327.3	$247.2	$241.3
2031	$580.9	$575.0	$332.3	$248.6	$242.6
2032	$587.4	$581.3	$337.1	$250.3	$244.2
2033	$593.8	$587.7	$341.7	$252.1	$246.0
2034	$600.3	$594.1	$346.1	$254.2	$248.0
2035	$606.7	$600.5	$350.4	$256.3	$250.1
2036	$613.1	$606.9	$354.5	$258.6	$252.3
2037	$619.6	$613.2	$358.5	$261.1	$254.7
2038	$626.0	$619.6	$362.5	$263.6	$257.1
NPV at 3%[a]	$9,996.2	$9,882.2	$4,356.2	$5,640.1	$5,562.0
NPV at 7%[a]	$5,863.6	$5,794.1	$2,291.5	$3,572.1	$3,502.6

[a] EPA EPA presents the present value of cost and benefits estimates using both a three percent and a seven percent social discount rate. According to OMB Circular A-4, "the 3 percent discount rate represents the 'social rate of time preference'… [which] means the rate at which 'society' discounts future consumption flows to their present value"; "the seven percent rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy … [that] approximates the opportunity cost of capital."

Figure 9.1-1: Estimated Engineering, Total Social, Net Social Costs and Fuel Savings

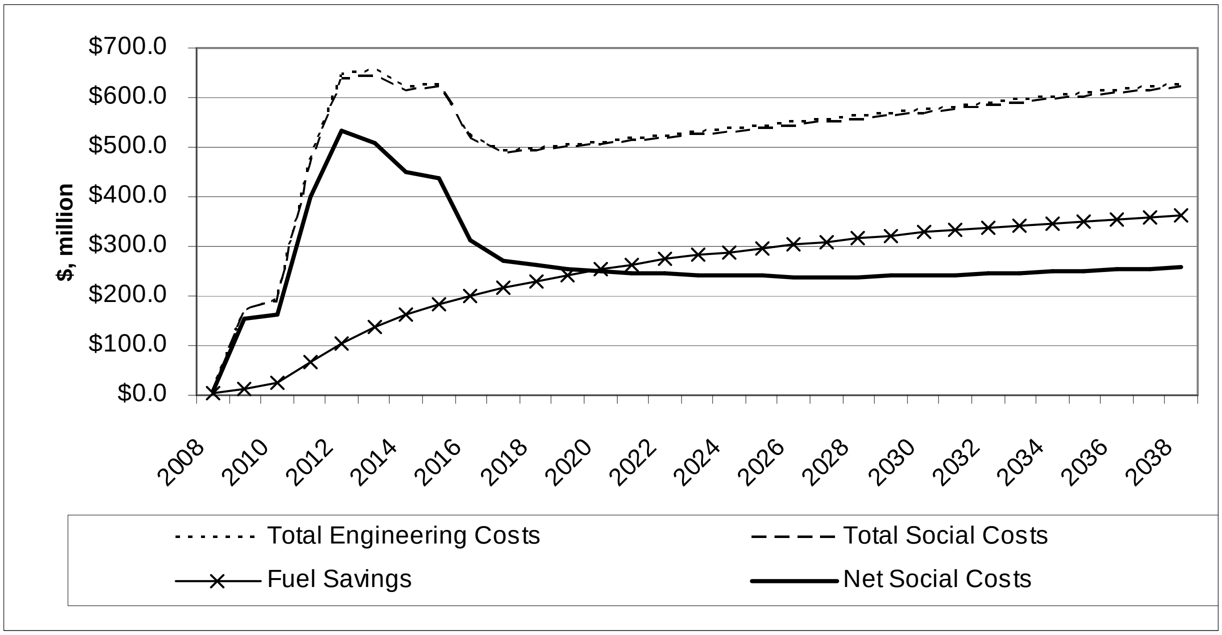

Table 9.1-4 shows how total social costs are expected to be shared across stakeholders, for selected years. According to these results, consumers in the Marine SI market are expected to bear approximately 66 percent of the cost of the Marine SI program. This is expected to be offset by the fuel savings. Vessel manufacturers are expected to bear about 22 percent of that program, and engine manufacturers the remaining 11 percent. In the Small SI market, consumers are expected to bear 79 percent of the cost of the Small SI program. This will also be offset by the fuel savings. Equipment manufacturers are expected to bear about 17 percent of that program, and engine manufacturers the remaining 4 percent. The estimated percentage changes in surplus are the same for all years because the initial equilibrium conditions are shocked by both fixed and variable costs; producers would pass the fixed costs to consumers at the same rate as the variable costs.

Table 9.1-4: Summary of Estimated Social Costs for 2013, 2018, 2030 (2005$, $million)

Market	Absolute Change in Surplus	Percent Change in Surplus	Fuel Savings	Total Change in Surplus
2013				
Marine SI				
Engine Manufacturers	*-$21.54*	*11%*		*-$21.54*
Equipment Manufacturers	*-$42.23*	*22%*		*-$42.23*
End User (Households)	*-$125.14*	*66%*	*$42.27*	*-$82.87*
Subtotal	*-$188.91*			*-$146.64*
Small SI				
Engine Manufacturers	*-$18.36*	*4%*		*-$18.36*
Equipment Manufacturers	*-$80.16*	*18%*		*-$80.16*
End User (Households)	*-$355.95*	*78%*	*$94.26*	*-$261.69*
Subtotal	*-$454.47*			*-$360.21*
TOTAL	***-$643.38***		***$136.53***	***-$506.85***
2018				
Marine SI				
Engine Manufacturers	*-$17.29*	*11%*		*-$17.29*
Equipment Manufacturers	*-$34.02*	*22%*		*-$34.02*
End User (Households)	*-$100.19*	*66%*	*$87.12*	*-$13.07*
Subtotal	*-$151.50*			*-$64.38*
Small SI				
Engine Manufacturers	*-$13.89*	*4%*		*-$13.89*
Equipment Manufacturers	*-$57.65*	*17%*		*-$57.65*
End User (Households)	*-$268.95*	*79%*	*$142.78*	*-$126.17*
Subtotal	*-$340.49*			*-$197.71*
TOTAL	***-$491.99***		***$229.90***	***-$262.09***
2030				
Marine SI				
Engine Manufacturers	*-$18.81*	*11%*		*-$18.81*
Equipment Manufacturers	*-$36.97*	*23%*		*-$36.97*
End User (Households)	*-$108.52*	*66%*	*$149.36*	*$40.84*
Subtotal	*-$164.30*			*-$14.94*
Small SI				
Engine Manufacturers	*-$16.49*	*4%*		*-$16.49*
Equipment Manufacturers	*-$68.45*	*17%*		*-$68.45*
End User (Households)	*-$319.31*	*79%*	*$177.89*	*-$141.42*
Subtotal	*-$404.25*			*-$226.36*
TOTAL	***-$568.55***		***$327.25***	***-$241.30***

Table 9.1-5 contains more detailed information on the sources of the social costs for 2013. This table shows that vessel and equipment manufacturers are expected to bear more of the burden of the program than engine manufacturers. On the marine side, the loss of producer surplus for the vessel manufacturers has two sources. First, they would bear part of the burden of the equipment costs. Second, they would also bear part of the engine costs, which are passed on to vessel manufacturers in the form of higher engine prices. Vessel manufacturers would not be able to pass along a greater share of the engine and vessel compliance costs to end consumers due to the elastic price elasticity of demand for consumers of these vessels. On the Small SI side, equipment manufacturers can pass on more of the compliance costs to end consumers

because the price elasticity of demand in these markets is less elastic.

Table 9.1-5: Estimated Surplus Changes by Market and Stakeholder for 2013 (2005$, $million)

Scenario	Engineering Compliance Costs	Producer Surplus	Consumer Surplus	Total Surplus	Fuel Savings	Net Surplus
Marine SI						
Engine Manufacturers	$133.2	-$21.5		-$21.5		-$21.5
Equipment Manufacturers	$59.1	-$42.2		-$42.2		-$42.2
Engine Price Changes		*-$18.7*				
Equipment Cost Changes		*-$23.6*				
End User (Households)			-$125.1	-$125.1	$42.3	-$82.8
Engine Price Changes			*-$91.8*			
Equipment Price Changes			*-$33.3*			
Subtotal	**$192.2**	**-$63.8**	**-$125.1**	**-$188.9**	**$42.3**	**-$146.6**
Small SI						
Engine Manufacturers	$371.9	-$18.4		-$18.4		-$18.4
Equipment Manufacturers	$88.4	-$80.2		-$80.2		-$80.2
Engine Price Changes		*-$59.0*				
Equipment Cost Changes		*-$21.1*				
End User (Households)			-$355.9	-$355.9	$94.3	-$261.7
Engine Price Changes			*-$289.8*			
Equipment Cost Changes			*-$66.1*			
Subtotal	**$460.3**	**-$98.5**	**-$355.9**	**-$454.5**	**$94.3**	**-$360.2**
TOTAL	**$652.5**	**-$162.3**	**-$481.1**	**-$643.4**	**$136.6**	**-$506.8**

The present value of net social costs of the proposed standards through 2038 at a 3 percent discount rate, shown in Table XII.F-6, is estimated to be $5.5 billion, taking the fuel savings into account. We also performed an analysis using a 7 percent social discount rate. Using that discount rate, the present value of the net social costs through 2038 is estimated to be $3.5 billion, including the fuel savings.

Table 9.1-6. Estimated Net Social Costs Through 2038 by Stakeholder (2005$, $million)

Market	Total Change in Surplus	Percentage Change in Total Surplus	Fuel Savings	Net Change in Surplus
Net Present Value 3%				
Marine SI				
Engine Manufacturers	-$354.4	11%		-$354.4
Equipment Manufacturers	-$688.8	22%		-$688.8
End User (Households)	-$2,058.8	66%	$1,831.3	-$227.5
Subtotal	-$3,102.0		$1,831.3	-$1,270.7
Small SI				
Engine Manufacturers	-$275.0	4%		-$275.0
Equipment Manufacturers	-$1,171.8	17%		-$1,171.8
End User (Households)	-$5,333.4	79%	$2,524.8	-$2,808.6
Subtotal	-$6,780.2		$2,524.8	-$4,255.4
TOTAL	**-$9,882.2**		**$4,356.1**	**-$5,526.1**
Net Present Value 7%				
Marine SI				
Engine Manufacturers	-$216.4	11%		-$216.4
Equipment Manufacturers	-$417.6	22%		-$471.6
End User (Households)	-$1,259.9	66%	$937.1	-$322.8
Subtotal	-$1,893.8		$937.1	-$956.8
Small SI				
Engine Manufacturers	-$157.8	4%		-$157.8
Equipment Manufacturers	-$680.4	17%	$1,354.4	-$680.4
End User (Households)	-$3,062.1	79%	$1,354.4	-$1,707.7
Subtotal	-$3,900.3			-$2,545.9
TOTAL	**-$5,794.2**		**$2,291.5**	**-$3,502.6**

9.2 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 publically available price and quantity data. A key factor in this type of analysis is the responsiveness of the quantity of engines and equipment 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.

9.2.1 Behavioral Economic Models

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

Engineering cost analysis is an example of the latter and provides detailed estimates of 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 resulting from the market adjustments 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 illustrate how the costs flow through the economic system and it identifies which stakeholders, producers, and consumers are most likely to be affected.

9.2.2 What Is the Economic Theory Underlying the EIM?

The EIM is a multi-market partial-equilibrium 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.

9.2.2.1 Partial Equilibrium Multi-Market 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. A regulation that imposes a small direct compliance cost on an important input, or any direct compliance costs on an input that is only a small share of production costs, would be expected to have less of an impact on all markets in the economy.

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 *multi-market* 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 analysis uses a partial equilibrium approach in that it models only those markets that are directly affected by the proposed emission control program: the Small SI and Marine SI markets. In addition, these markets are modeled separately. This approach is appropriate because the Small SI and Marine SI sector represent different activities (residential garden care and personal recreation), and production and consumption of one is not affected by the other. In other words, an increase in the price of lawnmowers is not expected to have an impact on the production and supply of recreational marine vessels, and vice versa. Production and consumption of these products are the result of other factors that have little cross-over impacts.

The EIM uses a single-market approach for some sectors (Small SI handheld, Class I nonhandheld, personal watercraft, outboards recreational) and a two-market approach for the others (Small SI Class II nonhandheld; sterndrive/inboards; and outboards luxury) reflecting whether the markets are integrated and whether the controls affect only engines or both engines and equipment. The advantage of a two-market approach is that it allows us to describe the expected distribution of the program's effects across equipment and engine markets as well as the effects on purchasers of these engines and equipment. To simulate these relationships, the EIM consists of a series of standard partial equilibrium models that are linked through interactions between the equipment and engine markets. As a result, the model estimates changes in prices and quantities across all markets *simultaneously* for each of the linked engine and equipment markets.

The EIM does not specifically estimate potential price and quantity impacts on final goods and services that may be produced by equipment that would be subject to the proposed controls in the agricultural and construction sectors. This is appropriate because the vast majority of engines and equipment that would be subject to the proposed standards are purchased for residential use (recreational marine; home lawn and garden and residential utility uses; see Section 9.3 and the industry characterization prepared for this rule). Not only is the share of commercial users of this equipment small, but such equipment represents only a small portion of the total production costs for application markets such as agriculture, construction or manufacturing. The proposed standards would affect only a very small part of total inputs for those markets and would not be expected to result in an adverse impact on output and prices of goods produced in these commercial application sectors.

It should also be noted that the economic impact model employed for this analysis estimates the market-level economic impacts of the rule. It is not a firm-level analysis and therefore the impact for any particular manufacturer may be greater or less than the average impact for the market as a whole. 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 wide array of flexibilities provided in this rule are adequate to address any cost inequities that are likely to arise.

9.2.2.2 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). This EIM is abased 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 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 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.[4] Finally, according to contestable market theory, oligopolies and even monopolies will behave very much like firms in a competitive market if it is possible to enter particular markets costlessly (i.e., there are no sunk costs associated with market entry or exit). This would be the case, for example, when products are substantially similar.

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 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, we assume the perfectly competitive market structure. This is because these markets do not exhibit evidence of noncompetitive behavior: there are no indications of barriers to entry, the firms in these markets are not price setters, and there is no evidence of high levels of strategic behavior in the price and quantity decisions of the firms.

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[4]The number of firms in a market is not a necessary condition for a perfectly competitive market. See Robert H. Frank, Microeconomics and Behavior, 1991, McGraw-Hill, Incl., p. 33.

As described in the industry profiles for this proposed regulation (RTI, 2004), several of the recreational marine and Small SI sectors are highly concentrated and thus have the potential for the emergence of imperfect competition and price-setting behavior. Nonetheless, our analysis suggests that mitigating factors will limit this potential for raising price above marginal cost and thus that the assumption of perfect competition is justified. Among the mitigating factors are the presence of substantial import competition, relative ease of entry, existing excess production capacity, and a historical tendency of market participants to compete on price. These markets are also mature markets, as evidenced by unit sales growing at the rate of population increases. Pricing power in such markets is typically limited, and empirical data indicates that price pressure has existed in these markets for years and firms in these markets are price takers.[5] In addition, the products produced within each market are somewhat homogeneous in that engines and equipment from one firm can be purchased instead of engines and equipment from another firm, enhancing competition.

According to contestable market theory, oligopolies and even monopolies will behave very much like firms in a competitive market if it is possible to enter particular markets costlessly (i.e., there are no sunk costs associated with market entry or exit). This is the case with these markets as there is significant excess production capacity in both the Small SI and Marine SI industries, in part due to improved productivity and efficiency in current plants. Data on domestic plant capacity utilization rates are published by the U.S. Census (U.S. Census, 2005). The full production capability is defined as "the maximum level of production that an establishment could reasonably expect to attain under normal and realistic operating conditions fully utilizing the machinery and equipment in place." Recent domestic data for 2000 to 2004 indicate the internal combustion engine industry (NAICS 333618 Other Equipment Manufacturing) operated at 53 to 73 percent of full production capability. Similar data for vessels (NAICS 336612 Boat Building) indicate this industry operated between 59 and 62 percent of full production capability. The small SI equipment industry (NAICS 333112, lawn & garden tractor and home & lawn garden equipment manufacturing) operated at 50 to 65 percent of full production capability. Idle production capacity also limits the ability of firms to raise prices, since competitors can easily capture market share by increasing their production at the expense of a producer that increases its prices.

Finally, domestic producers face substantial competition from foreign manufacturers (RTI, 2006). These overseas firms may have strong incentives to compete vigorously on price with the well-established U.S. firms. For all of these reasons it is appropriate to use a perfect competition model to estimate the economic impacts of this proposal.

9.2.2.3 Intermediate-Run Model

In developing the multi-market partial equilibrium model, the choices available to producers must be considered. For example, are producers able to increase their factors of

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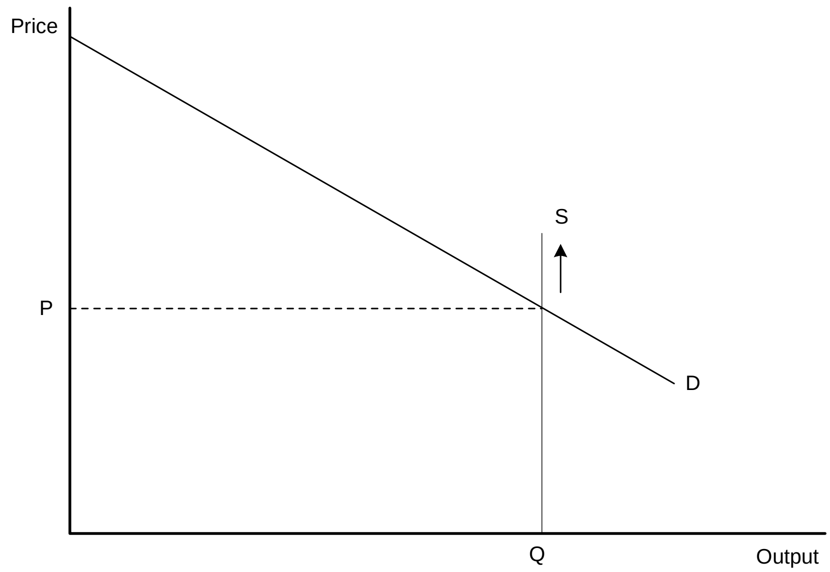
[5] RTI (2006). Historical Market Data and Trends, Industry Profile for Small SI Engines and Equipment, Section 2.5. Draft Report

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 9.2-1. In essence, this is equivalent to the nonbehavioral model described earlier. 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 9.2-1: Short Run: All Costs Born by Producers

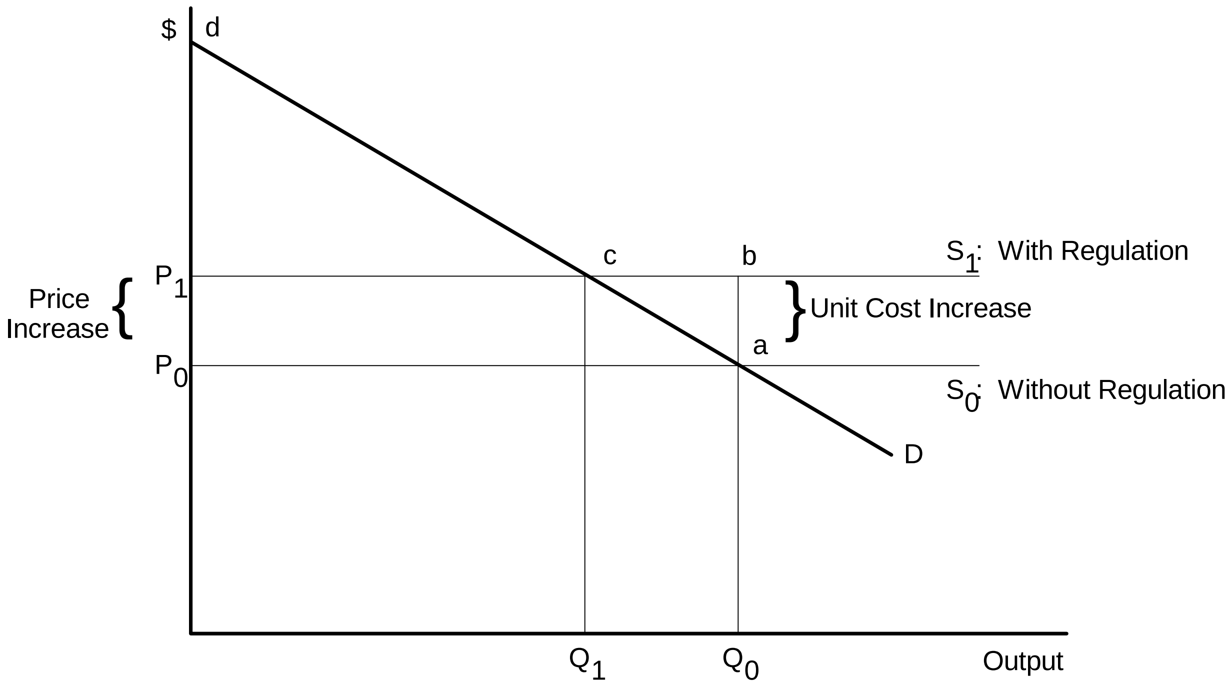


In the long run, all factors of production are variable, and producers can be expected to adjust production plans in response to cost changes imposed by a regulation (e.g., using a different labor/capital mix). Figure 9.2-2 illustrates a typical, if somewhat simplified, long-run industry supply function. The function is horizontal, indicating that the marginal and average costs of production are constant with respect to output.[6] 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 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 9.2-2.

[6] 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.

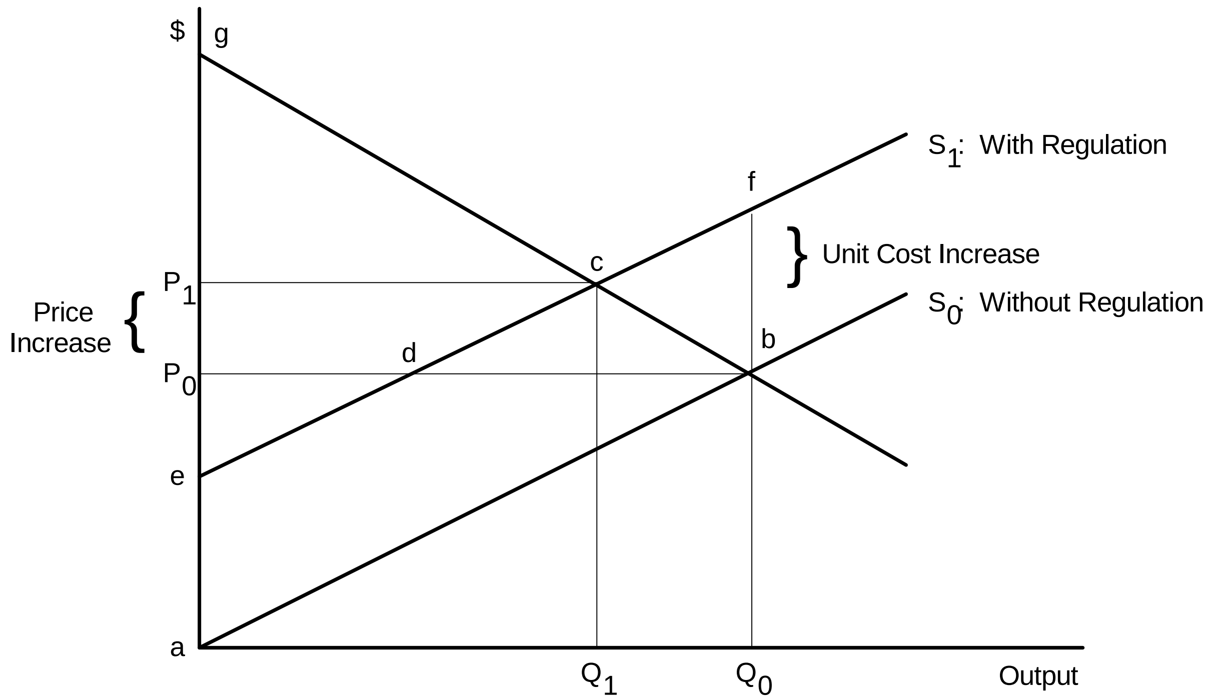
Figure 9.2-2: Long Run: Full-Cost Pass-Through



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. 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) function that rises with the output rate, as shown in Figure 9.2-3.

Figure 9.2-3: Intermediate Run: Partial-Cost Pass-Through



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.

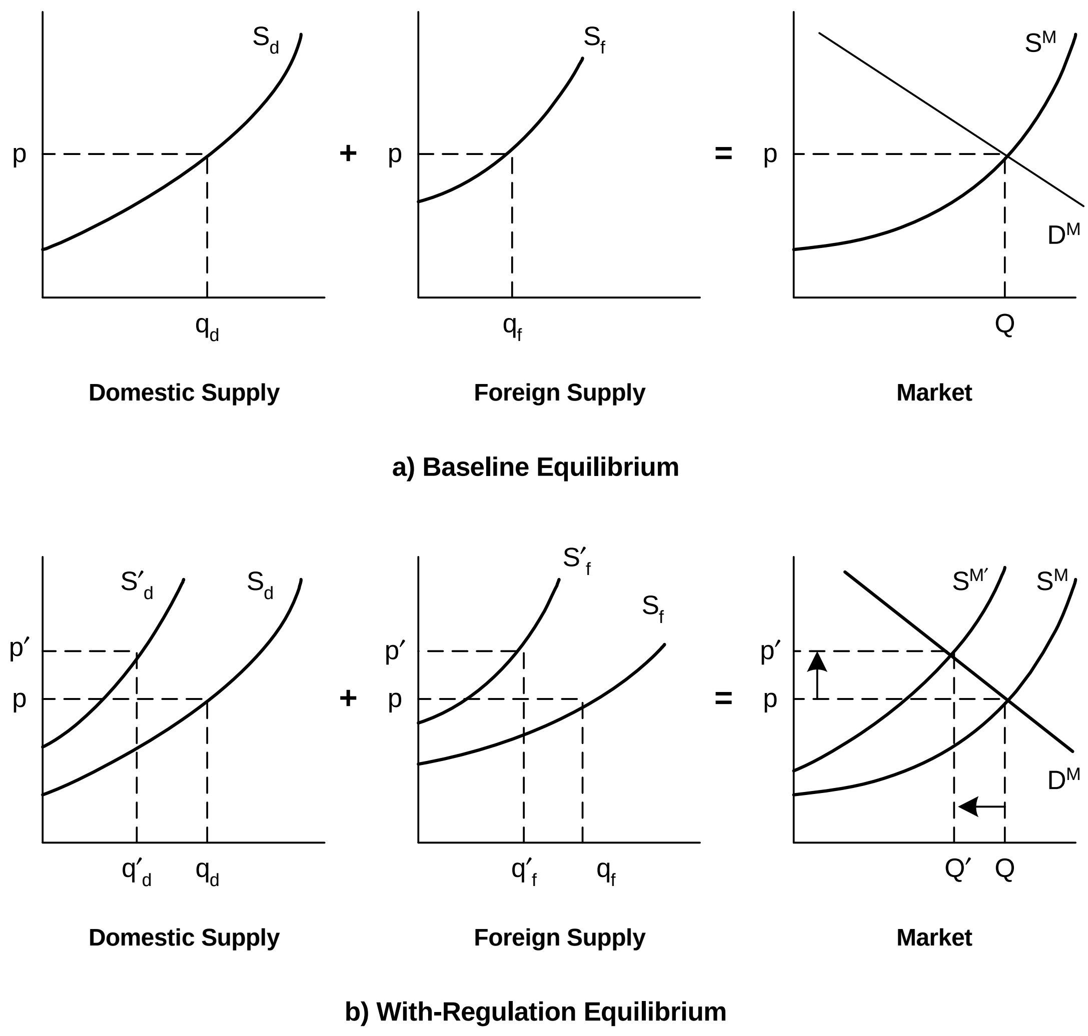
Consistent with other economic impact analyses performed by EPA, this EIM uses an intermediate run approach. This approach allows us to examine the market and social welfare impacts of the program as producers adjust their output and consumers adjust their consumption of affected products in response to the increased production costs. During this period, the distribution of the welfare losses between producer and consumer depends in large part on the relative supply and demand elasticity parameters used in the model. For example, if demand for Small SI equipment 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 Small SI equipment consumers in the form of higher prices.

9.2.3 How is the EIM Used to Estimate Economic Impacts?

9.2.3.1 Estimation of Market Impacts (Single Market)

A graphical representation of a general economic competitive model of price formation, as shown in Figure 9.2-4(a), 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 9.2-4: 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 9.2-3(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) decreases from Q to Q′. This reduction in market output is the net result of reductions in domestic and import supply.

As indicated in Figure 9.2-4, 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 in this analysis. This is explained by the dynamics underlying the demand curve. The demand curve represents the relationship between prices and quantity demanded. Changes in prices lead to changes in the quantity demanded and are illustrated by *movements along* a fixed demand curve. In contrast, changes in any of the other variables would lead to change in demand and are illustrated as *shifts* in the position of the demand curve.[7] For example, an increase in the number of consumers in a market would cause the demand curve to shift outward because there are more individuals willing to buy the good at every price. Similarly, an exogenous increase in nominal income would also lead the demand curve to shift outward as people choose to buy more of a good at a given price. Changes in the prices of related good and tastes or preferences can also lead to demand curve shifts.

The proposed standards are expected to increase the costs of production in the Small SI engine and equipment and Marine SI engine vessel markets and ultimately lead to higher equilibrium prices in the affected markets. As these prices increase, the quantity demanded falls (i.e., the price change leads to a movement along the demand curve).[8] However, the proposed program is not expected to lead to shifts in the demand curve for several reasons. First, the assume the program will not *directly* influence prices of related goods (i.e., prices of any potential substitutes remain constant in the analysis). In addition, the program will not change nominal incomes through public finance mechanisms (e.g., lump sum subsidies/taxes) or change labor supply decisions. Finally, we assume tastes and preference will not change during the period of analysis. For all of these reasons, it would be inappropriate to shift the demand curve for this analysis.

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[7] An accessible detailed discussion of these concepts can be found in Chapter 5-7 of Nicholson’s (1998) intermediate microeconomics textbook.

[8] Nicholson (1998) provides an example of the effects of a price increase on the quantity consumed (p: 134-135). Throughout this discussion, we use uncompensated Marshallian demand functions. As a result, a price increase will also change an individual’s “real” income and reinforce substitution quantity responses to a good’s price change through an “income” effect. Both substitution and (real) income effects are therefore built in the Marshallian demand function used for this analysis. It is important to note, however, that this type of “income” effect is conceptually different from an exogenous change in nominal income that leads to a shift in a demand function.

9.2.3.2 Incorporating Multi-Market Interactions

The above description is typical of the expected market effects for a single product markets (e.g., Small SI handheld and Class I nonhandheld; personal watercraft) considered in isolation. However, several of the markets considered in this EIA are more complicated because the engine and equipment manufacturers are not integrated.

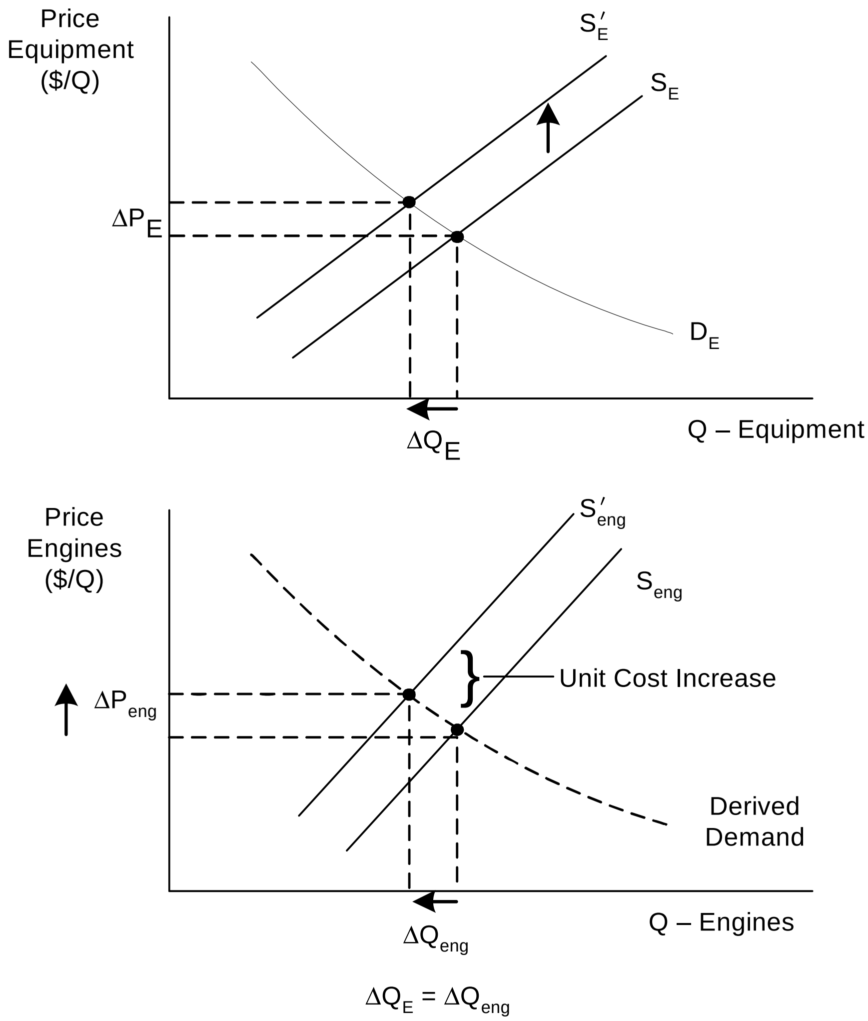
When both engine and equipment markets are considered separately, the regulatory program will affect equipment producers in two ways. First, equipment producers are affected by higher input costs (increases in the price of gasoline engines) associated with the rule. Second, the standards will also impose additional production costs on equipment producers associated with equipment changes necessary to accommodate changes in engine design. In the sections that follow, we describe the demand relationships between these markets and how they are incorporated in the economic model.

In markets such as Class II nonhandheld or SD/I marine, the demand for engines is directly linked to the production of equipment or vessels that uses those engines.[9] This means that it is reasonable to assume that the input-output relationship between the gasoline engines and the equipment is strictly fixed and that the demand for engines varies directly with the demand for equipment.[10] A demand curve specified in terms of its downstream consumption is referred to as a derived demand curve. Figure 9.2-5 illustrates how a derived demand curve is identified.

[9] In marine applications, one or two engines are used per boat, depending on its intrinsic design, and this configuration is insensitive to small changes in engine used. In the case of Small SI equipment, the one-to-one correspondence is exact. Furthermore, there is no potential for technical substitution, i.e., to make gasoline equipment one needs a gasoline engine.

[10] This one-to-one relationship holds for engines sold on the market and for engines consumed internally by integrated engine/equipment manufacturers.

Figure 9.2-5: Derived Demand for Engines



Consider an event in the marine equipment market that causes the price of equipment to increase by ΔP (such as an increase in the price of engines). This increase in the price of equipment will cause the supply curve in the equipment market to shift up, leading to a decreased quantity (ΔQ_E). The change in equipment production leads to a decrease in the demand for engines (ΔQ_{Eng}). The new point ($Q_E - \Delta Q_E$, $P - \Delta P$) traces out the derived demand curve. Note that the supply and demand curves in the marine equipment markets are needed to identify the derived demand in the engine market. All of the market supply and demand curves and the elasticity parameters used in the EIM are described in Appendix 9E

9.2.3.3 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.

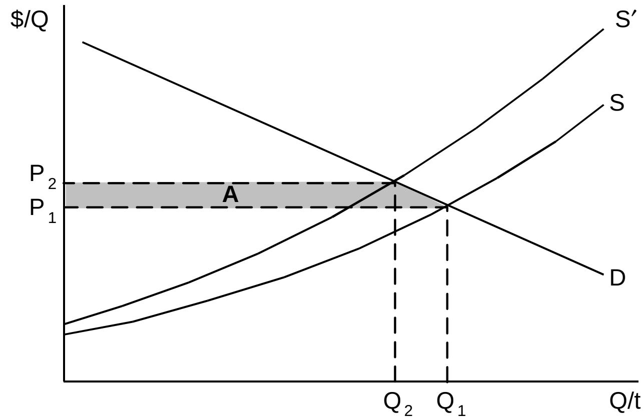
The demand and supply curves that are used to project market price and quantity impacts can be used to estimate the change in consumer, producer, and total surplus or social cost of the regulation (see Figure 9.2-6).

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.

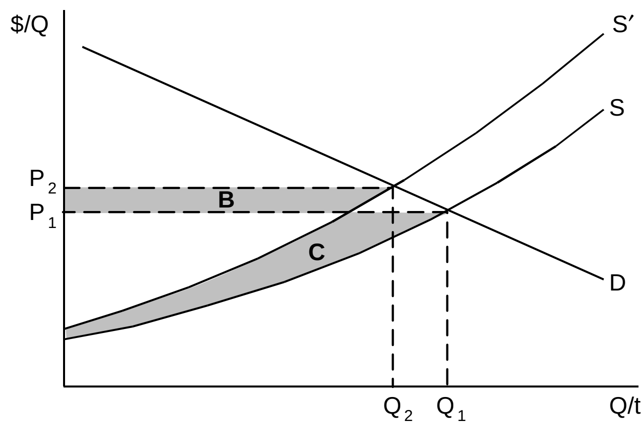
In Figure 9.2-6, baseline equilibrium occurs at the intersection of the demand curve, D, and supply curve, S. Price is P_1 with quantity Q_1. The increased cost of production with the regulation will cause the market supply curve to shift upward to S'. The new equilibrium price of the product is P_2. With a higher price for the product there is less consumer welfare, all else being unchanged. In Figure 9.2-6(a), 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, $Q_1 - Q_2$.

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 9.2-6(b), 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.

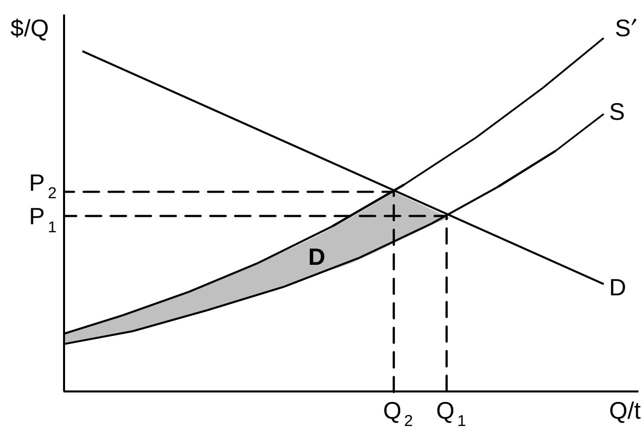
Figure 9.2-6: Market Surplus Changes with Regulations
Consumer and Producer Surplus



(a) Change in Consumer Surplus with Regulation



(b) Change in Producer Surplus with Regulation



(c) Net Change in Economic Welfare with Regulation

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 9.2-6(c) shows the net (negative) change in economic welfare associated with the regulation as area D.

9.2.4 How Are Special Market Characteristics Addressed?

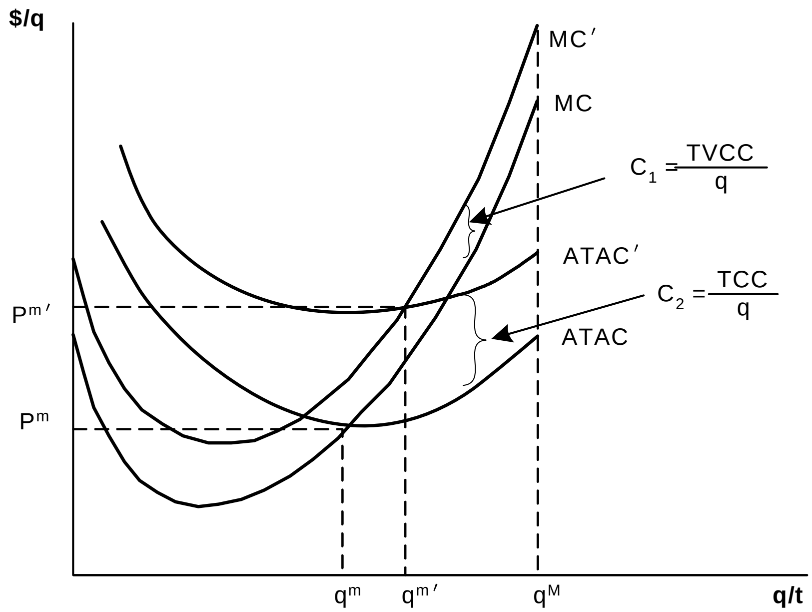
In addition to the general model features described in Section 9.2.2, there are several specific characteristics of the Small SI and Marine SI markets that need to be addressed in the EIM. These are the treatment of fixed and variable costs, fuel savings, programmatic flexibilities, and substitution, and distribution systems effects.

9.2.4.1 Fixed and Variable Costs in a Competitive Market

The estimated engineering compliance costs, consisting of fixed costs (R&D, capital/tooling, certification costs), variable costs, and operating 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 9.2-7, the marginal cost (MC) curve will only be affected, or shift upwards, by the per-unit variable compliance costs (c1=TVCC/q), while the average total cost (ATAC) curve will shift up by the per-unit total compliance costs (c2=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., Pm'). 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.

Figure 9.2-7: Modeling Fixed Costs



(a) Upward-sloping supply function

Depending on the industry type, fixed costs associated with complying with a new regulation can generally be 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 anlaysis for a competitive market is based on variable costs only.

The nature of the Small SI and Marine SI markets suggests the market supply curve shifts in the model should include fixed and variable compliance costs. This is because Small SI and Marine SI engine and equipment manufacturers produce a product that changes very little over time. These manufacturers may not engage in research and development to improve their products on a continuous basis (as opposed to highway vehicles or nonroad engines and equipment). In this case, the product changes that would be required to comply with the proposed standards would require these manufacturers to devote new funds and resources to product redesign and facilities changes. In this situation, Small SI and Marine SI engine and equipment manufacturers would be expected to increase their prices by the full amount of the compliance costs (both fixed and variable) to attempt to recover those costs. This is in contrast to the nonroad diesel engine and equipment markets: manufacturers in those markets generally allocate redesign resources each year to accommodate a changing market. To reflect these conditions, the supply shift in this EIM is based on both fixed and variable costs, even though the model assumes perfect competition. A sensitivity analysis was performed to investigate the impacts under the alternative scenario of shifting the supply curve by the variable costs only. The results of that analysis can be found in Appendix 9H.

9.2.4.2 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 9.2-6(c) 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 evaporative and exhaust controls are expected to result in fuel savings for users. Small SI engine and equipment manufacturers are expected to use fuel injection techniques to comply with the proposed standards for some of their two-cylinder Class II engines. These fuel injected engines are expected to have better fuel efficiency than carbureted engines. Marine SI manufacturers are expected to use 4-stroke and direction-injection 2-stroke technology for outboards and PWC. In addition, all sterndrive and inboard engines are expected to use fuel injection. These technologies are expected to result in reductions in fuel consumption.

These fuel savings are not included in the market analysis for this economic impact analysis. This is because all available evidence suggests that fuel savings do not affect consumer decisions with respect to the purchase of this equipment. Unlike motor vehicles or other consumer goods, neither Small SI nor Marine SI equipment is labeled with expected fuel consumption or expected annual operating costs. Therefore, there is no information available for the consumer to use to make this decision. Instead consumers base their purchase decision on other attributes of the product for which the manufacturer provides information. For lawn mowers this may be the horsepower of the engine, whether the machine has a bag or has a mulching feature, its blade size, etc. For PWC it may be how many people it can carry, its maximum speed, its horsepower, etc. In many cases, especially for Small SI equipment, the consumer may not even be aware of the fuel savings when operating the equipment, especially if he or she uses the same portable fuel storage container to fuel several different pieces of equipment.

These fuel savings are included in the social cost analysis. This is because they are savings that accrue to society. These savings are attributed to consumers of the relevant equipment. As explained in more detail in 9.3.5, the social cost analysis is based on the equivalent of the pre-tax price of gasoline in that analysis. Although the consumer will realize a savings equal to the pump price of gasoline (post-tax), part of that savings is offset by a tax loss to governmental agencies and is thus a loss to consumers of the services supported by those taxes. This tax revenue loss, considered a transfer payment in this analysis, does not affect the benefit-cost analysis results.

9.2.4.3 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.

9.2.4.4 Substitution

Gasoline-powered SI engines convert the potential energy contained in the fuel into mechanical energy, which can then be used to do useful work, to provide locomotion, and/or to generate electricity. These machines are technologically similar compression-ignition engines powered by diesel fuel, and often compete in the same equipment and applications markets. Similarly, electric motors are capable of performing many of the same tasks as gasoline engines in small and inexpensive equipment.

The relationships modeled in the EIM do not include substitution away from Small SI and Marine SI engines and equipment to diesel or electric alternatives. This is appropriate because consumers are not likely to make these substitutions. Diesel engines' superior efficiency in energy conversion makes them more attractive for large engines, and for those with long required service lives, whether measured in operating hours or years of service. Gasoline-powered engines, on the other hand, have lower initial cost, and utilization in garden or recreational activities is not high enough for diesel fuel efficiency to overcome this gasoline advantage. On the SI marine side, the current population of recreational boats is overwhelmingly powered by gasoline engines, even in the large horsepower classes where diesel's superior efficiency would seem to provide significant cost advantages, and gasoline engines are the prevalent choice for garden equipment and residential generators. On the Small SI side, substitution to diesel is not a viable option for most residential consumers, either because diesel equipment does not exist (e.g., diesel string trimmers) or because there would be a large price premium that would discourage the use of diesel equipment (e.g., diesel lawnmowers and diesel recreational marine vessels). In addition, most households are not equipped to handle the additional fuel type and misfueling would carry a high cost. Finally, the lack of a large infrastructure system already in place like the one supporting the use of gasoline equipment for residential and recreational purposes, including refueling and maintenance, represents a large barrier to substitution from gasoline to diesel equipment. With regard to electric alternatives, the impact of substitution to electric for Small SI equipment (there are no comparable options for Marine SI) is also expected to be negligible. Gasoline is the power source of choice for small and inexpensive equipment due to its low initial cost. Gasoline equipment is also inherently portable, which make them more attractive to competing electric equipment that must be connected with a power grid or use batteries that require frequent recharging. Data that would allow investigation of the details of this clear consumer preference are not available, but it is reasonable to assume that increases in the cost of gasoline engines of the magnitude associated with this program would not cause widespread substitution to diesel or electric alternatives.

9.2.4.5 Distribution System Effects

The market interactions modeled in the EIM are those between producers and consumers of the specified engines and equipment that use those engines. The EIM does not consider sales distribution networks or how the regulated goods are sold to final consumers through wholesalers and/or retailers. This is appropriate because the proposed regulatory program does not impose additional costs on the distribution networks and those relationships are not expected to change as a result of the standards.

In the case of Small SI equipment, however, concerns have been raised about the potential for dominant retailers (big box stores such as Wal-Mart, Sears and K-Mart) to affect market equilibria and the ability of manufacturers to pass along cost increases associated with new emission control requirements. Specifically, some Small SI equipment manufacturers assert that Big Box stores impose a price structure that would force them to absorb the compliance costs associated with the proposed standards. They contend that this is a relatively new phenomenon for their market and that EPA should consider these effects in the economic impact analysis for this proposal.

Dominant retailers are a fairly well-understood sector of the consumer good distribution network, especially with regard to clothing and household goods. These stores reduce product prices by exerting important influences on relevant producers. Specifically, they discipline markets by encouraging manufacturers to compete on price, and force inefficient firms to cut costs or leave the market.

Dominant retailers may also prevent efficient producers from passing on increases in fixed costs to consumers, including R&D costs associated with engine or equipment redesign. So, for example, it may be the case that if a particular firm redesigns a lawnmower to produce more power a dominant retailer may not choose to change its pricing structure to account for that redesign. Nevertheless, the firm may still choose to incorporate the design change in the hope of capturing a greater share of the market and/or improve its name recognition.

It is unlikely, however, that a dominant retailer could prevent firms from passing on market-wide increases in marginal costs in response to a regulatory program. Profit maximizing manufacturers will continue to follow a marginal cost equals price pricing rule regardless of the distribution arrangements. A dominant retailer could not force the manufacturer to produce units where the marginal cost exceeds the price. If large retail distributors attempted to prevent efficient manufacturers from raising prices in response to the standards, manufacturers would likely respond to a retailer's price pressure by reducing output. This would result in large excess demand in the equipment market which would ultimately have to be satisfied through some sort of arbitrage mechanism to a new higher equilibrium price.

An individual manufacturing company has little, if any, ability to pass on a price increase if it is the only entity affected by that price increase. In such a case, retailers would clearly have an incentive to purchase comparable engines or equipment that were not affected by the price increase, placing the affected firm at a competitive disadvantage and reducing its market share. However, in this case all engine manufacturers will face increased marginal costs of production associated with the regulatory program. Therefore, the program does not necessarily put one engine manufacturer at a competitive disadvantage, although manufacturers that can more easily accommodate the new requirements will likely see lower costs than those who cannot.

9.3 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 9.2. The EIM analysis consists of four basic steps:

- Define the initial 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, and model elasticity parameters. Also included is a brief discussion of the analytical expression used to estimate with-regulation market conditions.

9.3.1 Description of Product Markets

This EIM estimates the behavioral responses of the Small SI and Marine SI markets to the cost of complying with the proposed emission control program. Each of these markets is very briefly described below. More information can be found in the industry characterizations prepared for this proposal (Chapter 1 and RTI 2006).

9.3.1.1 Small SI Market

The Small SI market is the market for a variety of nonroad equipment powered by two-stroke or four-stroke spark-ignition engines rated up to 19 kW (25 hp). This economic impact assessment distinguishes between two Small SI market sectors: handheld and nonhandheld. The handheld (HH) sector consists generally of equipment that is carried by the operator and is operated multipositionally, although some equipment in this category may have two wheels. HH equipment includes string trimmers, edgers, leaf blowers, and chain saws. The nonhandheld (NHH) sector consists mostly of wheeled equipment such as lawn mowers, garden tractors, and wheeled trimmers, blowers, and edgers. Also included in the Small SI market are generators, compressors, and construction, agricultural, and small industrial equipment, as well as some recreational and utility vehicles and snowblowers.

The HH market can be characterized as an integrated market in which producers manufacture both the engine and the associated equipment. In the NHH market, in contrast, the engine and equipment manufacturers are typically separate entities. Engines produced by a manufacturer for use in its own equipment are called "captive" engines. Engines produced by manufacturers for sale on the open market to anyone who wants to buy them are called "merchant" engines. This distinction is important because compliance costs affect captive and merchant engines differently. Engine-related compliance costs for captive engines are absorbed into the equipment costs of integrated suppliers in their entirety. In contrast, nonintegrated suppliers who buy merchant engines absorb only part of the engine compliance costs into their equipment costs; the rest is borne by the engine manufacturer. Depending on the price sensitivity of demand in the engine market, the pass-through of engine compliance costs to the equipment manufacturer may be larger (more inelastic demand) or smaller (more elastic demand).

This analysis makes the simplifying assumption that virtually all Small SI equipment is sold to residential end-users for their personal use and a negligible number are sold to commercial entities for use as an input to the production of goods or services. This simplifying assumption allows us to disregard the impact of the compliance costs on the production of goods and services that would have Small SI equipment as an input. Any such impacts would be expected to be negligible given the relative share of Small SI equipment to any such production processes. This assumption is supported by data from the Outdoor Power Equipment and Engine Service Association (OPEESA), contained in Table 9.3-1, which indicates that only about 3 percent of the NHH products sold in 2003 and 2004 were sold to commercial users. The rest, 97 percent, were sold to residential users. While this data reflects only NHH equipment, a similar situation likely exists for HH equipment given the nature of that equipment (light-duty lawn and garden equipment or gensets). Recent EPA certification data also supports this simplifying assumption. According to model year 2005 data, about 5 percent of Class I and 7 percent of Class II engines were high hour useful life (commercial) categories, or a total of about 9 percent of Classes I and II combined. About 19 percent of HH engines were high useful life categories.

Table 9.3-1: Share of Residential and Commercial Small SI Shipments (Various years)

	2003	2004
Total Commercial Turf Products	297,085	234,475
Total Consumer NHH Products	8,598,901	8.188,614
Commercial Unit Volume NHH Share	3.3%	2.8%
HH products (assumed consumer)	12,600,440	11,949,557
Commercial share - all Small SI	1.4%	1.2%

Source: Outdoor Power Equipment & Engine Service Association, 2004.

The analysis also assumes that there is a one-to-one correspondence between engines and equipment (there is only one engine per equipment unit) and that there is no market for loose engines. These assumptions are reasonable given the nature of this equipment and because owners generally do not repower this equipment when the engine fails; instead, they repair the engine or replace the equipment. This assumption makes it possible to estimate the number of engines produced directly from the number of equipment.

9.3.1.1.1 Handheld Market

The HH engine market consists of Class III (< 20 cc), IV (20-50 cc) and V (>50 cc) engines. These engines are used in similar types of equipment, all of which are small and relatively lightweight. According to the industry profile prepared for this rule, the HH market is an integrated market in that about 90 percent of HH engines are “captive” engines, with the engine and equipment manufacturer being the same company (RTI, 2006). An integrated market means the EIM can use a one-market approach.

For the purpose of this analysis, all HH engines and equipment are grouped into one engine/equipment market. This is reasonable both because it is an integrated market and because the estimated compliance costs for the HH standards are expected to be similar for all types of HH engines and equipment regardless of size or application. The proposed standards for HH consist only of evaporative emission controls and tThe cost to comply with the standards are primarily related to fuel tank volume and fuel hose length, which do not vary significantly for most equipment.

9.3.1.1.2 Nonhandheld Market

The NHH engine market consists of Class I (<225 cc) and Class II (>225 cc) engines. There are three useful life categories for each and the costs for complying with the exhaust standards will vary by useful life category for each engine class. According to the industry profile prepared for this rule, the NHH market is not integrated in that about 95 percent of Class I and Class II NHH engines are merchant engines (RTI, 2006). The model thus explores the impacts on engine producers and equipment producers separately. This means it is necessary to use a two-market approach, with the engine and equipment markets sharing some of the compliance costs and consumers bearing the rest.

Snowblowers engines are treated differently under EPA’s proposed program. The proposed program would impose only evaporative controls on these engines. Because Class I manufacturers of snowblower engines make the whole engine as a set (i.e., including fuel tank and fuel lines), it was decided to place all of the compliance costs on the engine manufacturer. These manufacturers are expected to produce a separate snowblower engine to be used in this equipment. Class II engines are commonly sold without fuel tanks, and so the evaporative controls for Class II snowblowers are attributed to the equipment manufacturer.

The nine Small SI nonhandheld engine markets are summarized in Table 9.3-2.

Table 9.3-2: Small SI Nonhandheld Engine Categories

Class	Useful Life
Class I	125 hours
	250 hours
	500 hours
Class I - Snowblower	125 hours
	250 hours
	500 hours
Class II	250 hours
	500 hours
	1000 hours

The EIM includes eight types of NHH equipment, as described in Table 9.3-3. However, because not all engine/equipment combination are applicable, there are a total of 40 engine/equipment markets. Specifically, there are no Class II lawnmowers, there are no Class I tractors, and all equipment in the "other lawn and garden" category using Class I engines are in the UL125 grouping.

Table 9.3-3: Nonhandheld Equipment Categories

Equipment	Class I	Class II
Agriculture/construction/general industrial	Yes	Yes
Utility and recreational vehicles	Yes	Yes
Lawn mowers	Yes	No
Tractors	No	Yes
Lawn and garden, other	UL125 only	Yes
Gensets/welders	Yes	Yes
Pumps/compressors/pressure washers	Yes	Yes
Snowblowers	Yes	Yes

9.3.1.2 Marine SI market

The Marine SI market is the market for a variety of marine vessels powered by gasoline engines. These proposed Marine SI standards discussed here are for propulsion engines only. Auxiliary Marine SI engines <37 kW are included as Small SI engines for this rule. Larger auxiliary Marine SI engines were covered in the new standards for Large SI engines. Many of the auxiliary Marine SI engines are being designed with catalysts independent of the proposed standards, so the proposed standards will codify what is already happening in the industry and force new entrants in the market to employ the same types of emission controls. Given that the industry is already using catalysts, the estimated costs of complying are with the proposed standards are negligible. These engines typically use the same fuel tank as the propulsion engines so evaporative emission controls for these engines impose a nominal cost that is already covered in the vessel costs since the vessel costs include costs for hoses and tanks. The impact of treating marine Auxiliary Marine SI engines in this way are expected to be minimal because the number of vessels with installed auxiliary units is small and limited to sterndrive/inboard and outboard luxury vessels: about 23,000 out of a total of 378,500 vessels.

9.3.1.2.1 Marine SI Engine Markets

Unlike Small SI engines that can be used in a variety of different types of equipment, Marine SI engines are designed and manufactured for specific applications. Engines used in sterndrive or inboard vessels are different from those used in outboard applications, and are made by different manufacturers. Outboards and SD/I engines produced for luxury vessels are different from those produced for the general market. Personal watercraft, on the other hand, are generally an integrated system. Taking this into consideration, there are 15 engine markets included in this EIA, based on design and horsepower. These are described in Table 9.3-4.

Table 9.3-4: Marine SI Engine Markets

Engine Design	<25 hp	25-50 hp	51-100 hp	101-175 hp	176-300 hp	>301 hp
PWC			XXX	XXX	XXX	
SD/I Recreation				XXX	XXX	XXX
SD/I Luxury					XXX	XXX
OB Recreational	XXX	XXX	XXX	XXX	XXX	
OB Luxury				XXX	XXX	

Similar to the Small SI market, most marine SI engines are used for recreational purposes. According to a 2000 study of the boat building industry, about 79 percent of Marine SI vessels are used for recreational purposes and only 7 percent for commercial purposes, with the remaining 14 percent for other purposes (CCA, 2000).[11] The propulsion system of choice for commercial marine vessels is diesel due to its greater reliability and lower fuel costs. The combustion characteristics of diesel engines also make them a better choice for vessels that are likely to spend large amounts of time at sea. While gasoline marine engines are used in applications such as lifeboats, patrol boats and small fishing vessels, their numbers are not large enough to warrant separate consideration in this Economic Impact Analysis.

[11]This study looked at NAICS 336612 – establishments primarily engaged in building boats, defined as watercraft not built in shipyards and typically of the type suitable or intended for personal use; it is not clear what is meant by "other" in this study.

For the purposes of this analysis, all personal watercraft manufacturers are considered to be integrated manufacturers, and thus the engines are "captive." This is reasonable because personal watercraft are similar to land-based recreational vehicles in that the engines are produced by the equipment manufacturer specifically for certain models.

The other two primary types of SI marine engines are outboards and sterndrives/inboards (SD/I). For these engines, we model a merchant relationship between the engine manufacturers and boat builders. This is reasonable because these engines are typically sold on the open market (outboards) or sold internally but through a market-type relationship between the engine and the equipment businesses (SD/I).

Outboard engines are typically produced by the engine manufacturer with little or no knowledge of what vessels the engines will be used on. Outboards are a self-contained assembly, with a power unit and drive unit, that can be fit to a wide range of boats. They may be used either with a portable fuel tank or connected to a fuel system installed on a vessel. In most cases, the engine manufacturer and boat builder are separate companies. However, it is becoming more common for engine manufacturing companies to purchase boat builders. Based on conversations with engine manufacturers and boat builders, we have received indications that this trend has not significantly changed the relationship between the engine business units and the boat building business units. The boat builders typically pay market price for the engines and there is little integration of design beyond a typical manufacturer/supplier relationship. It seems that engine manufacturers generally buy outboard vessel building companies to gain access to target markets rather than to develop an integrated design. Generally, the vessel is sold without the engine and the consumer chooses the engine at the point of sale. This means that the vessel builder may not be involved in the transaction and that the distribution of the compliance costs is between the engine builder and the end consumer rather than between the engine builder and the vessel builder.

The relationship between engine manufacturers and boat builders is similar for SD/I engines as for outboard engines. One difference is that there are only two large businesses and many small businesses producing SD/I engines. These small businesses typically do not produce boats or own companies that do. SD/I engines are often sold to buyer groups created by boat builders to gain volume discounts on engines. Because of this, SD/I engine manufacturers often do not know what boats their engines are being used in. In the case where a large SD/I manufacturer has purchased boat building companies, the relationship is similar to that for outboards. Nevertheless, the distribution of compliance costs would be between the engine manufacturer and the vessel builder, since the engine is integrated in the final vessel design.

9.3.1.2.2 Marine SI Equipment Markets

There are five types of marine vessel markets:

- SD/I recreational (runabouts, airboats, jetboats)
- SD/I luxury (yachts, cruisers offshore)
- OB recreational (runabouts, pontoons, fishing)

- OB luxury (yacht, cruiser, express fish)
- Personal watercraft

Of the 30 possible engine/vessel combinations, there are 15 combinations that are not applicable. For example, SD/I vessels use engines above 100 hp only. Personal watercraft use engines above 50 hp but do not use engines above 300 hp. This yields a total of 15 engine/vessel markets.

Table 9.3-5: Marine SI Vessel Types

Vessel	<25 hp	25-50 hp	51-100 hp	101-175 hp	176-300 hp	>301 hp
PWC			XXX	XXX	XXX	
SD/I Recreational				XXX	XXX	XXX
SD/I Luxury					XXX	XXX
OB Recreational	XXX	XXX	XXX	XXX	XXX	
OB Luxury				XXX	XXX	

Unlike Small SI equipment, there is not a one-to-one relationship between engines and equipment. Some vessels may have more than one propulsion engine. Table 9.3-6 shows the average number of engines per vessel assumed for the purposes of this analysis. In this table, OB engines per boat sale represents the average number of engines per outboard vessel in general. This average consists of three components: 1) some outboard vessels have more than one engine; 2) engines that are made as replacement engines; and 3) loose engines that are not sold with the boat, such as “kicker” engines which are used for low speed trolling.

Table 9.3-6: Average Number of Marine SI Engines per Vessel (2005)

Vessel	<25 hp	25-50 hp	51-100 hp	101-175 hp	176-300 hp	>301 hp	Average
PWC			1.00	1.00	1.00		1.00
SD/I Recreational				1.00	1.02	1.01	1.01
SD/I Luxury					1.25	1.52	1.39
OB Recreational	1.25	1.25	1.29	1.29	1.29		1.28
OB Luxury				2.50	2.50		2.50
OB Engine/boat sale							1.47

9.3.1.3 Market Linkages

In the EIM, the Small SI and Marine SI markets are not linked (there is no feedback mechanism between the Small SI and Marine SI market segments). This is appropriate because the affected equipment is not interchangeable and because there is very little overlap between the engine producers in each market. These two sectors represent different aspects of economic activity (lawn and garden care and power generation as opposed to recreational marine) and production and consumption of one product is not affected by the other. In other words, an increase in the price of lawnmowers is not expected to have an impact on the production and supply of personal watercraft, and vice versa. Production and consumption of each of these productions are the results of other factors that have little cross-over impacts (the need for residential garden upkeep or power generation; the desire for personal recreation).

9.3.2 Market Equilibrium Conditions

The starting point for the economic impact analysis is initial market equilibrium conditions (prices and quantities) 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.

9.3.2.1 Small SI Initial Equilibrium Quantities and Prices

9.3.2.1.1 Small SI Engine and Equipment Initial Equilibrium Quantities

The EIM uses the same engine sales quantities that are used in the Small SI cost analysis presented in Chapter 6. The sales numbers for 2005 are reproduced in Tables 9.3-7 and 9.3-8. They are based on engine and equipment sales are for 49 states (all states except California) for 2005. However, the sales numbers include construction and agriculture equipment sold in California, since that equipment is not covered by California's small engine program.

These engine sales numbers are taken from EPA's NONROAD 2005 emission inventory model. To breakout the sales data by equipment, industry information from Power Systems Research database-OELink was used to characterize the distribution of equipment by the eight different equipment categories noted earlier. In addition, the sales within each equipment category were apportioned to the different useful life categories based on the fraction of engines certified in each class determined from EPA certification data for model year 2005.

Because of the one-to-one correspondence between Small SI engines and equipment, the number of equipment is equal to the number of engines sold in a given year.

Table 9.3-7: Small SI Handheld Engine and Equipment Sales (2005)

Sales - All Handheld Engines, Equipment
8,153,106

Table 9.3-8: Small SI Nonhandheld Engine and Equipment Sales (2005)

Application	Class I			Class II			Total
	UL 125	UL 250	UL 500	UL 250	UL 500	UL 1000	
Agricultural/Construction/ General Industrial/ Material Handling Equip	71,682	7,675	5,287	71,380	15,503	17,585	189,112
Utility and Rec Vehicles	81,703	8,748	6,026	173,846	37,758	42,827	350,908
Lawn Mowers	5,895,682	631,264	434,859	NA	NA	NA	6,961,805
Tractors	NA	NA	NA	1,701,351	369,523	419,134	2,490,008
Lawn and Garden Other	647,256	NA	NA	127,915	27,782	31,512	834,465
Gensets/ Welders	271,391	29,058	20,017	605,169	131,439	149,086	1,206,160
Pumps/ Compressors/ Pressure Washers	579,773	62,078	42,763	253,971	55,161	62,576	1,056,322
Snowblowers	551,506	59,051	40,679	475,353	103,244	117,105	1,346,938
Total	8,098,993	797,874	549,631	3,408,985	740,410	839,816	14,435,709

9.3.2.1.2 Small SI Engine and Equipment Initial Equilibrium Prices

The initial equilibrium prices for Small SI engines and equipment are contained in Tables 9.3-9 and 9.3-10. The engine prices were prices estimated by EPA using prices compiled from various websites and obtained from manufacturers. The engine prices were averaged for each useful life category for each class. The equipment prices were gathered through a survey of retailers, government dealers, and equipment websites (Caffrey, 2006).

For the handheld market, although all costs are placed on the engine manufacturer, the engine and equipment manufacturers are integrated so only the equipment price is necessary for the analysis.

Table 9.3-9: Small SI Handheld Engine and Equipment Prices (2005$)

Equipment Price
$87

Table 9.3-10: Small SI Nonhandheld Engine and Equipment Equilibrium (2005$)

Application	Class I			Class II		
	UL 125	UL 250	UL 500	UL 250	UL 500	UL 1000
Agricultural/Construction/ General Industrial/ Material Handling Equip	$1,108	$1,621	$2,133	$1,825	$3,538	$5,251
Utility and Rec Vehicles	$570	$750	$931	$2,894	$3,981	$5,068
Lawn Mowers	$218	$420	$2,786			
Tractors				$1,937	$5,241	$6,841
Lawn and Garden Other	$245			$312	$969	$1,626
Gensets/ Welders	$999	$1,428	$1,856	$666	$1,414	$2,162
Pumps/ Compressors/ Pressure Washers	$96	$661	$1,225	$349	$1,485	$2,834
Snowblowers	$324	$480	$637	$665	$890	$1,115

9.3.2.2 Marine SI Initial Equilibrium Quantities and Prices

9.3.2.2.1 Marine SI Engine and Equipment InitialEquilibrium Quantities

The EIM uses the same engine sales quantities that are used in the Marine SI cost analysis presented in Chapter 6. The sales numbers for 2005 are reproduced in Tables 9.3-11 and 9.3-12. The engine sales data are derived for 2003 from certification databases for EPA and the California Air Resources Board and nationwide statistical data published by the National Marine Manufacturers Association (Samulski, 2004). These 2003 sales were adjusted to 2005 and future years using the growth rate described in 9.3.4.

Table 9.3-11: Marine SI Engine Sales (2005)

Vessel	<25 hp	25-50 hp	51-100 hp	101-175 hp	176-300 hp	>301 hp	Total
PWC			20,825	57,257	3,767		81,849
SD/I Recreational				15,069	35,668	25,975	76,712
SD/I Luxury					9,565	12,960	22,525
OB Recreational	38,529	52,858	79,083	46,229	42,680		259,380
OB Luxury				9,043	9,043		18,087
OB loose engines	32,667						32,667
Total	71,196	52,858	99,909	127,599	100,724	38,935	491,220

Table 9.3-12: Marine SI Vessel Sales (2005)

Vessel	<25 hp	25-50 hp	51-100 hp	101-175 hp	176-300 hp	>301 hp	Total
PWC			20,825	57,257	3,767		81,849
SD/I Recreational				15,069	34,894	25,645	75,608
SD/I Luxury					7,630	8,542	16,172
OB Recreational	30,823	42,287	61,182	35,765	33,019		203,076
OB Luxury				3,617	3,617		7,235
Total	30,823	42,287	82,007	111,708	82,928	34,186	383,940

9.3.2.2.2 Marine SI Engine and Vessel InitialEquilibrium Prices

The Marine SI engine and vessel initial equilibrium prices are contained in Tables 9.3-13 and 9.3-14. They are based on advertised prices in trade literatures and on the web and on statistical data collected by the National Marine Manufacturers Association (Samulski, 2004). For the estimated vessel prices, replacement engines are included but are discounted at 7 percent for outboard recreational and luxury outboard and sterndrive vessels. The discount is used to account for the assumption that replacement engines are purchased several years after the boat is purchased. For this analysis, the discount is based on the average useful engine life estimates in the NONROAD2005 model. The original price data was 2003 data; these were adjusted by applying the Product Price Index Series published by the U.S. Bureau of Labor Statistics.[12]

Table 9.3-13: Marine SI Engine Prices (2005$)

Vessel	<25 hp	25-50 hp	51-100 hp	101-175 hp	176-300 hp	>301 hp
PWC			N/A	N/A	N/A	
SD/I Recreational				$7,577	$12,604	$18,715
SD/I Luxury					$16,508	$31,959
OB Recreational	$2,606	$5,693	$9,114	$13,481	$20,786	
OB Luxury				$26,001	$40,074	
OB loose engines	$2,491					

[12]For Marine SI engines, the PPI for Gasoline Engines (except aircraft, automobile, highway truck, bus, and tank; PCU3336183336181) was used; the ratio for this index is 110.1/105.7 = 1.042. For marine vessel, the PPI for Boat Building (PCU 336612336612) was used; the ratio for this index is 206.7/194.2 = 1.064.

Table 9.3-14: Marine SI Vessel Prices* (2005$)

Vessel	<25 hp	25-50 hp	51-100 hp	101-175 hp	176-300 hp	>301 hp
PWC			$7,566	$9,982	$11,960	
SD/I Recreational				$16,549	$32,356	$46,432
SD/I Luxury					$58,024	$205,658
OB Recreational	$3,658	$10,884	$21,561	$32,467	$49,420	
OB Luxury				$65,097	$104,562	

*Includes replacement engines discounted at 7% for outboard recreational and luxury outboard in sterndrive/inboard vessels.

9.3.3 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 6 of this RIA and are summarized in this section.

The fixed cost portion of the engineering costs incorporate a 7 percent cost of capital recovered over the first five years of the exhaust standards even though the costs actually occur prior to the beginning of the program. The period of recovery is 2011 through 2015 for Class I Small SI engines and 2012 through 2016 for Class II Small SI engines. Marine engine fixed costs are recovered over the period 2009 through 2013 for engines and 2011 through 2016 for vessels, PWC, and outboards <25 hp. The other marine vessels have a small amount of fixed costs associated with the evaporative controls.

9.3.3.1 Small SI Market Compliance Costs

The Small SI engine and equipment compliance costs are summarized in Tables 9.3-15 and 9.3-16. There is one set of compliance costs for HH engines, since there is only one market. There are nine sets of engine compliance costs for NHH engines, one for each engine market. These costs begin in 2009 for HH and 2008 for NHH; the costs changes over time reflecting the phase-in of the different standards.

There are no equipment compliance cost estimates for HH or for Class I NHH equipment. Since the HH market is integrated, all costs are applied to engines. For NHH Class I equipment, the engine manufacturers typically produce a complete engine and fuel system package. Therefore, the proposed program is not expected to impose any additional costs on the equipment manufacturers. Costs are provided for NHH Class II equipment, reflecting the need for evaporative and emission controls. An average cost for all Class II equipment was applied in this analysis to each of the equipment categories.

Table 9.3-15: Compliance Costs per Engine - Small SI (2005$)

Class	Useful Life	Cost Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017+
Handheld												
All Engines		Variable	$0.00	$0.00	$0.81	$0.81	$0.81	$0.81	$0.81	$0.69	$0.69	$0.69
		Fixed	$0.00	$0.00	$0.01	$0.01	$0.01	$0.01	$0.01	$0.00	$0.00	$0.00
		Total	$0.00	$0.00	$0.82	$0.82	$0.82	$0.82	$0.82	$0.69	$0.69	$0.69
Nonhandheld												
1	125	Variable	$0.33	$0.33	$0.33	$0.33	$13.30	$13.17	$13.19	$13.19	$13.19	$11.95
		Fixed	$0.02	$0.02	$0.02	$0.02	$1.53	$1.49	$1.47	$1.46	$1.44	$0.19
		Total	$0.35	$0.35	$0.35	$0.35	$14.83	$14.66	$14.66	$14.64	$14.63	$12.14
1	250	Variable	$0.33	$0.33	$0.33	$0.33	$15.64	$15.51	$15.53	$15.53	$15.53	$14.21
		Fixed	$0.02	$0.02	$0.02	$0.02	$4.91	$4.81	$4.74	$4.67	$4.60	$0.19
		Total	$0.35	$0.35	$0.35	$0.35	$20.55	$20.32	$20.26	$20.19	$20.13	$14.40
1	500	Variable	$0.33	$0.33	$0.33	$0.33	$19.46	$19.33	$19.35	$19.35	$19.35	$17.73
		Fixed	$0.02	$0.02	$0.02	$0.02	$7.03	$6.89	$6.79	$6.68	$6.59	$0.19
		Total	$0.35	$0.35	$0.35	$0.35	$26.49	$26.22	$26.13	$26.03	$25.93	$17.92
1	125 Snow-blower	Variable	$0.33	$0.33	$0.33	$0.33	$2.69	$2.56	$2.58	$2.58	$2.58	$2.10
		Fixed	$0.02	$0.02	$0.02	$0.02	$0.47	$0.45	$0.45	$0.45	$0.45	$0.19
		Total	$0.35	$0.35	$0.35	$0.35	$3.16	$3.01	$3.03	$3.03	$3.03	$2.29
1	250 Snow-blower	Variable	$0.33	$0.33	$0.33	$0.33	$2.69	$2.56	$2.58	$2.58	$2.58	$2.10
		Fixed	$0.02	$0.02	$0.02	$0.02	$0.47	$0.45	$0.45	$0.45	$0.45	$0.19
		Total	$0.35	$0.35	$0.35	$0.35	$3.16	$3.01	$3.03	$3.03	$3.03	$2.29
1	500 Snow-blower	Variable	$0.33	$0.33	$0.33	$0.33	$2.69	$2.56	$2.58	$2.58	$2.58	$2.10
		Fixed	$0.02	$0.02	$0.02	$0.02	$0.47	$0.45	$0.45	$0.45	$0.45	$0.19
		Total	$0.35	$0.35	$0.35	$0.35	$3.16	$3.01	$3.03	$3.03	$3.03	$2.29
2	250	Variable	$0.00	$0.00	$0.00	$32.74	$32.74	$32.74	$32.74	$32.74	$27.06	$27.06
		Fixed	$0.00	$0.00	$0.00	$3.63	$3.56	$3.50	$3.44	$3.39	$0.00	$0.00
		Total	$0.00	$0.00	$0.00	$36.37	$36.30	$36.24	$36.18	$36.13	$27.06	$27.06
2	500	Variable	$0.00	$0.00	$0.00	$25.87	$25.87	$25.87	$25.87	$25.87	$21.63	$21.63
		Fixed	$0.00	$0.00	$0.00	$6.13	$6.02	$5.92	$5.82	$5.73	$0.00	$0.00
		Total	$0.00	$0.00	$0.00	$32.00	$31.89	$31.79	$31.69	$31.60	$21.63	$21.63
2	1,000	Variable	$0.00	$0.00	$0.00	$58.53	$58.53	$58.53	$58.53	$58.53	$45.00	$45.00
		Fixed	$0.00	$0.00	$0.00	$16.00	$15.73	$15.46	$15.20	$14.96	$0.00	$0.00
		Total	$0.00	$0.00	$0.00	$74.53	$73.99	$73.73	$73.73	$73.49	$45.00	$45.00

Table 9.3-16: Compliance Costs per Equipment - Small SI (2005$)

Class	Useful Life	Cost Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017+
Handheld												
All Engines		Variable	No equipment costs for HH; all costs are allocated to engine manufacturer									
		Fixed										
		Total										
Nonhandheld												
1	125	Variable	No equipment costs for NHH Class I; all costs are allocated to engine manufacturer									
		Fixed										
		Total										
2	250	Variable	$1.09	$1.09	$1.09	$6.44	$6.44	$6.31	$6.31	$6.31	$5.40	$5.40
		Fixed	$0.04	$0.04	$0.04	$5.11	$5.05	$4.94	$4.87	$4.81	$0.68	$0.68
		Total	$1.13	$1.13	$1.13	$11.55	$11.48	$11.24	$11.18	$11.12	$6.08	$6.08
2	500	Variable	$1.09	$1.09	$1.09	$6.44	$6.44	$6.31	$6.31	$6.31	$5.40	$5.40
		Fixed	$0.04	$0.04	$0.04	$19.03	$18.73	$18.38	$18.10	$17.83	$0.68	$0.68
		Total	$1.13	$1.13	$1.13	$25.47	$25.16	$24.69	$24.41	$24.13	$6.08	$6.08
2	1000	Variable	$1.09	$1.09	$1.09	$6.44	$6.44	$6.31	$6.31	$6.31	$5.40	$5.40
		Fixed	$0.04	$0.04	$0.04	$16.93	$16.66	$16.35	$16.10	$15.86	$0.68	$0.68
		Total	$1.13	$1.13	$1.13	$23.36	$23.10	$22.66	$22.41	$22.16	$6.08	$6.08

9.3.3.2 Marine SI Market Compliance Costs

The Marine SI engine and equipment compliance costs are summarized in Tables 9.3-17 and 9.3-18. Cost estimates are given for each of the 15 engine/equipment combinations, plus cost estimates for loose OB engines. The engine costs begin in 2009 and decrease in 2014 when the fixed costs are fully amortized. In addition, we apply a one time learning curve correction to the variable cost in the sixth year. The engine compliance costs remain the same for 2014 and later years. The equipment costs are more complicated due to the phase in of the different standards. They begin in 2009, increase until about 2012, and then decrease in 2018. Equipment compliance costs remain the same for 2018 and later years.

Table 9.3-17: Compliance Costs per Engine - Marine SI (2005$)

Application Category	HP Category	Cost Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018-23	2024+
PWC	50-100	Variable		$870	$870	$870	$870	$870	$696	$696	$696	$696	$696	$696
		Fixed		$29	$29	$29	$29	$29	---	---	---	---	---	---
		Total		$899	$899	$899	$899	$899	$696	$696	$696	$696	$696	$696
PWC	100-175	Variable		$85	$85	$85	$85	$85	$68	$68	$68	$68	$68	$68
		Fixed		$13	$13	$13	$13	$13	---	---	---	---	---	---
		Total		$98	$98	$98	$98	$98	$68	$68	$68	$68	$68	$68
PWC	175-300	Variable		$1,290	$1,290	$1,290	$1,290	$1,290	$1,032	$1,032	$1,032	$1,032	$1,032	$1,032
		Fixed		$45	$45	$45	$45	$45	---	---	---	---	---	---
		Total		$1,335	$1,335	$1,335	$1,335	$1,335	$1,032	$1,032	$1,032	$1,032	$1,032	$1,032
SD/I Recreational	100-175	Variable		$421	$421	$421	$421	$421	$337	$337	$337	$337	$337	$337
		Fixed		$19	$19	$19	$19	$19	---	---	---	---	---	---
		Total		$440	$440	$440	$440	$440	$337	$337	$337	$337	$337	$337
SD/I Recreational	175-300	Variable		$292	$292	$292	$292	$292	$234	$234	$234	$234	$234	$234
		Fixed		$20	$20	$20	$20	$20	---	---	---	---	---	---
		Total		$312	$312	$312	$312	$312	$234	$234	$234	$234	$234	$234
SD/I Recreational	300 +	Variable		$349	$349	$349	$349	$349	$279	$279	$279	$279	$279	$279
		Fixed		$28	$28	$28	$28	$28	---	---	---	---	---	---
		Total		$377	$377	$377	$377	$377	$279	$279	$279	$279	$279	$279
SD/I Luxury	175-300	Variable		$292	$292	$292	$292	$292	$234	$234	$234	$234	$234	$234
		Fixed		$20	$20	$20	$20	$20	---	---	---	---	---	---
		Total		$312	$312	$312	$312	$312	$234	$234	$234	$234	$234	$234
SD/I Luxury	300 +	Variable		$349	$349	$349	$349	$349	$279	$279	$279	$279	$279	$279
		Fixed		$28	$28	$28	$28	$28	---	---	---	---	---	---
		Total		$377	$377	$377	$377	$377	$279	$279	$279	$279	$279	$279
OB Recreational	< 25	Variable		$69	$69	$69	$69	$69	$55	$55	$55	$55	$55	$55

Application Category	HP Category	Cost Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018-23	2024+
		Fixed		$5	$5	$5	$5	$5	---	---	---	---	---	---
		Total		$74	$74	$74	$74	$74	$55	$55	$55	$55	$55	$55
OB Recreational	25-50	Variable		$216	$216	$216	$216	$216	$173	$173	$173	$173	$173	$173
		Fixed		$6	$6	$6	$6	$6	---	---	---	---	---	---
		Total		$222	$222	$222	$222	$222	$173	$173	$173	$173	$173	$173
OB Recreational	50-100	Variable		$203	$203	$203	$203	$203	$162	$162	$162	$162	$162	$162
		Fixed		$8	$8	$8	$8	$8	---	---	---	---	---	---
		Total		$211	$211	$211	$211	$211	$162	$162	$162	$162	$162	$162
OB Recreational	100-175	Variable		$338	$338	$338	$338	$338	$270	$270	$270	$270	$270	$270
		Fixed		$15	$15	$15	$15	$15	---	---	---	---	---	---
		Total		$353	$353	$353	$353	$353	$270	$270	$270	$270	$270	$270
OB Recreational	175-300	Variable		$690	$690	$690	$690	$690	$552	$552	$552	$552	$552	$552
		Fixed		$27	$27	$27	$27	$27	---	---	---	---	---	---
		Total		$717	$717	$717	$717	$717	$552	$552	$552	$552	$552	$552
OB Luxury	100-175	Variable		$338	$338	$338	$338	$338	$270	$270	$270	$270	$270	$270
		Fixed		$15	$15	$15	$15	$15	---	---	---	---	---	---
		Total		$353	$353	$353	$353	$353	$270	$270	$270	$270	$270	$270
OB Luxury	175-300	Variable		$690	$690	$690	$690	$690	$552	$552	$552	$552	$552	$552
		Fixed		$27	$27	$27	$27	$27						
		Total		$717	$717	$717	$717	$717	$552	$552	$552	$552	$552	$552
OB Loose Engines	< 25	Variable		$69	$69	$69	$69	$69	$55	$55	$55	$55	$55	$55
		Fixed		$5	$5	$5	$5	$5						
		Total		$74	$74	$74	$74	$74	$55	$55	$55	$55	$55	$55

Table 9.3-18: Compliance Costs per Equipment- Marine SI (2005$)

Application Category	HP Category	Cost Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018-23	2024+
PWC	50-100	Variable		$1.6	$1.6	$3.8	$3.8	$3.8	$3.8	$3.8	$3.8	$3.8	$3.8	$3.8
		Fixed		$0.4	$0.4	$12.1	$12.1	$12.1	$12.1	$12.1	$12.1	$5.9	$5.9	$5.9
		Total		$1.9	$1.9	$15.9	$15.9	$15.9	$15.9	$15.9	$15.9	$9.7	$9.7	$9.7
PWC	100-175	Variable		$1.9	$1.9	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7
		Fixed		$0.4	$0.4	$13.3	$13.3	$13.3	$13.3	$13.3	$13.3	$6.5	$6.5	$6.5
		Total		$2.3	$2.3	$18.0	$18.0	$18.0	$18.0	$18.0	$18.0	$11.2	$11.2	$11.2
PWC	175-300	Variable		$1.9	$1.9	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7	$4.7
		Fixed		$0.4	$0.4	$13.3	$13.3	$13.3	$13.3	$13.3	$13.3	$6.5	$6.5	$6.5
		Total		$2.3	$2.3	$18.0	$18.0	$18.0	$18.0	$18.0	$18.0	$11.2	$11.2	$11.2
SD/I Recreational	100-175	Variable		$3.8	$31.4	$31.4	$67.2	$67.2	$67.2	$67.2	$61.7	$61.7	$56.3	$56.3
		Fixed		$0.5	$0.5	$0.5	$0.6	$0.6	$0.6	$0.6	$0.1			
		Total		$4.4	$31.9	$31.9	$67.8	$67.8	$67.8	$67.8	$61.8	$61.7	$56.3	$56.3
SD/I Recreational	175-300	Variable		$4.5	$42.8	$42.8	$92.3	$92.3	$92.3	$92.3	$84.7	$84.7	$78.9	$78.9
		Fixed		$0.5	$0.5	$0.5	$0.6	$0.6	$0.6	$0.1	$0.1			
		Total		$5.0	$43.3	$43.3	$93.0	$93.0	$93.0	$92.4	$84.8	$84.7	$78.9	$78.9
SD/I Recreational	300 +	Variable		$5.2	$70.7	$70.7	$155.6	$155.6	$155.6	$155.6	$142.5	$142.5	$135.6	$135.6
		Fixed		$0.5	$0.5	$0.5	$0.6	$0.6	$0.6	$0.1	$0.1	---	---	---
		Total		$5.7	$71.2	$71.2	$156.3	$156.3	$156.3	$155.7	$142.6	$142.5	$135.6	$135.6
SD/I Luxury	175-300	Variable		$9.0	$85.5	$85.5	$184.7	$184.7	$184.7	$184.7	$169.4	$169.4	$157.8	$157.8
		Fixed		$0.5	$0.5	$0.5	$0.8	$0.8	$0.8	$0.2	$0.2	---	---	---
		Total		$9.6	$86.0	$86.0	$185.4	$185.4	$185.4	$184.9	$169.6	$169.4	$157.8	$157.8
SD/I Luxury	300 +	Variable		$10.3	$141.4	$141.4	$311.2	$311.2	$311.2	$311.2	$285.0	$285.0	$271.3	$271.3
		Fixed		$0.5	$0.5	$0.5	$0.8	$0.8	$0.8	$0.2	$0.2	---	---	---
		Total		$10.9	$141.9	$141.9	$312.0	$312.0	$312.0	$311.5	$285.3	$285.0	$271.3	$271.3

Application Category	HP Category	Cost Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018-23	2024+
OB Recreational	< 25	Variable		$3.1	$4.4	$5.4	$5.4	$5.4	$5.4	$5.4	$5.1	$5.1	$5.1	$6.1
		Fixed		$0.2	$0.2	$6.7	$6.7	$6.7	$6.7	$6.7	$3.2	$3.2	$3.2	$6.5
		Total		$3.3	$4.6	$12.0	$12.0	$12.0	$12.0	$12.0	$8.3	$8.3	$8.3	$12.6
OB Recreational	25-50	Variable		$4.4	$17.3	$17.3	$30.9	$30.9	$30.9	$30.9	$28.3	$28.3	$23.6	$23.6
		Fixed		$0.5	$0.5	$0.5	$0.6	$0.6	$0.6	$0.6	$0.1	$0.1	---	---
		Total		$5.0	$17.8	$17.8	$31.6	$31.6	$31.6	$31.6	$28.5	$28.5	$23.6	$23.6
OB Recreational	50-100	Variable		$6.5	$26.7	$26.7	$47.7	$47.7	$47.7	$47.7	$43.6	$43.6	$38.6	$38.6
		Fixed		$0.5	$0.5	$0.5	$0.6	$0.6	$0.6	$0.6	$0.1	$0.1	---	---
		Total		$7.0	$27.3	$27.3	$48.3	$48.3	$48.3	$48.3	$43.7	$43.7	$38.6	$38.6
OB Recreational	100-175	Variable		$7.7	$40.6	$40.6	$73.8	$73.8	$73.8	$73.8	$67.3	$67.3	$61.7	$61.7
		Fixed		$0.5	$0.5	$0.5	$0.6	$0.6	$0.6	$0.6	$0.1	$0.1	---	---
		Total		$8.3	$41.1	$41.1	$74.5	$74.5	$74.5	$74.5	$67.4	$67.4	$61.7	$61.7
OB Recreational	175-300	Variable		$9.0	$57.9	$57.9	$107.0	$107.0	$107.0	$107.0	$97.2	$97.2	$91.0	$91.0
		Fixed		$0.5	$0.5	$0.5	$0.6	$0.6	$0.6	$0.6	$0.1	$0.1	---	---
		Total		$9.6	$58.4	$85.4	$107.6	$107.6	$107.6	$107.6	$97.3	$97.3	$91.0	$91.0
OB Luxury	100-175	Variable		$15.5	$81.1	$81.1	$147.6	$147.6	$147.6	$147.6	$134.5	$134.5	$123.4	$123.4
		Fixed		$0.5	$0.5	$0.5	$0.8	$0.8	$0.8	$0.8	$0.2	$0.2	---	---
		Total		$16.0	$81.6	$81.6	$148.4	$148.4	$148.4	$148.4	$134.7	$134.7	$123.4	$123.4
OB Luxury	175-300	Variable		$18.1	$115.8	$115.8	$213.9	$213.9	$213.9	$213.9	$14.4	$14.4	$182.0	$182.0
		Fixed		$0.5	$0.5	$0.5	$0.8	$0.8	$0.8	$0.8	$0.2	$0.2	---	---
		Total		$18.6	$116.4	$116.4	$214.7	$214.7	$214.7	$214.7	$194.6	$194.6	$182.0	$182.0
OB Loose Engines	< 25	Variable		$3.0	$4.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$6.0
		Fixed		$6.0	$0.0	$7.0	$7.0	$7.0	$7.0	$6.0	$6.0	$3.0	$3.0	$6.0
		Total		$3.0	$5.0	$12.0	$12.0	$12.0	$12.0	$12.0	$12.0	$8.0	$8.0	$13.0

9.3.4 Growth Rates

The growth rates used in this analysis for future Small SI and Marine SI engines and equipment sales are from EPA's Nonroad 2005 model and are the same the same as those use for the cost analysis (EPA 2004b). Because the growth rates are linear, the annual growth rate decreases over time. For Small SI, the growth rate is approximately 2 percent per year beginning in 2008 to decreases to approximately 1.5 percent for 2020 and later years. The growth rate for Marine SI is about 0.8 percent per year in the early years and 0.6 percent in later years.

9.3.5 Fuel Savings

As noted in Section 9.2.4.2, there are fuel savings attributable to the proposed emission control program, reflecting the reduction in evaporative emissions and the use of more fuel-efficient engine technology to meet the proposed engine exhaust standards. As explained in that section, these savings are included in the economic welfare analysis as a separate line item. Consumers of Small SI and Marine SI engines and equipment 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 composed of two parts. First, upgrades in engine technology is expected to reduce fuel consumption rates. These fuel consumption reductions were calculated using the NONROAD2005 model. In addition, fuel savings due to evaporative emission control is estimated based on the VOC reductions attributable to these controls. 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 estimated national reductions and were not estimated by PADD, we estimated a national average retail gasoline price (RTI, Memorandum on Calculation Motor Gasoline Prices in Small SI rule EIA, 2006). 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 2005 Petroleum Marketing Annual (DoE 2005, Table 31). The results of this analysis are shown in Tables 13.3-19 and 13.3-20.

Table 9.3-19: Estimated National Average Fuel Prices (2005$)

PADD	Weight	Pre-tax Price/Gallon	Average State Taxes	Federal Tax	Post-Tax Price/Gallon
PADD 1	0.40	$1.819	$0.207	$0.184	$2.210
PADD 2	0.31	$1.792	$0.209	$0.184	$2.185
PADD 3	0.18	$1.787	$0.194	$0.184	$2.165
PADD 4	0.04	$1.848	$0.225	$0.184	$2.257
PADD 5 (excluding CA)	0.07	$1.938	$0.198	$0.184	$2.320
Total		$1.814			$2.204

Source: *2005 Petroleum Marketing Annual* (Table 31). U.S. Department of Energy, Energy Information Administration (DoE 2005). *Memorandum on Calculation Motor Gasoline Prices in Small SI Rule EIA*, RTI, 2006.

From 2009 until 2016 the estimated consumer savings associated with reduced gasoline consumption from the gas can controls increases sharply, from $16.7 million to $244 million. After 2016 the savings continue to accrue, but at a reduced rate as the engines and equipment population turns over and fuel savings are due to the continuing benefits of using compliant engines and equipment. Similarly, the tax revenue losses are expected to be increased from $3 million in 2009 to $43 million in 2016.

Table 13.3-20: Estimated Fuel Savings and Tax Revenue Impacts (2005$)

Year	Small SI Gallons	Marine SI Gallons	Total Gallons	Consumer Fuel Savings (Million$)	Tax Revenue Impacts (Million$)	Net Fuel Savings (Millions$)
2008	1,710,034	0	1,710,034	$3.8	$0.7	$3.1
2009	3,430,377	4,143,348	7,573,726	$16.7	$3.0	$13.7
2010	5,447,927	8,561,114	14,009,041	$30.9	$5.5	$25.4
2011	22,646,301	13,117,609	35,763,910	$78.8	$13.9	$64.9
2012	38,820,204	18,222,489	57,042,693	$125.7	$22.2	$103.5
2013	51,968,776	23,304,500	75,273,275	$165.9	$29.3	$136.5
2014	60,526,996	28,367,111	88,894,107	$195.9	$34.7	$161.2
2015	67,159,572	33,371,341	100,530,913	$221.5	$39.2	$182.3
2016	72,453,313	38,326,645	110,779,958	$244.1	$43.2	$200.9
2017	75,973,455	43,218,105	119,191,560	$262.6	$46.5	$216.2
2018	78,721,263	48,034,529	126,755,792	$279.3	$49.4	$229.9
2019	81,051,936	52,441,003	133,492,939	$294.2	$52.0	$242.1
2020	83,107,200	56,436,144	139,543,344	$307.5	$54.4	$253.1
2021	84,875,051	60,288,468	145,163,518	$319.9	$56.6	$263.3
2022	86,484,675	63,989,930	150,474,605	$331.6	$58.7	$272.9
2023	87,990,954	67,173,629	155,164,583	$341.9	$60.5	$281.4
2024	89,466,431	70,031,410	159,497,841	$351.5	$62.2	$289.3
2025	90,924,555	72,627,522	163,552,076	$360.4	$63.8	$296.6
2026	92,374,877	74,999,472	167,374,349	$368.8	$65.2	$303.6
2027	93,815,016	77,157,506	170,972,522	$376.7	$66.6	$310.1
2028	95,245,161	79,117,289	174,362,449	$384.2	$68.0	$316.3
2029	96,666,097	80,838,412	177,504,508	$391.1	$69.2	$321.9
2030	98,077,275	82,349,823	180,427,098	$397.6	$70.3	$327.3
2031	99,481,730	83,737,102	183,218,832	$403.7	$71.4	$332.3
2032	100,883,561	84,965,626	185,849,187	$409.5	$72.4	$337.1
2033	102,282,368	86,094,905	188,377,272	$415.1	$73.4	$341.7
2034	103,678,793	87,140,798	190,819,590	$420.5	$74.4	$346.1
2035	105,073,460	88,101,996	193,175,456	$425.7	$75.3	$350.4
2036	106,463,214	88,990,652	195,453,866	$430.7	$76.2	$354.5
2037	107,848,254	89,818,189	197,666,443	$435.6	$77.1	$358.5
2038	109,231,748	90,613,170	199,844,918	$440.4	$77.9	$362.5

9.3.6 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 Small SI and Marine SI engines and equipment 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.

Because we were unable to find published supply and demand elasticities for the Small SI and Marine SI markets, we estimated these parameters using the procedures described in Appendix 9E. 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 estimated supply and demand elasticities were based on best data we could find. For supply elasticities, we used the industry-level data published by the National Bureau of Economic Research (NBER)-Center for Economic Studies (Bartlesman, Becker, and Gray, 2000). For demand elasticities, in addition to data from the NBER, we used the Current Industrial Reports (CIR) series from the U.S. Census Bureau to produce an annual summary of the production of motors and generators and a summary of production of several types of lawn and garden equipment; both of these reports include the number of units manufactured and the value of production (U.S. Census Bureau, 1998; 2000). For walk-behind lawnmowers, we used several data series reported in a study by Air Improvement Resource, Inc., and National Economic Research Associates (AIR/NERA, 2003). The U.S. Census Bureau publishes historical data on household income and housing starts (U.S. Census Bureau, 2002; 2004), and we collected price, wage, and material cost indexes from the Bureau of Labor Statistics (BLS, 2004a,b,c,d,e). 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).[13] It should be noted that the aggregate data we used to estimate elasticities include data on other markets as well as the Small SI or Marine SI markets. If we had been able to obtain market-specific data for Small SI or Marine SI only, the estimated price elasticities may have been different.

Tables 9.3-21 and 9.3-22 provide a summary of the demand and supply elasticities used to estimate the economic impact of the proposed rule.

The estimated supply elasticities for all of the equipment and engine markets are elastic, ranging from 2.3 for all recreational marine except PWC, to 3.3 for generators, 3.4 for PWCs and all Small SI applications except generators, and 3.8 for engines. This means that quantities supplied are expected to be fairly sensitive to price changes (e.g., a 1 percent change in price yields a 3.3 percent change in quantity of generators produced).

On the demand side, the Marine SI equipment market estimated demand elasticity is elastic, at -2.0. This is consistent with the discretionary nature of purchases of recreational marine vessels (consumers can easily decide to spend their recreational budget on other alternatives).

The estimated demand elasticity for handheld equipment is elastic, at -1.9. This suggests that consumers are more sensitive to price changes for handheld equipment than for other Small SI equipment. In other words, they are more likely to change their purchase decision for a small change in the price of a string trimmer, perhaps opting for trimmer shears or deciding to forego trimming altogether.

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[13]All values are expressed in 1987$. Note the GDP deflators have been updated since the original estimation of supply elasticities for the Clean Air Nonroad Diesel rule. As a result, the elasticity estimation method is the same; however, the coefficients may vary slightly.

The estimated demand elasticity for lawnmowers is very inelastic at -0.2. This suggests that consumers of this equipment are not very sensitive to price changes. Most of this equipment is sold to individual homeowners, who are often required by local authorities to keep their lawns trimmed. Household ownership of a gasoline lawnmower is often their least expensive option. Lawncare services are more expensive since the price for these services includes labor and other factors of production. Purchasing other equipment may also not be attractive, since electric and diesel mowers are generally more expensive and often less convenient. Finally, the option of using landscape alternatives (e.g., prairie, wildflower, or rock gardens) may not be attractive for home homeowners who may also use their yards for recreational purposes. For all these reasons, the price sensitivity of homeowners to lawnmower prices would be expected to be inelastic.

All the other demand elasticities, for gensets, welders, compressors, and agriculture/ construction equipment, are about unit elastic, at -1.0 meaning a 1 percent change in price is expected to result in a 1 percent change in demand.

The demand elasticities for the engine markets are internally derived as part of the process of running the model. This is an important feature of the EIM, which allows it to link the engine and equipment components of each model and simulate how compliance costs can be expected to ripple through the affected market. In actual markets, for example, the quantity of lawnmowers produced in a particular period depends on the price of engines (the Small SI engine market) and the demand for equipment by residential consumers. Similarly, the number of engines produced depends on the demand for engines (the lawnmower market), which depends on consumer demand for equipment. Changes in conditions in one of these markets will affect the others. By designing the model to derive the engine demand elasticities, the EIM simulates these connections between supply and demand among the product markets and replicates the economic interactions between producers and consumers.

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 in considering the uncertainty involved in the estimated elasticities. The results are presented in Appendix 9H.

Table 9.3-21: Summary of Market Supply Elasticities Used in EIM

Market	Estimate	Source	Method	Input Data Source
Engine Markets Small SI and Marine SI	3.8	EPA econometric estimate	Cobb-Douglas production function	Bartlesman et al (2000); 1958-1996; SIC 3519
Marine Equipment Markets				
PWC	3.4	EPA econometric estimate	Cobb-Douglas production function	Bartlesman et al (2000); 1958-1996; SIC 3799
All other vessel types	2.3	EPA econometric estimate	Cobb-Douglas production function	Bartlesman et al (2000); 1958-1996; SIC 3732
Small SI Equipment Markets				
Gensets/welders	3.3	EPA econometric estimate	Cobb-Douglas production function	Bartlesman et al (2000); 1958-1996; SIC 3621
All other Small SI equipment (handheld and nonhandheld)	3.4	EPA econometric estimate	Cobb-Douglas production function	Bartlesman et al (2000); 1958-1996; SIC 3524

Table 9.3-22: Summary of Market Demand Elasticities Used in EIM

Market	Estimate	Source	Method	Input Data Source
Engine Markets Small SI and Marine SI	Derived Demand			
Marine Equipment Markets				
All vessel types	-2.0	EPA econometric estimate	Simultaneous equation (3SLS)	Bartlesman et al (2000); 1958-1996; SIC 3732
Small SI Equipment Markets				
HANDHELD: All	-1.9	EPA econometric estimate	Simultaneous equation (2SLS)	U.S. Census Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980-1997
NONHANDHELD				
Lawn mowers	-0.2	EPA econometric estimate	Simultaneous equation (3SLS)	AIR/NERA (2003); 1973-2002
Other lawn and garden	-0.9	EPA econometric estimate	Simultaneous equation (2SLS)	Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980-1997
Gensets/welders - Class I	-1.4	EPA econometric estimate	Simultaneous equation (2SLS)	Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980-1997
Gensets/welders - Class II	-1.1	EPA econometric estimate	Simultaneous equation (2SLS)	Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980-1997
All other nonhandheld	-1.0	EPA econometric estimate	Simultaneous equation (2SLS)	U.S. Census Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980-1997

9.3.7 Economic Impact Model Structure

9.3.7.1 Computing Baseline and With-Regulation Equilibrium Conditions

The economic impact analysis is conducted using the data and the supply and demand framework described above. The price and quantity data, along with the supply and demand elasticities, are used to identify the market supply and demand curves. The regulatory costs are then used to shift the supply curve, and the resulting new equilibrium determines the market impacts and distribution of social impacts.

Figure 9.3-1 illustrates the economic impact modeling structure. Point A represents the initial baseline equilibrium price and quantity (corresponding to the prices and quantities presented in section 9.3.2). The slope of the supply and demand curves passing through the baseline point A are determined by applying the appropriate supply and demand elasticities presented in section 9.3.6. These slopes reflect the responsiveness of producers and consumers when prices change and determine how much of the compliance costs producers are able to pass along to consumers in the with-regulation equilibrium.

The compliance costs associated with the regulation (presented in Section 9.3.3) enter the model expressed as per-unit costs and result in an upward shift in the supply curve from S_0 to S_1 in Figure 9.3-1. Note that the demand curve does not shift because consumer preferences and income are not affected by the regulation.

With the addition of the compliance costs, if prices were not allowed to adjust demanders would still want to consume the quantity at point A, but suppliers would only be willing to supply the quantity at point B (i.e., demand exceeds supply at the baseline price, P). The model then solves for the new equilibrium price (P*) where the quantity demanded equals the quantity supplied. The movement from the baseline equilibrium point A to with-regulation equilibrium point C determines the market impacts (changes in price and quantity) as well as the distribution of social costs. Appendix 9D describes the set of supply and demand equations included in the model. Given the number of equations included in the model, the solution algorithm described below is used to identify the new with-regulation set of equilibrium prices and quantities (Point C).

The analysis illustrated in Figure 9.3-1 is repeated for each year included in the period of analysis. For future years, a projected time series of prices and quantities are developed and used as the baseline (point A) from which market changes are evaluated. The engineering cost analysis provides quantities for future years using historical annual growth rates. In contrast, there is much more uncertainty surrounding future prices for these markets. As a result, we use a constant 2005 observed prices for the relevant markets during the period of analysis.

9.3.7.2 Solution Algorithm

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 is the result of a series of iterations in which price is adjusted and producers and consumers respond, until a set of stable market prices arises where total market supply equals market demand. Market price adjustment takes place based on a price-revision rule, described below, that adjusts price upward (downward) by a given percentage in response to excess demand (excess supply).

The EIM model uses a similar type of algorithm for determining with-regulation equilibria and the process can be summarized by six recursive steps:

1. Impose the control costs on affected supply segments, thereby affecting their supply decisions.

2. Recalculate the market supply in each market. Excess demand currently exists.

3. Determine the new prices via a price revision rule. We use a rule similar to the factor price revision rule described by Kimbell and Harrison (1986). P_i is the market price at iteration I, q_d is the quantity demanded, and q_s is the quantity supplied. The parameter z influences the magnitude of the price revision and speed of convergence. The revision rule increases the price when excess demand exists, lowers the price when excess supply exists, and leaves the price unchanged when market demand equals market supply. The price adjustment is expressed as follows:

$$P_{i+1} = P_1 \bullet \left(\frac{q_d}{q_s}\right)^z \qquad (10.1)$$

4. Recalculate market supply with new prices,

5. Compute market demand in each market.

6. Compare supply and demand in each market. If equilibrium conditions are not satisfied, go to Step 3, resulting in a new set of market prices. Repeat until equilibrium conditions are satisfied (i.e., the ratio of supply and demand is arbitrarily close to one). When the ratio is appropriately close to one, the market-clearing condition of supply equals demand is satisfied.

9.3.7.3 Estimating Impacts

Using the static partial equilibrium analysis, the EIM model loops through each year calculating new market equilibriums based on the projected baseline economic conditions and compliance cost estimates that shift the supply curves in the model. The model calculates price and quantity changes and uses these measures to estimate the social costs of the rule and partition the impact between producers and consumers.

9.4 Methods for Describing Uncertainty

Every economic impact analysis examining the market and social welfare impacts of a regulatory program is limited to some extent by limitations in model capabilities, deficiencies in the economic literatures with respect to estimated values of key variables necessary to configure the model, and data gaps. In this EIA, there are three main potential sources of uncertainty: (1) uncertainty resulting from the way the EIM is designed, particularly from the use of a partial equilibrium model; (2) uncertainty resulting from the values for key model parameters, particularly the price elasticity of supply and demand; and (3) uncertainty resulting from the values for key model inputs, particularly baseline equilibrium price and quantities. Sources of uncertainty that have a bearing on the results of the EIA for the proposed program are listed and described in more detail in Table 9.4-1.

The values used for the price elasticities of supply and demand are critical parameters in the EIM. The values of these parameters have an impact on both the estimated change in price and quantity produced expected as a result of compliance with the proposed standards and on how the burden of the social costs will be shared among producer and consumer groups. In selecting the values to use in the EIM it is important that they reflect the behavioral responses of the industries under analysis.

The first source of values for elasticities of supply and demand is the published economic literature. These estimates are peer reviewed and generally constitute reasonable estimates for the industries in question. In this analysis, because we were unable to find published supply and demand elasticities for the Small SI and Marine SI markets, we estimated these parameters econometrically using the procedures described in Appendix 9E.

The estimates of supply elasticities reflect a production function approach using data at the aggregate industry level. This method was chosen because of limitations with the available data: we were not able to obtain firm-level or plant-level production data for companies that operate in the affected sectors. However, the use of aggregate industry level data may not be appropriate or an accurate way to estimate the price elasticity of supply compared to firm-level or plant-level data. This is because, at the aggregate industry level, the size of the data sample is limited to the time series of the available years and because aggregate industry data may not reveal each individual firm or plant production function (heterogeneity). There may be significant differences among the firms that may be hidden in the aggregate data but that may affect the estimated elasticity. In addition, the use of time series aggregate industry data may introduce time trend effects that are difficult to isolate and control.

To address these concerns, EPA intends to investigate estimates for the price elasticity of supply for the affected industries for which published estimates are not available, using alternative methods and data inputs. This research program will use the cross-sectional data model at either the firm-level or plant level from the U.S. Census Bureau to estimate these elasticities. We plan to use the results of this research provided the results are robust and that they are available in time for the analysis for the final rule.

Table 9 .4-1 Primary Sources of Uncertainty in the Economic Impact Analysis

Source of Uncertainty	Description	Potential Impact
UNCERTAINTIES ASSOCIATED WITH ECONOMIC IMPACT MODEL STRUCTURE		
Partial equilibrium model	The EIM domain is limited to the economic sectors directly affected by the emission control program; impacts on secondary markets are not accounted for. However, such impacts are not expected to be large since directly affected products and services (small SI equipment and marine SI vessels) are mostly used by households and only a very small portion of these engines and equipment are used as production inputs to other industry (e.g., agriculture, manufacturing, construction). In addition, Small SI engines and equipment would not be a large share of total production costs for final goods and services in those commercial markets.	Results understate social costs; magnitude of impact is uncertain.
National level model	The EIM considers only national-level impacts; regional impacts are not modeled. This is appropriate because Small SI engine and equipment or Marine SI engine and vessel markets are national markets. While there may be some regional differences these are likely to be small due to the competitive nature of the manufacture industry.	Impacts uncertain
Supply side assumptions	On the supply side, industries are assumed to be mature and behave linearly within the range of analysis; no substitution between production inputs. This is appropriate because per unit compliance costs are not large enough to prompt a major change in product design or assembly.	Impacts uncertain
Demand side assumption	On the demand side, end consumer's preferences or consumption patterns are assumed to be constant and behave linearly within the range of analysis. This is appropriate because all other factors in the demand function will not be changed by the proposed rule.	Impacts uncertain
Constant price assumption	Prices are assumed to be constant across the period of analysis. This is a reasonable assumption since it is not possible to predict changes in these prices over time (see Appendix G).	Impacts uncertain
Period of analysis	Each period of analysis is assumed to be independent of previous period and producers are assumed to not engage in long-term planning to smooth the compliance costs over a longer period of time. Because the new exhaust standards will not go into effect for several years after the program is finalized, producers may in fact take the full program into account in production plans to minimize their costs.	Estimated price changes may be too high for early periods, too low for later periods; magnitude of impact is uncertain

Market shock	In the EIM, the market is shocked by the full compliance costs, including variable and fixed costs. This is appropriate because producers in these industries may not engage in R&D on a continuous basis and thus the product changes that would be required to comply with the proposed standards would require manufacturers to devote new funds and resources to product redesign. A sensitivity analysis performed that excludes fixed costs in supply shift.	Results may overstate distribution of social costs to some producers, understate market impacts; magnitude of impact is uncertain *Sensitivity analysis performed*
UNCERTAINTIES ASSOCIATED WITH PRICE ELASTICITY ESTIMATION		
	Uncertainty resulting from the functional form used in the estimation, the data used (aggregate or firm-level), the time period involved, sample size.	Impacts on distribution of social costs among stakeholders (e.g., higher supply elasticity would result in less social costs for manufacturers and more social costs for consumers) Impacts on market analysis (change in price, change in quantity produced) Magnitude of impact is uncertain *Sensitivity analysis performed*
UNCERTAINTIES ASSOCIATED WITH DATA INPUTS		
Submarket groupings	Submarket data is assumed to be representative and capture the range of affected equipment. However, the product groupings in NAICS or SIC 4-digit categories may include other engines or equipment that may not have the same production or consumption characteristics; these groupings not behave the same way as the directly-affected industries.	Impacts on social welfare and market analyses uncertain
Baseline equilibrium prices	Estimated baseline equilibrium prices are assumed to be representative and capture the range of affected equipment, and reflect actual transaction prices. However, the actual prices paid by consumers may be different. Also, the mix of products included in price analysis may not be representative of the population.	Impacts on market analysis uncertain
Baseline equilibrium quantities	Estimated baseline equilibrium quantities and future quantities assumed to be representative; these are the same as the cost analysis.	Impacts on market analysis uncertain

To explore the effects of key sources of uncertainty, we performed a sensitivity analysis in which we examine the results of using alternative values for the price elasticity of supply and demand (using the upper and lower bound of at 95 percent confidence interval around the point estimate for each elasticity estimate), alternative methods to shock to the market equilibrium (using variable costs only) and alternative baseline equilibrium prices for lawnmowers and tractors. The results of these analyses are contained in Appendix 9H. A summary of the results are presented in Table 9.4-2.

Table 9.4-2. Results of Sensitivity Analysis

Parameter	Year	Change in Value	Impact
Price Elasticity of Supply	2013	More elastic (upper bound of 95 percent confidence interval for each elasticity estimate)	Negligible impact on expected price increase and quantity decrease (less than 0.2 additional increase in price increase compared to primary analysis; less than 0.2 additional increase in quantity decrease compared to primary analysis) More elasticity price elasticity of supply associated with increase in social cost burden for users of Small SI and Marine SI engines and equipment (shift of about 1.4 percent of burden of compliance costs from producers to consumers in Marine SI market; shift of about 2.0 percent of burden of compliance costs from producers to consumers in Small SI market)
	2013	Less Elastic (lower bound of 95 percent confidence interval for each elasticity estimate)	Negligible impact on expected price increase and quantity decrease (less than 0.1 additional increase in price increase compared to primary analysis; less than 0.2 percent additional increase in quantity decrease compared to primary analysis) Higher value associated with increase in social cost burden for producers of Small SI and Marine SI engines and equipment (shift of about 1.3 percent of burden of compliance costs from consumers to producers in Marine SI market; shift of about 1.9 percent of burden of compliance costs from consumers to producers in Small SI market)
Price Elasticity of Demand	2013	More Elastic (upper bound of 95 percent confidence interval for each elasticity estimate)	Negligible impact on expected price increase and quantity decrease (less than 1.0 percent additional increase in price increase compared to primary analysis; less than 1.5 additional increase in quantity decrease, compared to primary analysis) More elastic price elasticity of demand associated with increase in social cost burden for producers of Small SI and Marine SI engines and equipment (shift of about 11 percent of burden of compliance costs from consumers to producers in Marine SI market; shift of about 10 percent of burden of compliance costs from consumers to producers in Small SI market)

	2013	Less Elastic (lower bound of 95 percent confidence interval for each elasticity estimate)	Negligible impact on expected price increase and quantity decrease (less than 2.0 percent additional increase in price increase compared to primary analysis; less than 2.5 additional increase in quantity decrease, compared to primary analysis) Less elastic price elasticity of demand associated with increase in social cost burden for users of Small SI and Marine SI engines and equipment (shift of about 30.5 percent of burden of compliance costs from producers to consumers in Marine SI market; shift of about 14.5 percent of burden of compliance costs from producers to consumers in Small SI market)
Market Supply Shift	2013	Include only variable costs	Smaller projected price increases and quantity decreases (less than 1.5 percent additional increase in price compared to primary analysis; less than 1.0 percent additional increase in quantity decrease, compared to primary analysis) Engine and equipment manufacturers expected to bear larger share of total compliance costs (shift of about 3.1 percent of burden of compliance costs from consumers to producers in Marine SI market; shift of about 16.2 percent of burden of compliance costs from consumers to producers in Small SI market)
Alternative Baseline Equilibrium Price - Lawnmowers and Tractors	2013	Lower baseline equilibrium price	Larger percent increase in price and percent decrease in quantity, although absolute changes are smaller (about 2 percent additional price increase for both sectors compared to primary analysis; about 0.4 percent additional quantity decrease for lawn mowers and about 1.9 percent additional quantity decrease for tractors compared to primary analysis) Social welfare impacts unchanged.

Chapter 9 References

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Appendix 9A: Impacts on Small SI Markets

This appendix provides the time series of impacts from 2008 through 2038 for the following Small SI engines and equipment markets; a complete set of results for all markets can be found in the docket for this rule (Li, 2007). Results are presented for equipment in the Class I UL125 and Class II UL250 categories because those are the categories with the highest sales.

- Class I engines
- Class II engines
- Agriculture/construcion/general industrial, UL125 and UL250
- Utility and recreational vehicles, UL125 and UL250
- Lawn mowers, UL125
- Tractors, UL250
- Lawn and garden other, UL125 and UL250
- Gensets/welders, UL125 and 250
- Pumps/compressors, pressure washers, UL125 and UL250
- Snowblowers, UL125 and UL250

Table 9A-1 through Table 9A-17 provide the time series of impacts for each engine class market and each selected equipment market, respectively, includes the following:

- average engine or equipment price
- average engineering costs (variable and fixed) per engine or equipment
- absolute change in the market price ($)
- relative change in market price (%)
- relative change in market quantity (%)
- total engineering costs associated with each engine or equipment market
- changes in producer surplus associated with each engine or equipment market

All prices and costs are presented in 2005 dollars and real engine or equipment prices are assumed to be constant during the period of analysis. Net present values were estimated using social discount rates of 3 percent and 7 percent over the period of analysis.

Table 9A-1: Impact on Small SI Engine Market
Class I (Average Price per Engine = $130)[a]

	Small SI Engine (Class I)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers Surplus (million $)
2008	$0	$0	0.3%	0.0%	$0.0	–$0.2
2009	$0	$0	0.3%	0.0%	$3.6	–$0.2
2010	$0	$0	0.3%	0.0%	$3.7	–$0.2
2011	$0	$0	0.3%	0.0%	$3.7	–$0.2
2012	$15	$14	10.9%	–2.0%	$161.9	–$7.3
2013	$15	$14	10.7%	–2.0%	$162.8	–$7.4
2014	$15	$14	10.7%	–2.0%	$165.4	–$7.5
2015	$15	$14	10.7%	–2.0%	$167.8	–$7.6
2016	$15	$14	10.7%	–2.0%	$170.2	–$7.7
2017	$12	$11	8.6%	–1.6%	$139.0	–$6.3
2018	$12	$11	8.6%	–1.6%	$141.2	–$6.4
2019	$12	$11	8.6%	–1.6%	$143.4	–$6.5
2020	$12	$11	8.6%	–1.6%	$145.6	–$6.6
2021	$12	$11	8.6%	–1.6%	$147.7	–$6.7
2022	$12	$11	8.6%	–1.6%	$149.9	–$6.8
2023	$12	$11	8.6%	–1.6%	$152.1	–$6.9
2024	$12	$11	8.6%	–1.6%	$154.3	–$7.0
2025	$12	$11	8.6%	–1.6%	$156.5	–$7.1
2026	$12	$11	8.6%	–1.6%	$158.7	–$7.2
2027	$12	$11	8.6%	–1.6%	$160.9	–$7.3
2028	$12	$11	8.6%	–1.6%	$163.1	–$7.4
2029	$12	$11	8.6%	–1.6%	$165.3	–$7.5
2030	$12	$11	8.6%	–1.6%	$167.5	–$7.6
2031	$12	$11	8.6%	–1.6%	$169.7	–$7.7
2032	$12	$11	8.6%	–1.6%	$171.9	–$7.8
2033	$12	$11	8.6%	–1.6%	$174.1	–$7.9
2034	$12	$11	8.6%	–1.6%	$176.3	–$7.9
2035	$12	$11	8.6%	–1.6%	$178.5	–$8.1
2036	$12	$11	8.6%	–1.6%	$180.7	–$8.2
2037	$12	$11	8.6%	–1.6%	$182.9	–$8.3
2038	$12	$11	8.6%	–1.6%	$185.2	–$8.4
NPV (3%)					$2,630.8	–$119.5
NPV (7%)					$1,466.2	–$66.7

[a] Figures are in 2005 dollars.

Table 9A-2. Impact on Small SI Engine Market
Class II (Average Price per Engine = $290)[a]

	Small SI Engine (Class II)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers Surplus (million $)
2008	$0	$0	0.0%	–0.1%	$0.0	–$0.2
2009	$0	$0	0.0%	–0.1%	$0.0	–$0.2
2010	$0	$0	0.0%	–0.1%	$0.0	–$0.2
2011	$42	$40	14.0%	–3.1%	$202.2	–$10.8
2012	$42	$40	13.9%	–3.1%	$205.2	–$10.9
2013	$42	$40	13.9%	–3.1%	$208.3	–$11.0
2014	$42	$40	13.9%	–3.0%	$211.3	–$11.2
2015	$42	$40	13.8%	–3.0%	$214.3	–$11.3
2016	$29	$28	10.1%	–2.0%	$152.7	–$7.3
2017	$29	$28	10.1%	–2.0%	$155.1	–$7.4
2018	$29	$28	10.1%	–2.0%	$157.6	–$7.5
2019	$29	$28	10.1%	–2.0%	$160.1	–$7.6
2020	$29	$28	10.1%	–2.0%	$162.5	–$7.8
2021	$29	$28	10.1%	–2.0%	$165.0	–$7.9
2022	$29	$28	10.1%	–2.0%	$167.4	–$8.0
2023	$29	$28	10.1%	–2.0%	$169.9	–$8.1
2024	$29	$28	10.1%	–2.0%	$172.4	–$8.2
2025	$29	$28	10.1%	–2.0%	$174.8	–$8.3
2026	$29	$28	10.1%	–2.0%	$177.3	–$8.5
2027	$29	$28	10.1%	–2.0%	$179.8	–$8.6
2028	$29	$28	10.1%	–2.0%	$182.3	–$8.7
2029	$29	$28	10.1%	–2.0%	$184.7	–$8.8
2030	$29	$28	10.1%	–2.0%	$187.2	–$8.9
2031	$29	$28	10.1%	–2.0%	$189.7	–$9.1
2032	$29	$28	10.1%	–2.0%	$192.2	–$9.2
2033	$29	$28	10.1%	–2.0%	$194.7	–$9.3
2034	$29	$28	10.1%	–2.0%	$197.1	–$9.4
2035	$29	$28	10.1%	–2.0%	$199.6	–$9.5
2036	$29	$28	10.1%	–2.0%	$202.1	–$9.7
2037	$29	$28	10.1%	–2.0%	$204.6	–$9.8
2038	$29	$28	10.1%	–2.0%	$207.0	–$9.9
NPV (3%)					$3,164.8	–$156.3
NPV (7%)					$1,828.9	–$91.5

[a] Figures are in 2005 dollars.

Table 9A-3: Impact on Small SI Equipment Market
Handheld (Average Price per Equipment = $87)[a,b]

	Small SI Equipment (Handheld)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers Surplus (million $)
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$0	$0	0.0%	0.0%	$0.0	$0.0
2010	$1	$1	0.6%	–1.1%	$7.3	–$2.6
2011	$1	$1	0.6%	–1.1%	$7.4	–$2.6
2012	$1	$1	0.6%	–1.1%	$7.5	–$2.7
2013	$1	$1	0.6%	–1.1%	$7.7	–$2.7
2014	$1	$1	0.6%	–1.1%	$7.8	–$2.8
2015	$1	$0	0.5%	–1.0%	$6.7	–$2.4
2016	$1	$0	0.5%	–1.0%	$6.8	–$2.4
2017	$1	$0	0.5%	–1.0%	$6.9	–$2.5
2018	$1	$0	0.5%	–1.0%	$7.0	–$2.5
2019	$1	$0	0.5%	–1.0%	$7.1	–$2.6
2020	$1	$0	0.5%	–1.0%	$7.2	–$2.6
2021	$1	$0	0.5%	–1.0%	$7.4	–$2.6
2022	$1	$0	0.5%	–1.0%	$7.5	–$2.7
2023	$1	$0	0.5%	–1.0%	$7.6	–$2.7
2024	$1	$0	0.5%	–1.0%	$7.7	–$2.7
2025	$1	$0	0.5%	–1.0%	$7.8	–$2.8
2026	$1	$0	0.5%	–1.0%	$7.9	–$2.8
2027	$1	$0	0.5%	–1.0%	$8.0	–$2.9
2028	$1	$0	0.5%	–1.0%	$8.1	–$2.9
2029	$1	$0	0.5%	–1.0%	$8.2	–$2.9
2030	$1	$0	0.5%	–1.0%	$8.3	–$3.0
2031	$1	$0	0.5%	–1.0%	$8.4	–$3.0
2032	$1	$0	0.5%	–1.0%	$8.5	–$3.1
2033	$1	$0	0.5%	–1.0%	$8.7	–$3.1
2034	$1	$0	0.5%	–1.0%	$8.8	–$3.1
2035	$1	$0	0.5%	–1.0%	$8.9	–$3.2
2036	$1	$0	0.5%	–1.0%	$9.0	–$3.2
2037	$1	$0	0.5%	–1.0%	$9.1	–$3.2
2038	$1	$0	0.5%	–1.0%	$9.2	–$3.3
NPV (3%)					$139.9	–$49.9
NPV (7%)					$81.3	–$29.0

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-4: Impact on Small SI Equipment Market: Class I Ag/Constr./Gen. Ind/ Material Handling Equipment UL 125 (Average Price per Equipment = $1,108)[a,b]

	Class 1 Agricultural/Construction/General Industrial/ Material Handling Equipment UL 125					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$0	$0	0.0%	0.0%	$0.0	$0.0
2010	$0	$0	0.0%	0.0%	$0.0	$0.0
2011	$0	$0	0.0%	0.0%	$0.0	$0.0
2012	$0	$12	1.1%	–1.1%	$0.0	–$0.3
2013	$0	$12	1.1%	–1.1%	$0.0	–$0.3
2014	$0	$12	1.1%	–1.1%	$0.0	–$0.3
2015	$0	$12	1.1%	–1.1%	$0.0	–$0.3
2016	$0	$12	1.1%	–1.1%	$0.0	–$0.3
2017	$0	$9	0.8%	–0.8%	$0.0	–$0.2
2018	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2019	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2020	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2021	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2022	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2023	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2024	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2025	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2026	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2027	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2028	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2029	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2030	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2031	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2032	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2033	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2034	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2035	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2036	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2037	$0	$9	0.8%	–0.8%	$0.0	–$0.3
2038	$0	$9	0.8%	–0.8%	$0.0	–$0.3
NPV (3%)					$0.0	–$4.8
NPV (7%)					$0.0	–$2.7

[a] Figures are in 2005 dollars.

[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-5: Impact on Small SI Equipment Market: Class I Utility and Recreational Vehicles UL 125 (Average Price per Equipment = $570)[a,b]

	Small SI Equipment (Class I Utility and Recreational Vehicles UL 125)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$0	$0	0.0%	0.0%	$0.0	$0.0
2010	$0	$0	0.0%	0.0%	$0.0	$0.0
2011	$0	$0	0.0%	0.0%	$0.0	$0.0
2012	$0	$12	2.1%	–2.1%	$0.0	–$0.3
2013	$0	$12	2.0%	–2.0%	$0.0	–$0.3
2014	$0	$12	2.0%	–2.0%	$0.0	–$0.3
2015	$0	$12	2.0%	–2.0%	$0.0	–$0.3
2016	$0	$12	2.0%	–2.0%	$0.0	–$0.3
2017	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2018	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2019	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2020	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2021	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2022	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2023	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2024	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2025	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2026	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2027	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2028	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2029	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2030	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2031	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2032	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2033	$0	$9	1.6%	–1.6%	$0.0	–$0.3
2034	$0	$9	1.6%	–1.6%	$0.0	–$0.4
2035	$0	$9	1.6%	–1.6%	$0.0	–$0.4
2036	$0	$9	1.6%	–1.6%	$0.0	–$0.4
2037	$0	$9	1.6%	–1.6%	$0.0	–$0.4
2038	$0	$9	1.6%	–1.6%	$0.0	–$0.4
NPV (3%)					$0.0	–$5.1
NPV (7%)					$0.0	–$2.8

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-6: Impact on Small SI Equipment Market: Class I Lawn Mowers UL 125 (Average Price per Equipment = $218)[a,b]

	Small SI Equipment (Class I Lawn Mowers UL 125)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.1%	0.0%	$0.0	–$0.1
2009	$0	$0	0.1%	0.0%	$0.0	–$0.1
2010	$0	$0	0.1%	0.0%	$0.0	–$0.1
2011	$0	$0	0.1%	0.0%	$0.0	–$0.1
2012	$0	$14	6.6%	–1.3%	$0.0	–$5.4
2013	$0	$14	6.6%	–1.2%	$0.0	–$5.4
2014	$0	$14	6.6%	–1.2%	$0.0	–$5.5
2015	$0	$14	6.6%	–1.2%	$0.0	–$5.6
2016	$0	$14	6.5%	–1.2%	$0.0	–$5.7
2017	$0	$11	5.2%	–1.0%	$0.0	–$4.6
2018	$0	$11	5.2%	–1.0%	$0.0	–$4.7
2019	$0	$11	5.2%	–1.0%	$0.0	–$4.8
2020	$0	$11	5.2%	–1.0%	$0.0	–$4.8
2021	$0	$11	5.2%	–1.0%	$0.0	–$4.9
2022	$0	$11	5.2%	–1.0%	$0.0	–$5.0
2023	$0	$11	5.2%	–1.0%	$0.0	–$5.1
2024	$0	$11	5.2%	–1.0%	$0.0	–$5.1
2025	$0	$11	5.2%	–1.0%	$0.0	–$5.2
2026	$0	$11	5.2%	–1.0%	$0.0	–$5.3
2027	$0	$11	5.2%	–1.0%	$0.0	–$5.4
2028	$0	$11	5.2%	–1.0%	$0.0	–$5.4
2029	$0	$11	5.2%	–1.0%	$0.0	–$5.5
2030	$0	$11	5.2%	–1.0%	$0.0	–$5.6
2031	$0	$11	5.2%	–1.0%	$0.0	–$5.6
2032	$0	$11	5.2%	–1.0%	$0.0	–$5.7
2033	$0	$11	5.2%	–1.0%	$0.0	–$5.8
2034	$0	$11	5.2%	–1.0%	$0.0	–$5.9
2035	$0	$11	5.2%	–1.0%	$0.0	–$5.9
2036	$0	$11	5.2%	–1.0%	$0.0	–$6.0
2037	$0	$11	5.2%	–1.0%	$0.0	–$6.1
2038	$0	$11	5.2%	–1.0%	$0.0	–$6.2
NPV (3%)					$0.0	–$87.6
NPV (7%)					$0.0	–$48.8

[a] Figures are in 2005 dollars.

[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-7: Impact on Small SI Equipment Market: Class I Other Lawn and Garden Equipment UL 125 (Average Price per Equipment = $245)[a,b]

	Small SI Equipment (Class I Other Lawn and Garden Equipment UL 125)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.1%	–0.1%	$0.0	–$0.1
2009	$0	$0	0.1%	–0.1%	$0.0	–$0.1
2010	$0	$0	0.1%	–0.1%	$0.0	–$0.1
2011	$0	$0	0.1%	–0.1%	$0.0	–$0.1
2012	$0	$12	4.9%	–4.4%	$0.0	–$2.3
2013	$0	$12	4.9%	–4.4%	$0.0	–$2.3
2014	$0	$12	4.9%	–4.4%	$0.0	–$2.4
2015	$0	$12	4.9%	–4.4%	$0.0	–$2.4
2016	$0	$12	4.9%	–4.4%	$0.0	–$2.4
2017	$0	$10	3.9%	–3.5%	$0.0	–$2.0
2018	$0	$10	3.9%	–3.5%	$0.0	–$2.0
2019	$0	$10	3.9%	–3.5%	$0.0	–$2.0
2020	$0	$10	3.9%	–3.5%	$0.0	–$2.1
2021	$0	$10	3.9%	–3.5%	$0.0	–$2.1
2022	$0	$10	3.9%	–3.5%	$0.0	–$2.1
2023	$0	$10	3.9%	–3.5%	$0.0	–$2.2
2024	$0	$10	3.9%	–3.5%	$0.0	–$2.2
2025	$0	$10	3.9%	–3.5%	$0.0	–$2.2
2026	$0	$10	3.9%	–3.5%	$0.0	–$2.3
2027	$0	$10	3.9%	–3.5%	$0.0	–$2.3
2028	$0	$10	3.9%	–3.5%	$0.0	–$2.3
2029	$0	$10	3.9%	–3.5%	$0.0	–$2.4
2030	$0	$10	3.9%	–3.5%	$0.0	–$2.4
2031	$0	$10	3.9%	–3.5%	$0.0	–$2.4
2032	$0	$10	3.9%	–3.5%	$0.0	–$2.5
2033	$0	$10	3.9%	–3.5%	$0.0	–$2.5
2034	$0	$10	3.9%	–3.5%	$0.0	–$2.5
2035	$0	$10	3.9%	–3.5%	$0.0	–$2.5
2036	$0	$10	3.9%	–3.5%	$0.0	–$2.6
2037	$0	$10	3.9%	–3.5%	$0.0	–$2.6
2038	$0	$10	3.9%	–3.5%	$0.0	–$2.6
NPV (3%)					$0.0	–$37.7
NPV (7%)					$0.0	–$21.1

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-8: Impact on Small SI Equipment Market: Class I Gensets/Welders UL 125 (Average Price per Equipment = $999)[a,b]

	Small SI Equipment (Class I Gensets/Welders UL 125)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$0	$0	0.0%	0.0%	$0.0	$0.0
2010	$0	$0	0.0%	0.0%	$0.0	$0.0
2011	$0	$0	0.0%	0.0%	$0.0	$0.0
2012	$0	$11	1.1%	–1.5%	$0.0	–$1.4
2013	$0	$11	1.1%	–1.5%	$0.0	–$1.4
2014	$0	$11	1.1%	–1.5%	$0.0	–$1.4
2015	$0	$11	1.1%	–1.5%	$0.0	–$1.4
2016	$0	$11	1.1%	–1.5%	$0.0	–$1.4
2017	$0	$9	0.9%	–1.2%	$0.0	–$1.2
2018	$0	$9	0.9%	–1.2%	$0.0	–$1.2
2019	$0	$9	0.9%	–1.2%	$0.0	–$1.2
2020	$0	$9	0.9%	–1.2%	$0.0	–$1.2
2021	$0	$9	0.9%	–1.2%	$0.0	–$1.2
2022	$0	$9	0.9%	–1.2%	$0.0	–$1.3
2023	$0	$9	0.9%	–1.2%	$0.0	–$1.3
2024	$0	$9	0.9%	–1.2%	$0.0	–$1.3
2025	$0	$9	0.9%	–1.2%	$0.0	–$1.3
2026	$0	$9	0.9%	–1.2%	$0.0	–$1.3
2027	$0	$9	0.9%	–1.2%	$0.0	–$1.4
2028	$0	$9	0.9%	–1.2%	$0.0	–$1.4
2029	$0	$9	0.9%	–1.2%	$0.0	–$1.4
2030	$0	$9	0.9%	–1.2%	$0.0	–$1.4
2031	$0	$9	0.9%	–1.2%	$0.0	–$1.4
2032	$0	$9	0.9%	–1.2%	$0.0	–$1.5
2033	$0	$9	0.9%	–1.2%	$0.0	–$1.5
2034	$0	$9	0.9%	–1.2%	$0.0	–$1.5
2035	$0	$9	0.9%	–1.2%	$0.0	–$1.5
2036	$0	$9	0.9%	–1.2%	$0.0	–$1.5
2037	$0	$9	0.9%	–1.2%	$0.0	–$1.5
2038	$0	$9	0.9%	–1.2%	$0.0	–$1.6
NPV (3%)					$0.0	–$22.1
NPV (7%)					$0.0	–$12.3

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-9: Impact on Small SI Equipment Market: Class I Pumps/Compressors/Pressure Washers UL 125 (Average Price per Equipment = $96)[a,b]

	Small SI Equipment (Class I Pumps/Compressors/Pressure Washers UL 125)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers Surplus (million $)
2008	$0	$0	0.3%	–0.3%	$0.0	–$0.1
2009	$0	$0	0.3%	–0.3%	$0.0	–$0.1
2010	$0	$0	0.3%	–0.3%	$0.0	–$0.1
2011	$0	$0	0.3%	–0.3%	$0.0	–$0.1
2012	$0	$12	12.3%	–12.3%	$0.0	–$2.2
2013	$0	$12	12.2%	–12.2%	$0.0	–$2.2
2014	$0	$12	12.2%	–12.2%	$0.0	–$2.2
2015	$0	$12	12.1%	–12.1%	$0.0	–$2.2
2016	$0	$12	12.1%	–12.1%	$0.0	–$2.3
2017	$0	$9	9.7%	–9.7%	$0.0	–$1.9
2018	$0	$9	9.7%	–9.7%	$0.0	–$1.9
2019	$0	$9	9.7%	–9.7%	$0.0	–$1.9
2020	$0	$9	9.7%	–9.7%	$0.0	–$2.0
2021	$0	$9	9.7%	–9.7%	$0.0	–$2.0
2022	$0	$9	9.7%	–9.7%	$0.0	–$2.0
2023	$0	$9	9.7%	–9.7%	$0.0	–$2.0
2024	$0	$9	9.7%	–9.7%	$0.0	–$2.1
2025	$0	$9	9.7%	–9.7%	$0.0	–$2.1
2026	$0	$9	9.7%	–9.7%	$0.0	–$2.1
2027	$0	$9	9.7%	–9.7%	$0.0	–$2.2
2028	$0	$9	9.7%	–9.7%	$0.0	–$2.2
2029	$0	$9	9.7%	–9.7%	$0.0	–$2.2
2030	$0	$9	9.7%	–9.7%	$0.0	–$2.3
2031	$0	$9	9.7%	–9.7%	$0.0	–$2.3
2032	$0	$9	9.7%	–9.7%	$0.0	–$2.3
2033	$0	$9	9.7%	–9.7%	$0.0	–$2.3
2034	$0	$9	9.7%	–9.7%	$0.0	–$2.4
2035	$0	$9	9.7%	–9.7%	$0.0	–$2.4
2036	$0	$9	9.7%	–9.7%	$0.0	–$2.4
2037	$0	$9	9.7%	–9.7%	$0.0	–$2.5
2038	$0	$9	9.7%	–9.7%	$0.0	–$2.5
NPV (3%)					$0.0	–$35.6
NPV (7%)					$0.0	–$19.9

[a] Figures are in 2005 dollars.

[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-10: Impact on Small SI Equipment Market: Class I Snowblowers UL 125 (Average Price per Equipment = $324)[a,b]

	Small SI Equipment (Class I Snowblowers UL 125)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers Surplus (million $)
2008	$0	$0	0.1%	–0.1%	$0.0	$0.0
2009	$0	$0	0.1%	–0.1%	$0.0	$0.0
2010	$0	$0	0.1%	–0.1%	$0.0	–$0.1
2011	$0	$0	0.1%	–0.1%	$0.0	–$0.1
2012	$0	$2	0.7%	–0.7%	$0.0	–$0.4
2013	$0	$2	0.7%	–0.7%	$0.0	–$0.4
2014	$0	$2	0.7%	–0.7%	$0.0	–$0.4
2015	$0	$2	0.7%	–0.7%	$0.0	–$0.4
2016	$0	$2	0.7%	–0.7%	$0.0	–$0.4
2017	$0	$2	0.5%	–0.5%	$0.0	–$0.3
2018	$0	$2	0.5%	–0.5%	$0.0	–$0.3
2019	$0	$2	0.5%	–0.5%	$0.0	–$0.3
2020	$0	$2	0.5%	–0.5%	$0.0	–$0.3
2021	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2022	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2023	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2024	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2025	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2026	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2027	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2028	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2029	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2030	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2031	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2032	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2033	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2034	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2035	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2036	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2037	$0	$2	0.5%	–0.5%	$0.0	–$0.4
2038	$0	$2	0.5%	–0.5%	$0.0	–$0.4
NPV (3%)					$0.0	–$6.4
NPV (7%)					$0.0	–$3.6

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-11: Impact on Small SI Equipment Market: Class II Agri/Constr./G. Ind/ Material Handling Equipment UL 250 (Average Price per Equipment = $1,825)[a,b]

	Small SI Equipment (Class II Agricultural/Construction /General Industrial/ Material Handling Equipment UL 250)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$1	0.0%	0.0%	$0.0	$0.0
2009	$1	$1	0.0%	0.0%	$0.1	$0.0
2010	$1	$1	0.0%	0.0%	$0.1	$0.0
2011	$12	$35	1.9%	–1.9%	$0.9	–$0.8
2012	$11	$35	1.9%	–1.9%	$0.9	–$0.8
2013	$11	$35	1.9%	–1.9%	$0.9	–$0.9
2014	$11	$35	1.9%	–1.9%	$0.9	–$0.9
2015	$11	$35	1.9%	–1.9%	$0.9	–$0.9
2016	$6	$25	1.3%	–1.3%	$0.5	–$0.6
2017	$6	$25	1.3%	–1.3%	$0.5	–$0.6
2018	$6	$25	1.3%	–1.3%	$0.5	–$0.6
2019	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2020	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2021	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2022	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2023	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2024	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2025	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2026	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2027	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2028	$6	$25	1.3%	–1.3%	$0.6	–$0.7
2029	$6	$25	1.3%	–1.3%	$0.6	–$0.8
2030	$6	$25	1.3%	–1.3%	$0.6	–$0.8
2031	$6	$25	1.3%	–1.3%	$0.7	–$0.8
2032	$6	$25	1.3%	–1.3%	$0.7	–$0.8
2033	$6	$25	1.3%	–1.3%	$0.7	–$0.8
2034	$6	$25	1.3%	–1.3%	$0.7	–$0.8
2035	$6	$25	1.3%	–1.3%	$0.7	–$0.8
2036	$6	$25	1.3%	–1.3%	$0.7	–$0.8
2037	$6	$25	1.3%	–1.3%	$0.7	–$0.8
2038	$6	$25	1.3%	–1.3%	$0.7	–$0.8
NPV (3%)					$11.9	–$12.9
NPV (7%)					$7.1	–$7.6

[a] Figures are in 2005 dollars.

[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-12: Impact on Small SI Equipment Market: Class II Utility and Recreational Vehicle UL 250 (Average Price per Equipment = $2,894)[a,b]

	Small SI Equipment (Class II Utility and Recreational Vehicle UL 250)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers Surplus (million $)
2008	$0	$1	0.0%	0.0%	$0.0	–$0.1
2009	$1	$1	0.0%	0.0%	$0.2	–$0.1
2010	$1	$1	0.0%	0.0%	$0.2	–$0.1
2011	$12	$35	1.2%	–1.2%	$2.2	–$2.0
2012	$11	$35	1.2%	–1.2%	$2.3	–$2.0
2013	$11	$35	1.2%	–1.2%	$2.3	–$2.1
2014	$11	$35	1.2%	–1.2%	$2.3	–$2.1
2015	$11	$35	1.2%	–1.2%	$2.3	–$2.1
2016	$6	$25	0.8%	–0.8%	$1.3	–$1.5
2017	$6	$25	0.8%	–0.8%	$1.3	–$1.5
2018	$6	$25	0.8%	–0.8%	$1.3	–$1.6
2019	$6	$25	0.8%	–0.8%	$1.3	–$1.6
2020	$6	$25	0.8%	–0.8%	$1.4	–$1.6
2021	$6	$25	0.8%	–0.8%	$1.4	–$1.6
2022	$6	$25	0.8%	–0.8%	$1.4	–$1.7
2023	$6	$25	0.8%	–0.8%	$1.4	–$1.7
2024	$6	$25	0.8%	–0.8%	$1.5	–$1.7
2025	$6	$25	0.8%	–0.8%	$1.5	–$1.7
2026	$6	$25	0.8%	–0.8%	$1.5	–$1.8
2027	$6	$25	0.8%	–0.8%	$1.5	–$1.8
2028	$6	$25	0.8%	–0.8%	$1.5	–$1.8
2029	$6	$25	0.8%	–0.8%	$1.6	–$1.8
2030	$6	$25	0.8%	–0.8%	$1.6	–$1.9
2031	$6	$25	0.8%	–0.8%	$1.6	–$1.9
2032	$6	$25	0.8%	–0.8%	$1.6	–$1.9
2033	$6	$25	0.8%	–0.8%	$1.6	–$1.9
2034	$6	$25	0.8%	–0.8%	$1.7	–$2.0
2035	$6	$25	0.8%	–0.8%	$1.7	–$2.0
2036	$6	$25	0.8%	–0.8%	$1.7	–$2.0
2037	$6	$25	0.8%	–0.8%	$1.7	–$2.0
2038	$6	$25	0.8%	–0.8%	$1.7	–$2.1
NPV (3%)					$29.2	–$31.7
NPV (7%)					$17.5	–$18.4

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-13: Impact on Small SI Equipment Market: Class II Tractors UL 250 (Average Price per Equipment = $1,937)[a,b]

	Small SI Equipment (Class II Tractors UL 250)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$1	0.0%	0.0%	$0.0	–$0.4
2009	$1	$1	0.0%	0.0%	$2.1	–$0.5
2010	$1	$1	0.0%	0.0%	$2.1	–$0.5
2011	$12	$35	1.8%	–1.8%	$22.0	–$19.7
2012	$11	$35	1.8%	–1.8%	$22.2	–$19.9
2013	$11	$35	1.8%	–1.8%	$22.1	–$20.2
2014	$11	$35	1.8%	–1.8%	$22.4	–$20.5
2015	$11	$35	1.8%	–1.8%	$22.6	–$20.7
2016	$6	$25	1.3%	–1.3%	$12.6	–$14.8
2017	$6	$25	1.3%	–1.3%	$12.8	–$15.1
2018	$6	$25	1.3%	–1.3%	$13.0	–$15.3
2019	$6	$25	1.3%	–1.3%	$13.2	–$15.5
2020	$6	$25	1.3%	–1.3%	$13.4	–$15.8
2021	$6	$25	1.3%	–1.3%	$13.6	–$16.0
2022	$6	$25	1.3%	–1.3%	$13.8	–$16.3
2023	$6	$25	1.3%	–1.3%	$14.0	–$16.5
2024	$6	$25	1.3%	–1.3%	$14.2	–$16.7
2025	$6	$25	1.3%	–1.3%	$14.4	–$17.0
2026	$6	$25	1.3%	–1.3%	$14.6	–$17.2
2027	$6	$25	1.3%	–1.3%	$14.8	–$17.5
2028	$6	$25	1.3%	–1.3%	$15.0	–$17.7
2029	$6	$25	1.3%	–1.3%	$15.2	–$17.9
2030	$6	$25	1.3%	–1.3%	$15.4	–$18.2
2031	$6	$25	1.3%	–1.3%	$15.6	–$18.4
2032	$6	$25	1.3%	–1.3%	$15.8	–$18.7
2033	$6	$25	1.3%	–1.3%	$16.0	–$18.9
2034	$6	$25	1.3%	–1.3%	$16.2	–$19.1
2035	$6	$25	1.3%	–1.3%	$16.4	–$19.4
2036	$6	$25	1.3%	–1.3%	$16.6	–$19.6
2037	$6	$25	1.3%	–1.3%	$16.8	–$19.9
2038	$6	$25	1.3%	–1.3%	$17.0	–$20.1
NPV (3%)					$285.9	–$308.5
NPV (7%)					$171.3	–$178.8

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-14: Impact on Small SI Equipment Market: Class II Other Lawn and Garden Equipment UL 250(Average Price per Equipment = $312)[a,b]

	Small SI Equipment (Class II Other Lawn and Garden Equipment UL 250)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$1	0.3%	–0.2%	$0.0	$0.0
2009	$1	$1	0.3%	–0.2%	$0.2	$0.0
2010	$1	$1	0.3%	–0.2%	$0.2	$0.0
2011	$12	$36	11.6%	–10.5%	$1.7	–$1.3
2012	$11	$36	11.6%	–10.4%	$1.7	–$1.3
2013	$11	$36	11.5%	–10.4%	$1.7	–$1.3
2014	$11	$36	11.5%	–10.3%	$1.7	–$1.4
2015	$11	$36	11.5%	–10.3%	$1.7	–$1.4
2016	$6	$25	8.0%	–7.2%	$0.9	–$1.0
2017	$6	$25	8.0%	–7.2%	$1.0	–$1.0
2018	$6	$25	8.0%	–7.2%	$1.0	–$1.0
2019	$6	$25	8.0%	–7.2%	$1.0	–$1.0
2020	$6	$25	8.0%	–7.2%	$1.0	–$1.1
2021	$6	$25	8.0%	–7.2%	$1.0	–$1.1
2022	$6	$25	8.0%	–7.2%	$1.0	–$1.1
2023	$6	$25	8.0%	–7.2%	$1.1	–$1.1
2024	$6	$25	8.0%	–7.2%	$1.1	–$1.1
2025	$6	$25	8.0%	–7.2%	$1.1	–$1.1
2026	$6	$25	8.0%	–7.2%	$1.1	–$1.2
2027	$6	$25	8.0%	–7.2%	$1.1	–$1.2
2028	$6	$25	8.0%	–7.2%	$1.1	–$1.2
2029	$6	$25	8.0%	–7.2%	$1.1	–$1.2
2030	$6	$25	8.0%	–7.2%	$1.2	–$1.2
2031	$6	$25	8.0%	–7.2%	$1.2	–$1.2
2032	$6	$25	8.0%	–7.2%	$1.2	–$1.3
2033	$6	$25	8.0%	–7.2%	$1.2	–$1.3
2034	$6	$25	8.0%	–7.2%	$1.2	–$1.3
2035	$6	$25	8.0%	–7.2%	$1.2	–$1.3
2036	$6	$25	8.0%	–7.2%	$1.3	–$1.3
2037	$6	$25	8.0%	–7.2%	$1.3	–$1.3
2038	$6	$25	8.0%	–7.2%	$1.3	–$1.4
NPV (3%)					$21.7	–$20.6
NPV (7%)					$13.1	–$11.9

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-15: Impact on Small SI Equipment Market: Class II Gensets/Welders UL 250 (Average Price per Equipment = $666)[a,b]

	Small SI Equipment (Class II Gensets/Welders UL 250)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers Surplus (million $)
2008	$0	$1	0.1%	–0.1%	$0.0	–$0.2
2009	$1	$1	0.1%	–0.1%	$0.7	–$0.2
2010	$1	$1	0.1%	–0.1%	$0.8	–$0.2
2011	$12	$34	5.2%	–5.7%	$7.8	–$7.5
2012	$11	$34	5.2%	–5.7%	$7.9	–$7.7
2013	$11	$34	5.1%	–5.6%	$7.9	–$7.7
2014	$11	$34	5.1%	–5.6%	$8.0	–$7.9
2015	$11	$34	5.1%	–5.6%	$8.0	–$8.0
2016	$6	$24	3.6%	–3.9%	$4.5	–$5.7
2017	$6	$24	3.6%	–3.9%	$4.5	–$5.8
2018	$6	$24	3.6%	–3.9%	$4.6	–$5.9
2019	$6	$24	3.6%	–3.9%	$4.7	–$6.0
2020	$6	$24	3.6%	–3.9%	$4.8	–$6.1
2021	$6	$24	3.6%	–3.9%	$4.8	–$6.2
2022	$6	$24	3.6%	–3.9%	$4.9	–$6.3
2023	$6	$24	3.6%	–3.9%	$5.0	–$6.4
2024	$6	$24	3.6%	–3.9%	$5.0	–$6.5
2025	$6	$24	3.6%	–3.9%	$5.1	–$6.6
2026	$6	$24	3.6%	–3.9%	$5.2	–$6.6
2027	$6	$24	3.6%	–3.9%	$5.3	–$6.7
2028	$6	$24	3.6%	–3.9%	$5.3	–$6.8
2029	$6	$24	3.6%	–3.9%	$5.4	–$6.9
2030	$6	$24	3.6%	–3.9%	$5.5	–$7.0
2031	$6	$24	3.6%	–3.9%	$5.6	–$7.1
2032	$6	$24	3.6%	–3.9%	$5.6	–$7.2
2033	$6	$24	3.6%	–3.9%	$5.7	–$7.3
2034	$6	$24	3.6%	–3.9%	$5.8	–$7.4
2035	$6	$24	3.6%	–3.9%	$5.8	–$7.5
2036	$6	$24	3.6%	–3.9%	$5.9	–$7.6
2037	$6	$24	3.6%	–3.9%	$6.0	–$7.7
2038	$6	$24	3.6%	–3.9%	$6.1	–$7.8
NPV (3%)					$101.7	–$119.0
NPV (7%)					$60.9	–$68.9

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-16: Impact on Small SI Equipment Market: Class II Pumps/Compressors/ Pressure Washers UL 250 (Average Price per Equipment = $349)[a,b]

	Small SI Equipment (Class II Pumps/Compressors/Pressure Washers UL 250)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$1	0.2%	–0.2%	$0.0	–$0.1
2009	$1	$1	0.2%	–0.2%	$0.3	–$0.1
2010	$1	$1	0.2%	–0.2%	$0.3	–$0.1
2011	$12	$35	10.2%	–10.2%	$3.3	–$2.8
2012	$11	$35	10.1%	–10.1%	$3.3	–$2.9
2013	$11	$35	10.1%	–10.1%	$3.3	–$2.9
2014	$11	$35	10.0%	–10.0%	$3.3	–$2.9
2015	$11	$35	10.0%	–10.0%	$3.4	–$3.0
2016	$6	$25	7.0%	–7.0%	$1.9	–$2.2
2017	$6	$25	7.0%	–7.0%	$1.9	–$2.2
2018	$6	$25	7.0%	–7.0%	$1.9	–$2.2
2019	$6	$25	7.0%	–7.0%	$2.0	–$2.3
2020	$6	$25	7.0%	–7.0%	$2.0	–$2.3
2021	$6	$25	7.0%	–7.0%	$2.0	–$2.3
2022	$6	$25	7.0%	–7.0%	$2.1	–$2.4
2023	$6	$25	7.0%	–7.0%	$2.1	–$2.4
2024	$6	$25	7.0%	–7.0%	$2.1	–$2.4
2025	$6	$25	7.0%	–7.0%	$2.1	–$2.5
2026	$6	$25	7.0%	–7.0%	$2.2	–$2.5
2027	$6	$25	7.0%	–7.0%	$2.2	–$2.5
2028	$6	$25	7.0%	–7.0%	$2.2	–$2.6
2029	$6	$25	7.0%	–7.0%	$2.3	–$2.6
2030	$6	$25	7.0%	–7.0%	$2.3	–$2.6
2031	$6	$25	7.0%	–7.0%	$2.3	–$2.7
2032	$6	$25	7.0%	–7.0%	$2.4	–$2.7
2033	$6	$25	7.0%	–7.0%	$2.4	–$2.7
2034	$6	$25	7.0%	–7.0%	$2.4	–$2.8
2035	$6	$25	7.0%	–7.0%	$2.5	–$2.8
2036	$6	$25	7.0%	–7.0%	$2.5	–$2.8
2037	$6	$25	7.0%	–7.0%	$2.5	–$2.9
2038	$6	$25	7.0%	–7.0%	$2.5	–$2.9
NPV (3%)					$42.6	–$44.8
NPV (7%)					$25.5	–$26.0

[a] Figures are in 2005 dollars.

[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9A-17: Impact on Small SI Equipment Market: Class II Snowblowers UL 250 (Average Price per Equipment = $665)[a,b]

	Small SI Equipment (Class II Snowblowers UL 250)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$1	0.1%	–0.1%	$0.0	–$0.1
2009	$1	$1	0.1%	–0.1%	$0.6	–$0.1
2010	$1	$1	0.1%	–0.1%	$0.6	–$0.1
2011	$7	$5	0.8%	–0.8%	$3.7	–$0.8
2012	$7	$5	0.8%	–0.8%	$3.7	–$0.8
2013	$7	$5	0.8%	–0.8%	$3.7	–$0.8
2014	$7	$5	0.8%	–0.8%	$3.7	–$0.9
2015	$7	$5	0.8%	–0.8%	$3.8	–$0.9
2016	$5	$4	0.6%	–0.6%	$3.0	–$0.7
2017	$5	$4	0.6%	–0.6%	$3.1	–$0.7
2018	$5	$4	0.6%	–0.6%	$3.1	–$0.7
2019	$5	$4	0.6%	–0.6%	$3.2	–$0.7
2020	$5	$4	0.6%	–0.6%	$3.2	–$0.7
2021	$5	$4	0.6%	–0.6%	$3.3	–$0.7
2022	$5	$4	0.6%	–0.6%	$3.3	–$0.8
2023	$5	$4	0.6%	–0.6%	$3.4	–$0.8
2024	$5	$4	0.6%	–0.6%	$3.4	–$0.8
2025	$5	$4	0.6%	–0.6%	$3.5	–$0.8
2026	$5	$4	0.6%	–0.6%	$3.5	–$0.8
2027	$5	$4	0.6%	–0.6%	$3.6	–$0.8
2028	$5	$4	0.6%	–0.6%	$3.6	–$0.8
2029	$5	$4	0.6%	–0.6%	$3.7	–$0.8
2030	$5	$4	0.6%	–0.6%	$3.7	–$0.8
2031	$5	$4	0.6%	–0.6%	$3.8	–$0.9
2032	$5	$4	0.6%	–0.6%	$3.8	–$0.9
2033	$5	$4	0.6%	–0.6%	$3.9	–$0.9
2034	$5	$4	0.6%	–0.6%	$3.9	–$0.9
2035	$5	$4	0.6%	–0.6%	$4.0	–$0.9
2036	$5	$4	0.6%	–0.6%	$4.0	–$0.9
2037	$5	$4	0.6%	–0.6%	$4.0	–$0.9
2038	$5	$4	0.6%	–0.6%	$4.1	–$0.9
NPV (3%)					$62.2	–$14.1
NPV (7%)					$35.9	–$8.2

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Appendix 9B: Impacts on Marine SI Markets

This appendix provides the time series of impacts from 2008 through 2038 for the following Small SI engines and equipment markets; a complete set of results for all markets can be found in the docket for this rule (Li, 2007). For engine markets, Results are presented for the aggregated categories by power. For the vessel markets, results are presented for the categories with the highest sales.

- Marine SI engines: <25 hp; 26-50 hp; 51-100 hp; 101-175 hp; 176-300 hp; >300 hp
- SD/I, 175-300 hp and >300 hp
- OB recreational, 50-100 hp
- OB luxury, 175-300 hp
- PWC 100-175 hp

Table 9B-1 through Table 9A-11 provide the time series of impacts for each engine class market and each selected equipment market, respectively, includes the following:

- average engine or equipment price
- average engineering costs (variable and fixed) per engine or equipment
- absolute change in the market price ($)
- relative change in market price (%)
- relative change in market quantity (%)
- total engineering costs associated with each engine or equipment market
- changes in producer surplus associated with each engine or equipment market

All prices and costs are presented in 2005 dollars and real engine or equipment prices are assumed to be constant during the period of analysis. Net present values were estimated using social discount rates of 3 percent and 7 percent over the period of analysis.

Table 9B-1: Impact on Marine SI Engine Market:
<25hp (Average Price per Engine = $2,500)[a]

	Marine SI Engine (<25hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Engine Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$74	$50	2.0%	–3.6%	$5.4	–$1.7
2010	$74	$49	1.9%	–3.6%	$5.4	–$1.8
2011	$74	$47	1.9%	–3.9%	$5.5	–$1.9
2012	$74	$47	1.9%	–3.9%	$5.5	–$1.9
2013	$74	$47	1.9%	–3.9%	$5.6	–$2.0
2014	$55	$35	1.4%	–3.1%	$4.2	–$1.5
2015	$55	$35	1.4%	–3.1%	$4.2	–$1.5
2016	$55	$35	1.4%	–3.0%	$4.3	–$1.6
2017	$55	$36	1.4%	–2.9%	$4.3	–$1.5
2018	$55	$36	1.4%	–2.9%	$4.3	–$1.5
2019	$55	$36	1.4%	–2.9%	$4.3	–$1.5
2020	$55	$36	1.4%	–2.9%	$4.4	–$1.5
2021	$55	$36	1.4%	–2.9%	$4.4	–$1.5
2022	$55	$36	1.4%	–2.9%	$4.4	–$1.5
2023	$55	$36	1.4%	–2.9%	$4.5	–$1.6
2024	$55	$34	1.4%	–3.1%	$4.5	–$1.7
2025	$55	$34	1.4%	–3.1%	$4.5	–$1.7
2026	$55	$34	1.4%	–3.1%	$4.6	–$1.7
2027	$55	$34	1.4%	–3.1%	$4.6	–$1.7
2028	$55	$34	1.4%	–3.1%	$4.6	–$1.7
2029	$55	$34	1.4%	–3.1%	$4.6	–$1.7
2030	$55	$34	1.4%	–3.1%	$4.7	–$1.7
2031	$55	$34	1.4%	–3.1%	$4.7	–$1.7
2032	$55	$34	1.4%	–3.1%	$4.7	–$1.8
2033	$55	$34	1.4%	–3.1%	$4.8	–$1.8
2034	$55	$34	1.4%	–3.1%	$4.8	–$1.8
2035	$55	$34	1.4%	–3.1%	$4.8	–$1.8
2036	$55	$34	1.4%	–3.1%	$4.8	–$1.8
2037	$55	$34	1.4%	–3.1%	$4.9	–$1.8
2038	$55	$34	1.4%	–3.1%	$4.9	–$1.8
NPV (3%)					$90.1	–$32.0
NPV (7%)					$55.6	–$19.6

[a] Figures are in 2005 dollars.

Table 9B-2: Impact on Marine SI Engine Market:
26–50hp (Average Price per Engine = $5,700)[a]

	Marine SI Engine (26–50hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Engine Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$222	$187	3.3%	–2.3%	$12.1	–$1.9
2010	$222	$185	3.3%	–2.4%	$12.2	–$2.0
2011	$222	$185	3.3%	–2.4%	$12.2	–$2.0
2012	$222	$183	3.2%	–2.6%	$12.3	–$2.1
2013	$222	$183	3.2%	–2.6%	$12.4	–$2.1
2014	$173	$142	2.5%	–2.1%	$9.8	–$1.7
2015	$173	$142	2.5%	–2.0%	$9.8	–$1.7
2016	$173	$142	2.5%	–2.0%	$9.9	–$1.7
2017	$173	$142	2.5%	–2.0%	$10.0	–$1.7
2018	$173	$143	2.5%	–2.0%	$10.0	–$1.7
2019	$173	$143	2.5%	–2.0%	$10.1	–$1.7
2020	$173	$143	2.5%	–2.0%	$10.2	–$1.7
2021	$173	$143	2.5%	–2.0%	$10.2	–$1.8
2022	$173	$143	2.5%	–2.0%	$10.3	–$1.8
2023	$173	$143	2.5%	–2.0%	$10.4	–$1.8
2024	$173	$143	2.5%	–2.0%	$10.4	–$1.8
2025	$173	$143	2.5%	–2.0%	$10.5	–$1.8
2026	$173	$143	2.5%	–2.0%	$10.6	–$1.8
2027	$173	$143	2.5%	–2.0%	$10.6	–$1.8
2028	$173	$143	2.5%	–2.0%	$10.7	–$1.8
2029	$173	$143	2.5%	–2.0%	$10.8	–$1.8
2030	$173	$143	2.5%	–2.0%	$10.9	–$1.9
2031	$173	$143	2.5%	–2.0%	$10.9	–$1.9
2032	$173	$143	2.5%	–2.0%	$11.0	–$1.9
2033	$173	$143	2.5%	–2.0%	$11.1	–$1.9
2034	$173	$143	2.5%	–2.0%	$11.1	–$1.9
2035	$173	$143	2.5%	–2.0%	$11.2	–$1.9
2036	$173	$143	2.5%	–2.0%	$11.3	–$1.9
2037	$173	$143	2.5%	–2.0%	$11.3	–$1.9
2038	$173	$143	2.5%	–2.0%	$11.4	–$2.0
NPV (3%)					$207.2	–$35.1
NPV (7%)					$127.2	–$21.5

[a] Figures are in 2005 dollars.

Table 9B-3: Impact on Marine SI Engine Market:
51–100hp (Average Price per Engine = $9,100)[a]

	Marine SI Engine (51–100hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Engine Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$211	$182	2.0%	–1.2%	$17.2	–$2.3
2010	$211	$180	2.0%	–1.3%	$17.3	–$2.5
2011	$211	$180	2.0%	–1.3%	$17.4	–$2.5
2012	$211	$178	1.9%	–1.4%	$17.5	–$2.7
2013	$211	$178	1.9%	–1.4%	$17.7	–$2.8
2014	$162	$136	1.5%	–1.1%	$13.7	–$2.2
2015	$162	$136	1.5%	–1.1%	$13.8	–$2.3
2016	$162	$136	1.5%	–1.1%	$13.9	–$2.2
2017	$162	$136	1.5%	–1.1%	$14.0	–$2.2
2018	$162	$137	1.5%	–1.1%	$14.1	–$2.2
2019	$162	$137	1.5%	–1.1%	$14.2	–$2.2
2020	$162	$137	1.5%	–1.1%	$14.3	–$2.2
2021	$162	$137	1.5%	–1.1%	$14.4	–$2.3
2022	$162	$137	1.5%	–1.1%	$14.5	–$2.3
2023	$162	$137	1.5%	–1.1%	$14.6	–$2.3
2024	$162	$137	1.5%	–1.1%	$14.7	–$2.3
2025	$162	$137	1.5%	–1.1%	$14.8	–$2.3
2026	$162	$137	1.5%	–1.1%	$14.9	–$2.3
2027	$162	$137	1.5%	–1.1%	$15.0	–$2.4
2028	$162	$137	1.5%	–1.1%	$15.1	–$2.4
2029	$162	$137	1.5%	–1.1%	$15.2	–$2.4
2030	$162	$137	1.5%	–1.1%	$15.3	–$2.4
2031	$162	$137	1.5%	–1.1%	$15.4	–$2.4
2032	$162	$137	1.5%	–1.1%	$15.5	–$2.4
2033	$162	$137	1.5%	–1.1%	$15.6	–$2.4
2034	$162	$137	1.5%	–1.1%	$15.7	–$2.5
2035	$162	$137	1.5%	–1.1%	$15.7	–$2.5
2036	$162	$137	1.5%	–1.1%	$15.8	–$2.5
2037	$162	$137	1.5%	–1.1%	$15.9	–$2.5
2038	$162	$137	1.5%	–1.1%	$16.0	–$2.5
NPV (3%)					$292.3	–$46.4
NPV (7%)					$179.7	–$29.5

[a] Figures are in 2005 dollars.

Table 9B-4: Impact on Marine SI Engine Market: 101–175hp (Average Price per Engine =$11,800)[a]

	Marine SI Engine (101–175hp)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Engine Manufacturers Surplus (million $)
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$371	$319	2.7%	–1.6%	$27.0	–$3.7
2010	$371	$315	2.7%	–1.7%	$27.2	–$4.0
2011	$371	$315	2.7%	–1.7%	$27.4	–$4.1
2012	$371	$312	2.7%	–1.8%	$27.6	–$4.4
2013	$371	$312	2.7%	–1.8%	$27.8	–$4.4
2014	$284	$237	2.0%	–1.4%	$21.4	–$3.5
2015	$284	$237	2.0%	–1.4%	$21.6	–$3.6
2016	$284	$238	2.0%	–1.4%	$21.7	–$3.5
2017	$284	$238	2.0%	–1.4%	$21.9	–$3.6
2018	$284	$238	2.0%	–1.4%	$22.0	–$3.5
2019	$284	$238	2.0%	–1.4%	$22.2	–$3.6
2020	$284	$238	2.0%	–1.4%	$22.3	–$3.6
2021	$284	$238	2.0%	–1.4%	$22.5	–$3.6
2022	$284	$238	2.0%	–1.4%	$22.6	–$3.6
2023	$284	$238	2.0%	–1.4%	$22.8	–$3.7
2024	$284	$238	2.0%	–1.4%	$22.9	–$3.7
2025	$284	$238	2.0%	–1.4%	$23.1	–$3.7
2026	$284	$238	2.0%	–1.4%	$23.2	–$3.7
2027	$284	$238	2.0%	–1.4%	$23.4	–$3.8
2028	$284	$238	2.0%	–1.4%	$23.5	–$3.8
2029	$284	$238	2.0%	–1.4%	$23.7	–$3.8
2030	$284	$238	2.0%	–1.4%	$23.8	–$3.8
2031	$284	$238	2.0%	–1.4%	$24.0	–$3.8
2032	$284	$238	2.0%	–1.4%	$24.2	–$3.9
2033	$284	$238	2.0%	–1.4%	$24.3	–$3.9
2034	$284	$238	2.0%	–1.4%	$24.5	–$3.9
2035	$284	$238	2.0%	–1.4%	$24.6	–$3.9
2036	$284	$238	2.0%	–1.4%	$24.8	–$4.0
2037	$284	$238	2.0%	–1.4%	$24.9	–$4.0
2038	$284	$238	2.0%	–1.4%	$25.1	–$4.0
NPV (3%)					$457.3	–$72.3
NPV (7%)					$281.4	–$44.2

[a] Figures are in 2005 dollars.

Table 9B-5: Impact on Marine SI Engine Market: 176–300hp (Average Price per Engine =$19,000)[a]

	Marine SI Engine (176–300hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Engine Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$527	$456	2.4%	–1.3%	$52.7	–$7.1
2010	$527	$451	2.4%	–1.4%	$53.0	–$7.6
2011	$527	$451	2.4%	–1.4%	$53.4	–$7.7
2012	$527	$445	2.4%	–1.5%	$53.8	–$8.3
2013	$527	$445	2.4%	–1.5%	$54.2	–$8.3
2014	$402	$337	1.8%	–1.2%	$41.7	–$6.7
2015	$402	$338	1.8%	–1.2%	$42.0	–$6.8
2016	$402	$339	1.8%	–1.2%	$42.3	–$6.7
2017	$402	$339	1.8%	–1.2%	$42.6	–$6.7
2018	$402	$339	1.8%	–1.2%	$42.9	–$6.7
2019	$402	$339	1.8%	–1.2%	$43.2	–$6.8
2020	$402	$339	1.8%	–1.2%	$43.5	–$6.8
2021	$402	$339	1.8%	–1.2%	$43.8	–$6.9
2022	$402	$339	1.8%	–1.2%	$44.1	–$6.9
2023	$402	$339	1.8%	–1.2%	$44.3	–$6.9
2024	$402	$339	1.8%	–1.2%	$44.6	–$7.0
2025	$402	$339	1.8%	–1.2%	$44.9	–$7.0
2026	$402	$339	1.8%	–1.2%	$45.2	–$7.1
2027	$402	$339	1.8%	–1.2%	$45.5	–$7.1
2028	$402	$339	1.8%	–1.2%	$45.8	–$7.2
2029	$402	$339	1.8%	–1.2%	$46.1	–$7.2
2030	$402	$339	1.8%	–1.2%	$46.4	–$7.3
2031	$402	$339	1.8%	–1.2%	$46.7	–$7.3
2032	$402	$339	1.8%	–1.2%	$47.0	–$7.4
2033	$402	$339	1.8%	–1.2%	$47.3	–$7.4
2034	$402	$339	1.8%	–1.2%	$47.6	–$7.4
2035	$402	$339	1.8%	–1.2%	$47.9	–$7.5
2036	$402	$339	1.8%	–1.2%	$48.2	–$7.6
2037	$402	$339	1.8%	–1.2%	$48.5	–$7.6
2038	$402	$339	1.8%	–1.2%	$48.8	–$7.6
NPV (3%)					$890.6	–$137.3
NPV (7%)					$548.1	–$83.8

[a] Figures are in 2005 dollars.

Table 9B-6: Impact on Marine SI Engine Market: 300+ hp (Average Price per Engine = $18,000)[a]

	Marine SI Engine (300+ hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Engine Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$377	$343	1.6%	–0.6%	$11.9	–$1.4
2010	$377	$337	1.5%	–0.7%	$12.0	–$1.6
2011	$377	$337	1.5%	–0.7%	$12.1	–$1.7
2012	$377	$328	1.5%	–0.9%	$12.2	–$2.0
2013	$377	$328	1.5%	–0.9%	$12.3	–$2.0
2014	$279	$239	1.1%	–0.7%	$9.2	–$1.7
2015	$279	$239	1.1%	–0.7%	$9.3	–$1.7
2016	$279	$241	1.1%	–0.7%	$9.3	–$1.6
2017	$279	$241	1.1%	–0.7%	$9.4	–$1.6
2018	$279	$241	1.1%	–0.7%	$9.5	–$1.6
2019	$279	$241	1.1%	–0.7%	$9.5	–$1.6
2020	$279	$241	1.1%	–0.7%	$9.6	–$1.6
2021	$279	$241	1.1%	–0.7%	$9.7	–$1.6
2022	$279	$241	1.1%	–0.7%	$9.7	–$1.7
2023	$279	$241	1.1%	–0.7%	$9.8	–$1.7
2024	$279	$241	1.1%	–0.7%	$9.9	–$1.7
2025	$279	$241	1.1%	–0.7%	$9.9	–$1.7
2026	$279	$241	1.1%	–0.7%	$10.0	–$1.7
2027	$279	$241	1.1%	–0.7%	$10.1	–$1.7
2028	$279	$241	1.1%	–0.7%	$10.1	–$1.7
2029	$279	$241	1.1%	–0.7%	$10.2	–$1.7
2030	$279	$241	1.1%	–0.7%	$10.3	–$1.8
2031	$279	$241	1.1%	–0.7%	$10.3	–$1.8
2032	$279	$241	1.1%	–0.7%	$10.4	–$1.8
2033	$279	$241	1.1%	–0.7%	$10.4	–$1.8
2034	$279	$241	1.1%	–0.7%	$10.5	–$1.8
2035	$279	$241	1.1%	–0.7%	$10.6	–$1.8
2036	$279	$241	1.1%	–0.7%	$10.6	–$1.8
2037	$279	$241	1.1%	–0.7%	$10.7	–$1.8
2038	$279	$241	1.1%	–0.7%	$10.8	–$1.8
NPV (3%)					$198.0	–$32.5
NPV (7%)					$122.2	–$19.7

[a] Figures are in 2005 dollars.

Table 9B-7: Impact on Marine Vessels Market:
SD/I Recreational 175–300 hp (Average Price per Equipment = $32,367)[a,b]

	Marine Vessel (SD/I Recreational 175–300 hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$5	$156	0.5%	–1.0%	$0.2	–$4.9
2010	$43	$174	0.5%	–1.1%	$1.6	–$5.5
2011	$43	$174	0.5%	–1.1%	$1.6	–$5.5
2012	$93	$198	0.6%	–1.2%	$3.4	–$6.3
2013	$93	$198	0.6%	–1.2%	$3.4	–$6.3
2014	$93	$160	0.5%	–1.0%	$3.5	–$5.1
2015	$92	$159	0.5%	–1.0%	$3.5	–$5.2
2016	$85	$156	0.5%	–1.0%	$3.2	–$5.1
2017	$85	$156	0.5%	–1.0%	$3.2	–$5.1
2018	$79	$153	0.5%	–0.9%	$3.0	–$5.1
2019	$79	$153	0.5%	–0.9%	$3.0	–$5.1
2020	$79	$153	0.5%	–0.9%	$3.1	–$5.1
2021	$79	$153	0.5%	–0.9%	$3.1	–$5.2
2022	$79	$153	0.5%	–0.9%	$3.1	–$5.2
2023	$79	$153	0.5%	–0.9%	$3.1	–$5.2
2024	$79	$153	0.5%	–0.9%	$3.1	–$5.3
2025	$79	$153	0.5%	–0.9%	$3.2	–$5.3
2026	$79	$153	0.5%	–0.9%	$3.2	–$5.3
2027	$79	$153	0.5%	–0.9%	$3.2	–$5.4
2028	$79	$153	0.5%	–0.9%	$3.2	–$5.4
2029	$79	$153	0.5%	–0.9%	$3.3	–$5.5
2030	$79	$153	0.5%	–0.9%	$3.3	–$5.5
2031	$79	$153	0.5%	–0.9%	$3.3	–$5.5
2032	$79	$153	0.5%	–0.9%	$3.3	–$5.6
2033	$79	$153	0.5%	–0.9%	$3.3	–$5.6
2034	$79	$153	0.5%	–0.9%	$3.4	–$5.6
2035	$79	$153	0.5%	–0.9%	$3.4	–$5.7
2036	$79	$153	0.5%	–0.9%	$3.4	–$5.7
2037	$79	$153	0.5%	–0.9%	$3.4	–$5.7
2038	$79	$153	0.5%	–0.9%	$3.4	–$5.8
NPV (3%)					$56.1	–$102.9
NPV (7%)					$32.5	–$62.6

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9B-8: Impact on Marine Vessels Market:
SD/I Luxury 300+ hp (Average Price per Equipment = $205,729)[a,b]

	Marine Vessel (SD/I Luxury 300+ hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$11	$292	0.1%	–0.3%	$0.1	–$2.2
2010	$142	$358	0.2%	–0.3%	$1.3	–$2.8
2011	$142	$358	0.2%	–0.3%	$1.3	–$2.8
2012	$312	$443	0.2%	–0.4%	$2.8	–$3.5
2013	$312	$443	0.2%	–0.4%	$2.8	–$3.5
2014	$312	$369	0.2%	–0.4%	$2.8	–$2.9
2015	$311	$369	0.2%	–0.4%	$2.9	–$2.9
2016	$285	$356	0.2%	–0.3%	$2.6	–$2.9
2017	$285	$356	0.2%	–0.3%	$2.7	–$2.9
2018	$271	$349	0.2%	–0.3%	$2.5	–$2.8
2019	$271	$349	0.2%	–0.3%	$2.6	–$2.9
2020	$271	$349	0.2%	–0.3%	$2.6	–$2.9
2021	$271	$349	0.2%	–0.3%	$2.6	–$2.9
2022	$271	$349	0.2%	–0.3%	$2.6	–$2.9
2023	$271	$349	0.2%	–0.3%	$2.6	–$2.9
2024	$271	$349	0.2%	–0.3%	$2.6	–$3.0
2025	$271	$349	0.2%	–0.3%	$2.7	–$3.0
2026	$271	$349	0.2%	–0.3%	$2.7	–$3.0
2027	$271	$349	0.2%	–0.3%	$2.7	–$3.0
2028	$271	$349	0.2%	–0.3%	$2.7	–$3.0
2029	$271	$349	0.2%	–0.3%	$2.7	–$3.1
2030	$271	$349	0.2%	–0.3%	$2.8	–$3.1
2031	$271	$349	0.2%	–0.3%	$2.8	–$3.1
2032	$271	$349	0.2%	–0.3%	$2.8	–$3.1
2033	$271	$349	0.2%	–0.3%	$2.8	–$3.1
2034	$271	$349	0.2%	–0.3%	$2.8	–$3.2
2035	$271	$349	0.2%	–0.3%	$2.8	–$3.2
2036	$271	$349	0.2%	–0.3%	$2.9	–$3.2
2037	$271	$349	0.2%	–0.3%	$2.9	–$3.2
2038	$271	$349	0.2%	–0.3%	$2.9	–$3.2
NPV (3%)					$46.7	–$56.7
NPV (7%)					$27.0	–$34.2

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9B-9: Impact on Marine Vessels Market:
OB Recreational 50–100 hp (Average Price per Equipment = $21,569)[a,b]

	Marine Vessel (OB Recreational 50–100 hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$7	$130	0.6%	–1.2%	$0.4	–$0.2
2010	$27	$139	0.6%	–1.3%	$1.7	–$0.8
2011	$27	$139	0.6%	–1.3%	$1.7	–$0.8
2012	$48	$149	0.7%	–1.4%	$3.1	–$1.4
2013	$48	$149	0.7%	–1.4%	$3.1	–$1.5
2014	$48	$120	0.6%	–1.1%	$3.2	–$1.5
2015	$48	$119	0.6%	–1.1%	$3.1	–$1.5
2016	$44	$118	0.5%	–1.1%	$2.9	–$1.3
2017	$44	$118	0.5%	–1.1%	$2.9	–$1.4
2018	$39	$115	0.5%	–1.1%	$2.6	–$1.2
2019	$39	$115	0.5%	–1.1%	$2.6	–$1.2
2020	$39	$115	0.5%	–1.1%	$2.6	–$1.2
2021	$39	$115	0.5%	–1.1%	$2.6	–$1.2
2022	$39	$115	0.5%	–1.1%	$2.7	–$1.2
2023	$39	$115	0.5%	–1.1%	$2.7	–$1.2
2024	$39	$115	0.5%	–1.1%	$2.7	–$1.3
2025	$39	$115	0.5%	–1.1%	$2.7	–$1.3
2026	$39	$115	0.5%	–1.1%	$2.7	–$1.3
2027	$39	$115	0.5%	–1.1%	$2.8	–$1.3
2028	$39	$115	0.5%	–1.1%	$2.8	–$1.3
2029	$39	$115	0.5%	–1.1%	$2.8	–$1.3
2030	$39	$115	0.5%	–1.1%	$2.8	–$1.3
2031	$39	$115	0.5%	–1.1%	$2.8	–$1.3
2032	$39	$115	0.5%	–1.1%	$2.8	–$1.3
2033	$39	$115	0.5%	–1.1%	$2.9	–$1.3
2034	$39	$115	0.5%	–1.1%	$2.9	–$1.3
2035	$39	$115	0.5%	–1.1%	$2.9	–$1.3
2036	$39	$115	0.5%	–1.1%	$2.9	–$1.4
2037	$39	$115	0.5%	–1.1%	$2.9	–$1.4
2038	$39	$115	0.5%	–1.1%	$2.9	–$1.4
NPV (3%)					$49.7	–$23.2
NPV (7%)					$29.2	–$13.6

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9B-10: Impact on Marine Vessels Market:
OB Luxury 175–300 hp (Average Price per Equipment = $104,598)[a,b]

	Marine Vessel (OB Luxury 175–300 hp)					
Year	**Engineering Cost/Unit**	**Absolute Change in Price**	**Change in Price (%)**	**Change in Quantity (%)**	**Total Engineering Costs (million $)**	**Change in Equipment Manufacturers Surplus (million $)**
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$19	$763	0.7%	–1.5%	$0.1	–$2.5
2010	$116	$804	0.8%	–1.5%	$0.4	–$2.6
2011	$116	$804	0.8%	–1.5%	$0.4	–$2.6
2012	$215	$845	0.8%	–1.6%	$0.8	–$2.8
2013	$215	$845	0.8%	–1.6%	$0.8	–$2.8
2014	$215	$672	0.6%	–1.3%	$0.8	–$2.2
2015	$214	$672	0.6%	–1.3%	$0.8	–$2.3
2016	$195	$663	0.6%	–1.3%	$0.8	–$2.2
2017	$195	$663	0.6%	–1.3%	$0.8	–$2.3
2018	$182	$658	0.6%	–1.3%	$0.7	–$2.3
2019	$182	$658	0.6%	–1.3%	$0.7	–$2.3
2020	$182	$658	0.6%	–1.3%	$0.7	–$2.3
2021	$182	$658	0.6%	–1.3%	$0.7	–$2.3
2022	$182	$658	0.6%	–1.3%	$0.7	–$2.3
2023	$182	$658	0.6%	–1.3%	$0.7	–$2.3
2024	$182	$658	0.6%	–1.3%	$0.8	–$2.4
2025	$182	$658	0.6%	–1.3%	$0.8	–$2.4
2026	$182	$658	0.6%	–1.3%	$0.8	–$2.4
2027	$182	$658	0.6%	–1.3%	$0.8	–$2.4
2028	$182	$658	0.6%	–1.3%	$0.8	–$2.4
2029	$182	$658	0.6%	–1.3%	$0.8	–$2.4
2030	$182	$658	0.6%	–1.3%	$0.8	–$2.4
2031	$182	$658	0.6%	–1.3%	$0.8	–$2.5
2032	$182	$658	0.6%	–1.3%	$0.8	–$2.5
2033	$182	$658	0.6%	–1.3%	$0.8	–$2.5
2034	$182	$658	0.6%	–1.3%	$0.8	–$2.5
2035	$182	$658	0.6%	–1.3%	$0.8	–$2.5
2036	$182	$658	0.6%	–1.3%	$0.8	–$2.5
2037	$182	$658	0.6%	–1.3%	$0.8	–$2.6
2038	$182	$658	0.6%	–1.3%	$0.8	–$2.6
NPV (3%)					$13.4	–$46.4
NPV (7%)					$7.8	–$28.4

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Table 9B-11: Impact on Marine Vessels Market:
PWC 100–175 hp (Average Price per Equipment = $9,986)[a,b]

	Marine Vessel (PWC 100–175 hp)					
Year	Engineering Cost/Unit	Absolute Change in Price	Change in Price (%)	Change in Quantity (%)	Total Engineering Costs (million $)	Change in Equipment Manufacturers Surplus (million $)
2008	$0	$0	0.0%	0.0%	$0.0	$0.0
2009	$98	$63	0.6%	–1.3%	$5.8	–$2.2
2010	$98	$63	0.6%	–1.3%	$5.8	–$2.2
2011	$98	$73	0.7%	–1.5%	$5.9	–$2.6
2012	$98	$73	0.7%	–1.5%	$5.9	–$2.6
2013	$98	$73	0.7%	–1.5%	$6.0	–$2.6
2014	$68	$54	0.5%	–1.1%	$4.2	–$1.9
2015	$68	$54	0.5%	–1.1%	$4.2	–$1.9
2016	$68	$54	0.5%	–1.1%	$4.2	–$2.0
2017	$68	$50	0.5%	–1.0%	$4.2	–$1.8
2018	$68	$50	0.5%	–1.0%	$4.3	–$1.8
2019	$68	$50	0.5%	–1.0%	$4.3	–$1.9
2020	$68	$50	0.5%	–1.0%	$4.3	–$1.9
2021	$68	$50	0.5%	–1.0%	$4.4	–$1.9
2022	$68	$50	0.5%	–1.0%	$4.4	–$1.9
2023	$68	$50	0.5%	–1.0%	$4.4	–$1.9
2024	$68	$50	0.5%	–1.0%	$4.4	–$1.9
2025	$68	$50	0.5%	–1.0%	$4.5	–$1.9
2026	$68	$50	0.5%	–1.0%	$4.5	–$1.9
2027	$68	$50	0.5%	–1.0%	$4.5	–$2.0
2028	$68	$50	0.5%	–1.0%	$4.6	–$2.0
2029	$68	$50	0.5%	–1.0%	$4.6	–$2.0
2030	$68	$50	0.5%	–1.0%	$4.6	–$2.0
2031	$68	$50	0.5%	–1.0%	$4.7	–$2.0
2032	$68	$50	0.5%	–1.0%	$4.7	–$2.0
2033	$68	$50	0.5%	–1.0%	$4.7	–$2.0
2034	$68	$50	0.5%	–1.0%	$4.7	–$2.0
2035	$68	$50	0.5%	–1.0%	$4.8	–$2.1
2036	$68	$50	0.5%	–1.0%	$4.8	–$2.1
2037	$68	$50	0.5%	–1.0%	$4.8	–$2.1
2038	$68	$50	0.5%	–1.0%	$4.9	–$2.1
NPV (3%)					$91.2	–$39.2
NPV (7%)					$56.8	–$24.3

[a] Figures are in 2005 dollars.
[b] Average price per equipment for the market is a weighted average of the price of equipment by hp.

Appendix 9C: Time Series Projections of Social Cost

This appendix provides a time series of the rule's projected social costs for each year through 2038. Costs are presented in 2005 dollars. In addition, this appendix includes the net present values by stakeholder using social discount rates of 3 percent and 7 percent over the period of analysis. As a result, it illustrates how the choice of discount rate determines the present value of the total social costs of the program.

Table 9C: Time Series Projection of Social Costs: 2008 to 2038 (Million $)[a]

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Consumer Surplus Change, Total	**–$7.5**	**–$118.2**	**–$128.5**	**–$331.6**	**–$477.2**	**–$481.1**	**–$460.7**	**–$465.4**	**–$389.4**	**–$365.1**	**–$369.1**
Marine SI											
End users (households)	$0.0	–$110.6	–$116.1	–$117.8	–$124.2	–$125.1	–$99.6	–$100.3	–$100.0	–$100.3	–$100.2
Small SI											
End users (households)	–$7.5	–$7.6	–$12.4	–$213.7	–$353.0	–$356.0	–$361.0	–$365.1	–$289.5	–$264.8	–$269.0
Producer Surplus Change, Total	**–$2.0**	**–$50.6**	**–$59.5**	**–$131.8**	**–$160.9**	**–$162.3**	**–$152.5**	**–$153.6**	**–$125.7**	**–$122.4**	**–$122.9**
Marine SI	$0.0	–$48.5	–$54.8	–$56.0	–$63.3	–$63.8	–$52.6	–$52.9	–$52.0	–$52.0	–$51.3
Engine manufacturers	$0.0	–$18.1	–$19.5	–$19.8	–$21.4	–$21.5	–$17.4	–$17.5	–$17.3	–$17.4	–$17.3
Equipment manufacturers	$0.0	–$30.4	–$35.3	–$36.2	–$41.9	–$42.2	–$35.2	–$35.4	–$34.7	–$34.6	–$34.0
Small SI	–$2.0	–$2.1	–$4.7	–$75.8	–$97.6	–$98.5	–$99.9	–$100.8	–$73.7	–$70.4	–$71.5
Engine manufacturers	–$0.4	–$0.4	–$0.4	–$10.9	–$18.2	–$18.4	–$18.6	–$18.9	–$15.0	–$13.7	–$13.9
Equipment manufacturers	–$1.7	–$1.7	–$4.3	–$64.8	–$79.4	–$80.2	–$81.3	–$81.9	–$58.8	–$56.8	–$57.7
Fuel Savings	**$3.1**	**$13.7**	**$25.4**	**$64.9**	**$103.5**	**$136.5**	**$161.2**	**$182.3**	**$200.9**	**$216.2**	**$229.9**
Consumer savings	$3.8	$16.7	$30.9	$78.8	$125.7	$165.9	$195.9	$221.5	$244.1	$262.6	$279.3
Fuel	$3.1	$13.7	$25.4	$64.9	$103.5	$136.5	$161.2	$182.3	$200.9	$216.2	$229.9
Tax	$0.7	$3.0	$5.5	$13.9	$22.2	$29.3	$34.7	$39.2	$43.2	$46.5	$49.4
Government revenue	–$0.7	–$3.0	–$5.5	–$13.9	–$22.2	–$29.3	–$34.7	–$39.2	–$43.2	–$46.5	–$49.4
Total Surplus Change	**–$6.4**	**–$155.1**	**–$162.6**	**–$398.5**	**–$534.7**	**–$506.9**	**–$451.9**	**–$436.7**	**–$314.2**	**–$271.3**	**–$262.1**

(continued)

Table 9C: Time Series Projection of Social Costs (Million $) (continued)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Consumer Surplus Change, Total	–$374.1	–$378.9	–$383.8	–$388.6	–$393.5	–$398.4	–$403.3	–$408.2	–$413.1	–$418.0	–$422.9
Marine SI											
End users (households)	–$100.9	–$101.6	–$102.3	–$102.9	–$103.6	–$104.4	–$105.1	–$105.8	–$106.5	–$107.1	–$107.8
Small SI											
End users (households)	–$273.2	–$277.4	–$281.5	–$285.7	–$289.9	–$294.1	–$298.3	–$302.5	–$306.7	–$310.9	–$315.1
Producer Surplus Change, Total	–$124.3	–$125.8	–$127.3	–$128.7	–$130.2	–$131.9	–$133.3	–$134.8	–$136.3	–$137.8	–$139.3
Marine SI	–$51.7	–$52.0	–$52.4	–$52.7	–$53.1	–$53.7	–$54.0	–$54.4	–$54.7	–$55.1	–$55.4
Engine manufacturers	–$17.4	–$17.5	–$17.6	–$17.8	–$17.9	–$18.1	–$18.2	–$18.3	–$18.5	–$18.6	–$18.7
Equipment manufacturers	–$34.3	–$34.5	–$34.7	–$35.0	–$35.2	–$35.6	–$35.8	–$36.0	–$36.3	–$36.5	–$36.7
Small SI	–$72.7	–$73.8	–$74.9	–$76.0	–$77.1	–$78.2	–$79.3	–$80.5	–$81.6	–$82.7	–$83.8
Engine manufacturers	–$14.1	–$14.3	–$14.5	–$14.8	–$15.0	–$15.2	–$15.4	–$15.6	–$15.8	–$16.1	–$16.3
Equipment manufacturers	–$58.6	–$59.5	–$60.4	–$61.2	–$62.1	–$63.0	–$63.9	–$64.8	–$65.7	–$66.7	–$67.6
Fuel Savings	$242.1	$253.1	$263.3	$272.9	$281.4	$289.3	$296.6	$303.6	$310.1	$316.3	$321.9
Consumer savings	$294.2	$307.5	$319.9	$331.6	$341.9	$351.5	$360.4	$368.8	$376.7	$384.2	$391.1
Fuel	$242.1	$253.1	$263.3	$272.9	$281.4	$289.3	$296.6	$303.6	$310.1	$316.3	$321.9
Tax	$52.0	$54.4	$56.6	$58.7	$60.5	$62.2	$63.8	$65.2	$66.6	$68.0	$69.2
Government revenue	–$52.0	–$54.4	–$56.6	–$58.7	–$60.5	–$62.2	–$63.8	–$65.2	–$66.6	–$68.0	–$69.2
Total Surplus Change	–$256.2	–$251.6	–$247.7	–$244.4	–$242.2	–$241.0	–$240.0	–$239.5	–$239.3	–$239.5	–$240.2

(continued)

Table 9C: Time Series Projection of Social Costs (million $) (continued)

	2030	2031	2032	2033	2034	2035	2036	2037	2038	NPV (3%)	NPV (7%)
Consumer Surplus Change, Total	–$427.8	–$432.7	–$437.6	–$442.6	–$447.5	–$452.4	–$457.3	–$462.2	–$467.1	–$7,392.2	–$4,322.0
Marine SI											
End users (households)	–$108.5	–$109.2	–$109.9	–$110.6	–$111.3	–$112.0	–$112.7	–$113.4	–$114.1	–$2,058.8	–$1,259.9
Small SI											
End users (households)	–$319.3	–$323.5	–$327.7	–$332.0	–$336.2	–$340.4	–$344.6	–$348.8	–$353.0	–$5,333.4	–$3,062.1
Producer Surplus Change, Total	–$140.7	–$142.2	–$143.7	–$145.2	–$146.6	–$148.1	–$149.6	–$151.1	–$152.5	–$2,490.0	–$1,472.0
Marine SI	–$55.8	–$56.1	–$56.5	–$56.9	–$57.2	–$57.6	–$57.9	–$58.3	–$58.6	–$1,043.2	–$633.9
Engine manufacturers	–$18.8	–$18.9	–$19.1	–$19.2	–$19.3	–$19.4	–$19.5	–$19.7	–$19.8	–$354.4	–$216.2
Equipment manufacturers	–$37.0	–$37.2	–$37.4	–$37.7	–$37.9	–$38.2	–$38.4	–$38.6	–$38.9	–$688.8	–$417.6
Small SI	–$84.9	–$86.1	–$87.2	–$88.3	–$89.4	–$90.6	–$91.7	–$92.8	–$93.9	–$1,446.9	–$838.2
Engine manufacturers	–$16.5	–$16.7	–$16.9	–$17.1	–$17.4	–$17.6	–$17.8	–$18.0	–$18.2	–$275.0	–$157.8
Equipment manufacturers	–$68.5	–$69.4	–$70.3	–$71.2	–$72.1	–$73.0	–$73.9	–$74.8	–$75.7	–$1,171.8	–$680.4
Fuel Savings	$327.3	$332.3	$337.1	$341.7	$346.1	$350.4	$354.5	$358.5	$362.5	$4,356.1	$2,291.5
Consumer savings	$397.6	$403.7	$409.5	$415.1	$420.5	$425.7	$430.7	$435.6	$440.4	$5,292.3	$2,784.0
Fuel	$327.3	$332.3	$337.1	$341.7	$346.1	$350.4	$354.5	$358.5	$362.5	$4,356.1	$2,291.5
Tax	$70.3	$71.4	$72.4	$73.4	$74.4	$75.3	$76.2	$77.1	$77.9	$936.2	$492.5
Government revenue	–$70.3	–$71.4	–$72.4	–$73.4	–$74.4	–$75.3	–$76.2	–$77.1	–$77.9	–$936.2	–$492.5
Total Surplus Change	–$241.3	–$242.6	–$244.2	–$246.0	–$248.0	–$250.1	–$252.3	–$254.7	–$257.1	–$5,526.1	–$3,502.6

[a] Figures are in 2005 dollars.

Appendix 9D: Overview of Model Equations and Calculation

To develop the economic impact model, we use set of nonlinear supply and demand equations for the affected markets and transform them into a set of linear supply and demand equations. These resulting equations describe stakeholder production and consumption responses to policy-induced cost and price changes in each market. They also are used to specify the conditions for a new with-policy equilibrium. We describe these equations in more detail below.

9D.1 Economic Model Equations

Supply Equations

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

$$\varepsilon_s \equiv \frac{dQ_s / Q_s}{dp / p} . \qquad (9D.1)$$

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

$$\hat{Q}_s = \varepsilon_s \hat{p} \qquad (9D.1a)$$

where

$\hat{Q}_s$ = 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, this approach takes the elasticity definition and turns it into a linear *behavioral* equation for each market.

To introduce the direct impact of the regulatory program, we assume the direct per-unit compliance 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:

$$\hat{MC} = \frac{c}{MC_o} = \frac{c}{p_o} . \qquad (9D.2)$$

The with-regulation supply response to price and cost changes can now be written as:

$$\hat{Q}_s = \varepsilon_s(\hat{p} - \hat{MC}) \tag{9D.3}$$

For equipment producers, the supply response should also simultaneously accounts for changes in equilibrium input prices (engines). To do this, we modify Eq. (9D.2) as follows:

$$\hat{MC} = \frac{c + \alpha(\Delta p_{engine})}{MC_o} = \frac{c + \alpha(\Delta p_{engine})}{p_o} \tag{9D.3a}$$

where Δp_{engine} is the equilibrium change in the engine price and α is the ratio of engines used per unit of equipment. For example, if one piece of equipment uses only one engine, then α = 1. This equation can accommodate other engine to equipment ratios by multiplying Δp_{eng} by the appropriate engine-to-equipment ratio (α).

Demand Equations

Similar to supply, we can characterize equipment demand responses to price changes as:

$$\hat{Q}_d = \eta_d \hat{p} \tag{9D.4}$$

where

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

η^d = market elasticity of demand, and

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

In contrast to equipment demand, the demand for engines is a derived demand and is related to equipment supply decisions. In order to maintain a constant engine-to-equipment ratio, the demand for engines is specified as:

$$\hat{Q}_d engines = \hat{Q}_s equipment \tag{9D.5}$$

Market Equilibrium Conditions

In response to the exogenous increase in equipment and engine production costs, stakeholder responses are completely characterized by represented in Eq. (9D.3)(equipment and engine supply), Eq. (9D.4) (equipment demand), and Eq. (9D.5)(engine demand). Next, we specify the relationship that must hold for markets to “clear”, that is, supply in each market equals demand. Given the equations specified above, the new equilibrium satisfies the condition that for each market, the proportional change in supply equals the proportional change in demand:

$$\hat{Q}_d = \hat{Q}_s \tag{9D.6}$$

9D.2 Computing With-Regulation Equilibrium Conditions

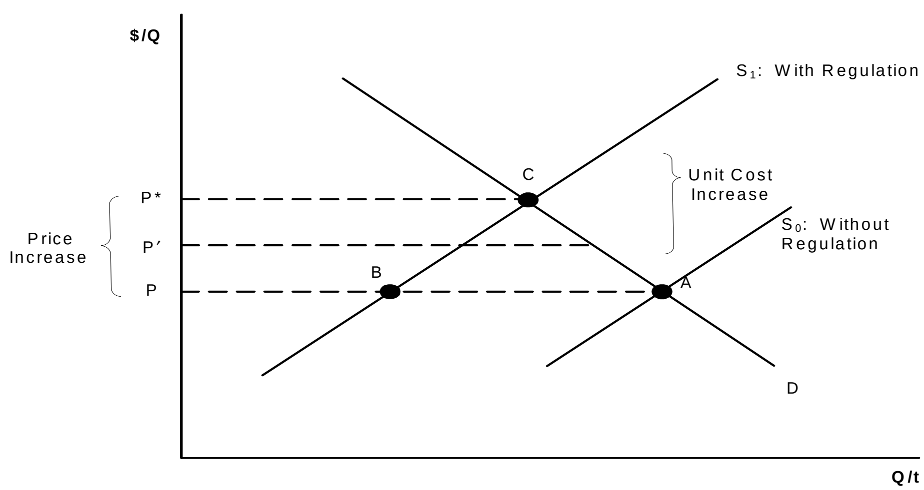
The choice of efficient model solution algorithms depends on several factors such as the number of markets included in the economic model, complexity of interactions between consumers and producers within these markets, and the software used to construct the model. To find the new market equilibrium prices and quantities, we used a solution algorithm that has proven very useful in "searching" for the equilibrium prices and quantities for partial equilibrium spreadsheet simulations with complicated relationships. We describe this approach in more detail below.

9D.2.1 Conceptual Description of RTI's Spreadsheet Model Solution Algorithm: PE_Walrasian_Auctioneer©2005

The French economist Léon Walras proposed one early model of market price adjustment by using the following thought experiment. Suppose there is a hypothetical agent that facilitates market adjustment by playing the role of an "auctioneer." He announces prices, collects information about supply and demand responses (without transactions actually taking place), and continues this process until market equilibrium is achieved.

For example, consider the with-regulation supply and demand conditions at the without-regulation equilibrium price (P) (see Figure 9D-1a). The auctioneer determines that the quantity demanded (A) exceeds the quantity supplied (B) at this price and calls out a new (higher) price (P′) based on the amount of excess demand. Consumers and producers make new consumption and production choices at this new price (i.e., they move along their respective demand and supply functions), and the auctioneer checks again to see if excess demand or supply exists. This process continues until P = P* (point C in Figure 9D-1a) is reached (i.e., excess demand is zero in the market). A similar analysis takes place when excess supply exists. The auctioneer calls out lower prices when the price is higher than the equilibrium price.

Figure 9D-1a. Computing with Regulation Equilibrium



The model uses a similar type of algorithm for determining with-regulation equilibria, and the process can be summarized by six recursive steps:

1. Impose the control costs on affected supply segments, thereby affecting their supply decisions.
2. Recalculate the market supply in each market. Excess demand currently exists.
3. Determine the new prices via a price revision rule. We used a rule similar to the factor price revision rule described by Kimbell and Harrison (1986). P_i is the market price at iteration i, q_d is the quantity demanded, and q_s is the quantity supplied. The parameter z influences the magnitude of the price revision and the speed of convergence. The revision rule increases the price when excess demand exists, lowers the price when excess supply exists, and leaves the price unchanged when market demand equals market supply. The price adjustment is expressed as follows:

$$P_{i+1} = P_1 \bullet \left(\frac{q_d}{q_s} \right)^z \qquad (9D.7)$$

4. Recalculate market supply with new prices.
5. Compute market demand in each market.
6. Compare supply and demand in each market. If equilibrium conditions are not satisfied, go to Step 3, resulting in a new set of market prices. Repeat until equilibrium conditions are satisfied (i.e., the ratio of supply and demand is arbitrarily close to one). When the ratio is appropriately close to one, the market-clearing condition of supply equals demand is satisfied.

9D.2.2 Consumer and Producer Welfare Calculations

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

$$\Delta CS = -\, Q_1 \bullet \Delta p + 0.5 \bullet \Delta Q \bullet \Delta p. \qquad (9D.8)$$

As shown, higher market prices and reduced consumption lead to welfare losses for consumers. A geometric representation of this calculation is illustrated in Figure 9D-1b.

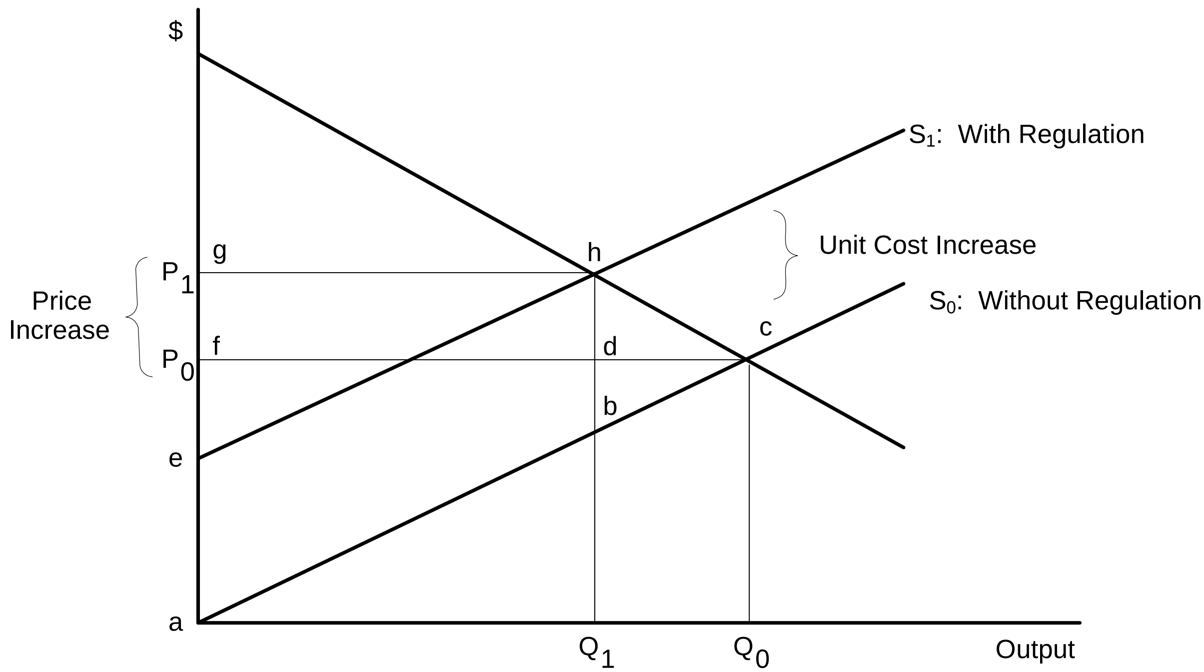
For affected supply, the change in producer surplus can be estimated with the following equation:

$$\Delta PS = Q_1 \bullet (\Delta p - c) - 0.5 \bullet \Delta Q \bullet (\Delta p - c). \qquad (9D.9)$$

Increased regulatory costs and output declines have a negative effect on producer surplus, because the net price change ($\Delta p - c$) 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 9D-1b.

Δ consumer surplus	=–[fghd + dhc]
Δ producer surplus	=[fghd – aehb] – bdc
Δ total surplus	=–[aehb + dhc + bdc]

Figure 9D-1b. Welfare Calculations



Appendix 9E: Elasticity Parameters for Economic Impact Modeling

The Economic Impact Model (EIM) relies on elasticity parameters to estimate the behavioral response of consumers and producers to the regulation and its associated social costs. To operationalize the market model, supply and demand elasticities are needed to represent the behavioral adjustments that are likely to be made by market participants. The following parameters are needed:

- supply and demand elasticities for Marine SI equipment markets
- supply and demand elasticities for Small SI equipment markets
- supply elasticities for Marine SI engine markets
- supply elasticities for Small SI engine markets

Note that demand elasticities for the Marine SI and Small SI engine markets are not estimated because they are derived internally in the model. They are a function of changes in output levels in the equipment markets.

Tables 9E-1 and 9E-2 contain the demand and supply elasticities used to estimate the economic impact of the rule. Two methods were used to obtain the supply and demand elasticities used in the EIM. First, the professional literature was surveyed to identify elasticity estimates used in published studies. Second, when literature estimates were not available for specific markets, established econometric techniques were used to estimate supply and demand elasticity parameters directly. Since very few studies have been identified to quantify elasticities for Small SI and Marine SI markets in the literature survey, the supply and demand elasticities for all of the equipment and engine markets were estimated econometrically.

This appendix describes the methods used to estimate demand and supply elasticities for Marine SI and Small SI engines and equipment markets and presents the data sources and the regression results obtained from applying those methods.

Finally, 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 since more substitutes may become available.

Table 9E-1: Summary of Market Supply Elasticities Used in the Market Model

Markets	Estimate	Source	Method	Input Data Summary
Recreational Marine				
All vessel types except PWC	2.3	EPA econometric estimate Table 9E-4	Cobb-Douglas production function	Bartlesman et al. (2000); 1958–1996; SIC 3732
PWC	3.4	EPA econometric estimate Table 9E-5	Cobb-Douglas production function	Bartlesman et al. (2000); 1958–1996; SIC 3799
Small SI				
All lawn and garden equipment	3.4	EPA econometric estimate Table 9E-6	Cobb-Douglas production function	Bartlesman et al. (2000); 1958–1996; SIC 3524
Generators	3.3	EPA econometric estimate Table 9E-7	Cobb-Douglas production function	Bartlesman et al. (2000); 1966–1996; SIC 3621
All Engines Categories	3.8	EPA econometric estimate Table 9E-3	Cobb-Douglas production function	Bartlesman et al. (2000); 1958–1996; SIC 3519

Table 9E-2: Summary of Market Demand Elasticities Used in the Market Model

Market	Estimate	Source	Method	Primary Input Data Summary
Equipment				
All recreational marine (including PWC)	−2.0	EPA econometric estimate Table 9E-8	Simultaneous equation (3SLS)	Bartlesman et al. (2000); 1958–1996; SIC 3732
Lawnmowers	−0.2	EPA econometric estimate Table 9E-9, Column 2	Simultaneous equation (3SLS)	AIR/NERA (2003); 1973–2002
Lawn and garden tractors	–1.0	EPA econometric estimate Table 9E-9, Column 5	Simultaneous equation (2SLS)	U.S. Census Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980–1997
Pumps/compressors/ pressure washers, snowblowers	–1.0[a]	EPA econometric estimate Table 9E-9, Column 5	Simultaneous equation (2SLS)	U.S. Census Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980–1997
Agriculture, construction, general industrial	–1.0[a]	EPA econometric estimate Table 9E-9, Column 5	Simultaneous equation (2SLS)	U.S. Census Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980–1997
Other lawn and garden	–0.9[b]	EPA econometric estimate Table 9E-9, Column 3	Simultaneous equation (2SLS)	U.S. Census Bureau, Current Industrial Reports, MA333A 2000 and selected previous years; 1980–1997
All handheld lawn and garden equipment	–1.9	EPA econometric estimate Table 9E-9, Column 4	Simultaneous equation (2SLS)	U.S. Census Bureau, Current Industrial Reports, MA333A 2000 and selected years; 1980–1997
Gensets/welders Class 1	–1.4	EPA econometric estimate Table 9E-10, Column 2	Simultaneous equation (3SLS)	U.S. Census Bureau, Current Industrial Reports, MA335H 2000 and selected years; 1980–1997
Gensets/welders Class 2	–1.1	EPA econometric estimate Table 9E-10, Column 3	Simultaneous equation (3SLS)	U.S. Census Bureau, Current Industrial Reports, MA335H 2000 and selected years; 1980–1997
All Engines		Derived demand	NA	

[a] Uses econometric estimate for lawn and garden tractors.
[b] Uses econometric estimate for commercial mowers.

9E.1 Supply Elasticities

We use a two-steps approach to estimate the price elasticity of supply. In the first step, we estimate an industry production function by using the regression model. In the second step, we calculate the supply elasticity by the parameters estimated in the estimated production function. This section discusses the regression model used to estimate the industry production function, data sources used for the regression, and estimated results for supply elasticities. The economics theory on the relationship between the supply elasticity and the production function is discussed in Appendix 9F.

In economics, the production function is defined as the relationship between inputs and outputs of the production process. In this case, we assume that Small SI and Marine SI industry follows the Cobb-Douglas production function, and is specified as

$$Q_t = A\,(K_t)^{\alpha_K}\,(L_t)^{\alpha_L}\,(M_t)^{\alpha_M}\,t^{\lambda} \qquad \text{(9E.1)}$$

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:

$$\ln Q_t = \ln A + \alpha_K \ln K_t + \alpha_L \ln L_t + \alpha_M \ln M_t + \lambda \ln t \qquad \text{(E9.2)}$$

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:[14]

$$\text{Supply Elasticity} = (\alpha_L + \alpha_M) / (1 - \alpha_L - \alpha_M). \qquad \text{(9E.3)}$$

To maintain the desired properties of the Cobb-Douglas production function, the analyst must 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.

[14] Appendix 9F provides the derivation of this result.

9E.1.1 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. 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).[15] 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 was calculated as follows:

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

9E.1.2 Results of Supply Elasticity Estimation

We used an autoregressive error model to estimate Eq. (9E.2). SAS procedure PROC AUTOREG computes a linear regression corrected for serial 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 data series updated with the most recent data. Using this model, reasonable estimates were obtained for Small SI products. Durbin-Watson statistics were calculated to check for autocorrelation and Goldfeld-Quandt tests to check for heteroskedasticity. As shown in Tables 9E-3 through 9E-7, supply elasticity estimates for Small SI products range from 2.3 (Boat Building) to 3.8 (Engines).

[15] All values are expressed in $1987. Note the GDP deflators have been updated since RTI’s estimation of supply elasticities for the nonroad rule. As a result, the elasticity estimation method is the same; however, the coefficient estimates may vary slightly.

Table 9E-3: Gasoline Engines: SIC 3519 Internal Combustion Engines, Not Elsewhere Classified: 1958 to 1996

Number of Observations = 39
Total R-square = 0.9978
Durbin-Watson = 1.80 (1% critical values = 1.085, 1.517)
Goldfeld-Quandt F = 3.10 (p-value = 0.018); DF=14
Supply Elasticity = 3.8

Variable	Estimated Coefficients	t-statistic	p value
intercept	0.962	24.21	<0.0001
ln K	0.207	4.73	<0.0001
ln L	0.207	5.60	<0.0001
ln M	0.587	13.04	<0.0001
ln t	0.022	2.37	0.0238

Table 9E-4: Gasoline-Powered Boats: SIC 3732 Boat Building and Repairing: 1958 to 1996

Number of Observations = 39
Total R-square = 0.9976
Durbin-Watson = 1.89 (1% critical values = 1.085, 1.517)
Goldfeld-Quandt F = 1.76 (p-value = 0.141); DF=14
Supply Elasticity = 2.3

Variable	Estimated Coefficients	t-statistic	p-value
intercept	1.144	25.42	<0.0001
ln K	0.303	5.73	<0.0001
ln L	0.328	7.28	<0.0001
ln M	0.369	7.34	<0.0001
ln t	0.022	1.56	0.1295

Table 9E-5: PWCs, ATVs, Snowmobiles: SIC 3799 Transportation Equipment, Not Elsewhere Classified: 1958 to 1996
Number of Observations = 39
Total R-square = 0.9978
Durbin-Watson = 1.758 (1% critical values = 1.085, 1.517)
Goldfeld-Quandt F = 2.99 (p-value = 0.025); DF=14
Supply Elasticity = 3.4

Variable	Estimated Coefficients	t-statistic	p value
intercept	0.786	19.4	<0.0001
ln K	0.229	10.4	<0.0001
ln L	0.127	4.57	<0.0001
ln M	0.644	20.2	<0.0001
ln t	0.028	2.90	0.0065

Table 9E-6: Small Handheld/Nonhandheld: SIC 3524 Lawn and Garden Tractors and Home Lawn and Garden Equipment: 1958 to 1996
Number of Observations = 39
Total R-square = 0.9964
Durbin-Watson = 1.71 (1% critical values = 1.085, 1.517)
Goldfeld-Quandt F = 2.08 (p-value = 0.084); DF=14
Supply Elasticity = 3.4

Variable	Estimated Coefficients	t-statistic	p value
intercept	0.662	13.03	<0.0001
ln K	0.225	3.69	0.0008
ln L	0.068	1.79	0.0822
ln M	0.707	11.09	<0.0001
ln t	0.042	2.77	0.0091

Table 9E-7: Gensets and Marine Generators: SIC 3621 Motors and Generators: 1966 to 1996
Number of Observations = 31
Total R-square = 0.9930
Durbin-Watson = 1.749 (1% critical values = 0.960,1.510)
Goldfeld-Quandt F = 0.89 (p-value = 0.576); DF=11
Supply Elasticity = 3.3

Variable	Estimated Coefficients	t-statistic	p value
intercept	1.0119	19.6	<0.0001
ln K	0.2346	4.62	<0.0001
ln L	0.1574	3.15	0.0042
ln M	0.6081	11.64	<0.0001
ln t	–0.0127	–0.51	0.6176

9E.2 Demand Elasticities

To obtain demand elasticity parameters, we estimated a simultaneous system of demand and supply equations using instrumental variables methodology by either two-stage least squares (2SLS) or three-stage least squares (3SLS) regression. This type of partial equilibrium market supply/demand model is specified as a system of interdependent equations in which the price and output of a product are simultaneously determined by the interaction of producers and consumers in the market. In simultaneous equation models, where variables in one equation feed back into variables in another equation, the error terms are correlated with the endogenous variables (price and output). Use of a single-equation ordinary least squares (OLS) estimation of individual equations will lead to biased and inconsistent parameter estimates because it does not account for the correlation of the error term with the endogenous variables. In 2SLS or 3SLS, however, each equation is identified through the inclusion of exogenous variables as instruments that control for shifts in the supply and demand curves over time.

Exogenous variables influencing the demand for gasoline-powered boats and Small SI equipment include measures of general economic activity (per capita household or disposable income, number of households or housing starts). Exogenous variables influencing the cost of production and supply of boats and Small SI equipment include changes in prices of key inputs like labor and raw materials.

The supply/demand system for gasoline powered equipment can be defined as follows:

$$Q_t^d = f(P_t,Z_t) + u_t \quad (9E.4)$$

$$Q_t^s = g(P_t,W_t) + v_t \quad (9E.5)$$

$$Q_t^d = Q_t^s \quad (9E.6)$$

Eq. (9E.4) shows quantity demanded as a function of price, P_t; a vector of demand shifters, Z_t (e.g., measures of economic activity); and an error term, u_t. Eq. (9E.5) represents quantity supplied as a function of price and a vector of supply shifters, W_t (e.g., input prices), and an error term, v_t, while Eq. (9E.6) specifies the equilibrium condition that quantity supplied equals quantity demanded, creating a system of three equations with three endogenous variables. The interaction of the specified market forces solves this system, generating equilibrium values for the variables P_t^* and $Q_t^* = Q_t^{d*} = Q_t^{s*}$.

To generate demand and supply elasticity estimates simultaneously, we used 2SLS and/or 3SLS procedures. For the 2SLS estimates, observed price is regressed against the exogenous instruments (i.e., the supply and demand “shifter” variables). The fitted (or predicted) values for the price variable are then employed as observations of the right-hand side price variable in the supply and demand equations. In the second stage, the 2SLS estimators are generated by running OLS on these calculated instrumental variables. Also, the 2SLS estimates are used to estimate errors in the structural equations, which then can be used to estimate the variance-covariance matrix of the structural equations' errors. For the 3SLS estimates, this information is used at the third stage to perform a generalized least squares (GLS) estimation of a single large equation composed from the individual structural equations. If this process is done with all variables expressed in natural logarithms, the coefficient on the price variable in the demand equation yields an estimate of the constant elasticity of demand.

9E.2.1 Demand Equation Estimation

Demand equations were estimated using a general specification where the quantity of boats or Small SI equipment consumed is expressed as a function of price, number of households or housing starts, per capita household or disposable income, and a time trend. Trends were included as a general way to model the effects of changes in tastes and preferences. All price and income variables were deflated by the implicit gross domestic product (GDP) deflator. The endogenous variables in the equations are unit sales and own-price. The exogenous variables include the household and income variables and the time trend. The list of instruments includes these exogenous variables and supply factors influencing the price of the product: wages and a producer price index for material inputs.

9E.2.2 Data Sets

The National Bureau of Economic Research (NBER) data discussed in the supply elasticity section of the analysis plan (RTI, 2005) contain data on production quantities, price indices, and suitable instruments to inform a demand analysis for recreational boats (SIC 3732). In its Current Industrial Reports (CIR) series, the U.S. Census Bureau produces an annual summary of the production of motors and generators and a summary of production of several types of lawn and garden equipment; both of these reports include the number of units manufactured and the value of production (U.S. Census Bureau, 1998; 2000). For the walk-behind lawnmowers regression, we used several data series reported in a study by Air Improvement Resource, Inc., and National Economic Research Associates (AIR/NERA, 2003). The U.S. Census Bureau publishes historical data on household income and housing starts (U.S. Census Bureau, 2002; 2004), and we collected price, wage, and material cost indexes from the Bureau of Labor Statistics (BLS) (BLS, 2004a,b,c,d,e). Lastly, we obtained an implicit GDP price deflator from the U.S. Bureau of Economic Analysis (BEA) (BEA, 2004). The following variables from these sources were used in the regression:

- unit sales of boats (Bartlesman et al., 2000),
- price index for boats (Bartlesman et al., 2000),
- lawn and garden equipment units produced (U.S. Census Bureau, AIR/NERA),
- lawn and garden equipment value of production (U.S. Census Bureau),
- producer price index for walk-behind lawnmowers (BLS),
- households (U.S. Census Bureau),
- housing starts (U.S. Census Bureau),
- per capita income and population (U.S. Census Bureau, 2002; BEA, 2004),
- average hourly earnings for production workers (BLS; Bartlesman et al., 2000),
- price index for plastic and other materials and engines (BLS; Bartlesman et al., 2000), and GDP deflator (BEA).

Some care was needed in using the time series from the CIR data set. Occasional changes in category definition and the Census Bureau's need to suppress some data to maintain confidentiality created difficulties in constructing consistent data series over the 2-decade time period. Nonetheless, we were able to assemble the following series: commercial nonriding mowers, commercial riding mowers, consumer lawn mowers, tillers and two-wheel tractors, snow throwers, edgers and trimmers, vacuums and blowers, and lawn and garden tractors. Statistically significant parameter estimates were obtained for commercial nonriding mowers, tillers/two-wheel tractors, edgers/trimmers, and lawn and garden tractors.

We were not able to obtain a useful elasticity estimate for consumer lawn mowers using CIR data, perhaps because of aggregation biases in that category of the CIR data set. Because consumer lawn mowers are a critical segment of the entire Small SI sector, we used an alternate data set for our demand elasticity estimate. The data AIR/NERA used in their recent study proved very useful in this regard (AIR/NERA, 2003). In that study, the authors used a single-equation OLS regression to obtain a demand elasticity parameter, a procedure that RTI believes to be inadequate because the market process simultaneously determines price and quantity in the demand equation. However, using the same data series cited by AIR/NERA supplemented by data collected by RTI, we were able to obtain a reasonable estimate using the 3SLS regression described above.

9E.2.3 Results of Demand Elasticity Estimation

In this section, we present regression results used in the EIA. Table 9E-8 shows the parameter estimate for the marine sector, which is –2.0. Although the methodology and data sets are quite different, this result is consistent with the ones obtained by Raboy (1987) in his study almost 20 years ago.

Table 9E-8: Results of Econometric Estimation of Boat Demand Equation: 1958 to 1996

Dependent Variable—Regression	Recreational Boats—SIC 3732 Unit Sales per Capita
Intercept	–27.9 (–10.3)
Price	–2.0 (–2.04)
Disposable income per capita	1.83 (5.85)
Trend	–0.19 (–2.15)
Adjusted R^2	0.81
Observations (years)	39 (1958–1996)

Notes: 1. Numbers in parentheses are t-ratios (coefficient estimate divided by its standard error) (except for the year ranges in the last row of the table).
2. All exogenous and endogenous variables are in natural log.

In Table 9E-9, we present demand elasticity results for Small SI equipment. Our estimate for walk-behind lawnmowers is –0.2 (inelastic). The value obtained for other nonhandheld categories such as commercial nonriding mowers and lawn and garden tractors is higher at (–0.9, –1.0). In contrast, the demand estimate for edgers/trimmers is elastic (–1.9), suggesting that consumers are more willing to forego purchases of these items at higher prices. The edgers/trimmers' value was used for all handheld equipment. Results for generators, which range from –1.1 to –1.4, are shown in Table 9E-10.

Table 9E-9: Results of Econometric Estimation of Small SI Demand Equations: 1980 to 1997 (1973–2002 for Consumer Mowers)

Dependent Variable—Regression	Consumer Walk-Behind Mowers	Commercial Mowers	Edgers and Trimmers	Lawn and Garden Tractors
	Units Sold per Household	Units Produced	Units Produced	Units Produced
Method	3SLS	2SLS	2SLS	2SLS
Intercept	–0.64 (–2.71)	–35.19 (–4.41)	–4.69 (–0.63)	–7.22 (–1.46)
Price	–0.2 (–3.73)	–0.9 (–2.74)	–1.9 (–6.05)	–1.0 (–2.29)
Per capita income	—	4.8 (5.76)	1.47 (1.79)	2.2 (4.36)
Housing starts per HH (1 lag)	0.23 (4.71)	—	—	—
Trend	—	–0.20 (–1.58)	0.32 (2.52)	0.02 (0.26)
Adjusted or system weighted R^2	0.547	0.663	0.877	0.939
Observations (years)	29 (1973–2002)	18 (1980–97)	18 (1980–97)	18 (1980–97)

Notes:
1. Numbers in parentheses are t-ratios (coefficient estimate divided by its standard error) (except for the year ranges in the last row of the table).
2. All exogenous and endogenous variables are in natural log.
3. For lawnmowers, the income variable is actually per capita disposable income.

Table 9E-10: Results of Econometric Estimation of Gasoline-Powered Generators Demand Equations: 1973 to 1998

	Units Produced	
Dependent Variable-Regression	**Small Generators (<5kW)**	**Large Generators (>15kW)**
Intercept	16.4 (2.64)	–14.3 (–2.48)
Price	–1.4 (–3.64)	–1.1 (–8.59)
Per capita income	–0.46 (–0.71)	2.7 (4.34)
Trend	–0.02 (–0.51)	–0.16 (–1.53)
Adjusted R^2	0.609	0.723
Observations (years)	26 (1973–1998)	26 (1973–1998)

Notes: 1. Numbers in parentheses are t-ratios (coefficient estimate divided by its standard error) (except for the year ranges in the last row of the table).

2. All exogenous and endogenous variables are in natural log.

Appendix 9F: Derivation of Supply Elasticity

In economics, a production function is used to describe the relationship between inputs and outputs of the production process. The production function in general is defined as follows

$$Q^s = f\,(L, K, M, t)$$

Q^s = the quantity of the outputs supplied
L = the labor input or the number of labor hours
K = real capital stock or real capital consumed in the production
M = the material inputs
t = a time trend variable to reflect technology changes

In the competitive market, market forces constrain firms to produce at the cost minimizing output level. Cost minimization allows for the duality mapping of a firm's technology (summarized by the firm's production function) to the firm's economic behavior (summarized by the firm's cost function). The total cost function of an industry in the short term follows:

$$TC = h(\,C, K, t, Q^s\,)$$

where TC is the total cost of production, C is the variable cost of production (such as the cost of materials and labor), and the other variables have previous defined. This approach assumes that capital stock is fixed, or a sunk cost of production. This assumption is consistent with the goal of the modeling post-control market changes likely to occur. Firms facing proposed regulatory emission controls will consider embedded capital stock as a fixed or sunk cost in economic decision making. Differentiating the total cost function with respect to Q^s derives the marginal cost function:

$$MC = \; h'\,(\,C, K, t, Q^s\,)$$

where MC is the marginal cost of production and all other variables have been previously defined.

Profit maximizing competitive firms will choose to produce the quantity of output that equate the market price (P) to the marginal cost of the production (MC). Setting the price equal to the preceding marginal cost function and solving for Q^s yields the following implied supply function:

$$Q^s = \; S\,(P, P_{L\,,} P_{M,}, K, t,)$$

where P is the market price of the products, P_L is the price of the labor, P_M is the price of materials, and all other variables have been previously defined.

To illustrates how the supply elasticity used in Appendix 9E can be expressed in terms of the parameters of the production function (Equation 9E.3), we assume that production function is represented by a Cobb-Douglas function with only two inputs (capital [K] and labor [L]) with a constant return to scale,

$$Q = L^{\alpha} K^{1-\alpha} \qquad (9F.1)$$

where Q = output, L = labor input, and K = capital input. The cost function is written as

$$TC = wL + rK \qquad (9F.2)$$

where w = wage rate or unit labor cost, r = interest cost or unit capital cost. From equation (9F.1), L can be written as,

$$L = Q^{1/\alpha} K^{(\alpha-1)/\alpha} \qquad (9F.3)$$

Substituting L in the cost function with equation (9F.3),

$$TC = wL + rK = w\{Q^{1/\alpha} K^{(\alpha-1)/\alpha}\} + r K$$

Differentiating cost function with respect to Q, the marginal cost function is

$$MC = w\{(1/\alpha) Q^{(1/\alpha)-1} K^{(\alpha-1)/\alpha}\} = (w/\alpha) Q^{(1-\alpha)/\alpha} K^{(\alpha-1)/\alpha}$$

According to the competitive condition, P = MC, that is

$$MC = (w/\alpha) Q^{(1-\alpha)/\alpha} K^{(\alpha-1)/\alpha} = P$$

To rearrange the above equation, Q is expressed by a function of P and K,

$$Q = \{(\alpha/w) P K^{(1-\alpha)/\alpha}\}^{\alpha/(1-\alpha)}$$

We have

$$Q = (\alpha/w)^{\alpha/(1-\alpha)} P^{\alpha/(1-\alpha)} K \qquad (9F.4)$$

Taking log function on both sides,

$$\ln Q = \alpha/(1-\alpha) \ln(\alpha/w) + \alpha/(1-\alpha) \ln P + \ln K \qquad (9F.5)$$

The price elasticity of supply can be written as

$$\text{Supply elasticity} = \partial \ln Q / \partial \ln P = \alpha/(1-\alpha) \qquad (9F.6)$$

Appendix 9G: 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 price forecasts typically use one of two approaches (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 7G-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.

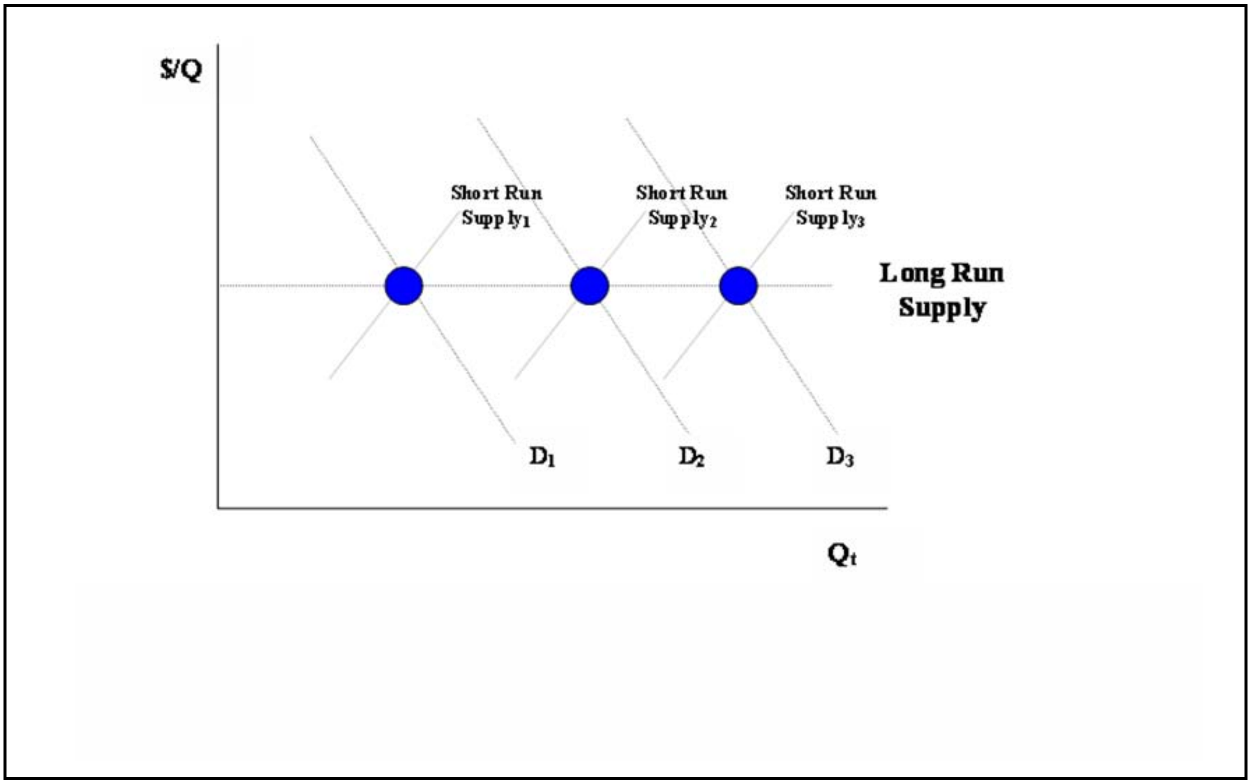


Figure 9G-1. Prices and Quantities in Long Run Market Equilibrium

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 2005 observed price.

Appendix 9H: Sensitivity Analysis

The Economic Impact Analysis presented in this Chapter 9 is based on the Economic Impact Model (EIM) developed for this analysis. The EIM reflects certain assumptions about behavioral responses (modeled by supply and demand elasticities), how costs are treated by producers, what the baseline equipment prices are used in the model. This appendix presents a sensitivity analysis for several alternatives in the model. Three scenarios are examined:

- Scenario 1: alternative market supply and demand elasticity parameters
- Scenario 2: alternative ways to treat engineering compliance costs
- Scenario 3: alternative baseline prices for lawn mower and tractor

The results of these sensitivity analyses are presented below. The results from Scenario 1 to 3 are presented for 2013 (the highest cost year) only with 2005$. These results for the Small SI and Marine SI engine and equipment markets do not include the fuel savings. Instead, fuel savings are added into the total social costs as a separate item.

In general, varying the elasticity parameters does not significantly change the results of the economic impact assessment analysis presented above. The expected price increase remains relative stable across the scenarios in comparing with the primary case for the Small SI and Marine SI engine and equipment. The difference in expected price change between alternative and primary scenarios is around 0.5 percent. Total social costs are about the same across all sensitivity analysis scenarios, $507 million. In addition, varying these model parameters does not significantly affect the way the social costs are borne. In all cases, the end user (households) bear the majority of the burden (over 70 percent), although there are differences in the way the costs are borne among the scenarios between the change in either demand or supply elasticity. The share of social costs end users (households) bear, for example, ranges from 70 to 90 percent.

In the alternative engineering compliance cost scenario, there are differences in the way the social costs are shared among producers and consumers in the market, although total social costs are about the same. The share of the social costs borne by either engine manufacturer or equipment manufacturer increases under this scenario because engines and equipment manufactures can not recover the fixed cost required in this rule. Especially for the Small SI market, the difference in the share of social cost borne by engine and equipment manufacturer is more than 16 percent.

With regard to the scenario of alternative baseline prices, although the difference in prices is about 25.5% and 53.0% for lawn mower and tractors, respectively, the estimates on absolute price change and social cost for each market are approximately the same as in the base case. However, given that the baseline prices are different in these scenarios, there is some variation in projected relative price and quantity change across the scenarios. The expected changes in relative prices and quantity increase under the lower alternative baseline market price scenarios.

9H.1 Model Elasticity Parameters

Consumer demand and producer supply responsiveness to changes in the commodity prices are referred to by economists as "elasticity." The measure is typically expressed as the percentage change in quantity (demanded or supplied) brought about by a percent change in own price. A detailed discussion regarding the estimation and selection of the elasticities used in the EIM are discussed in Appendix 9E. This component of the sensitivity analysis examines the impact of changes in selected elasticity values, holding other parameters constant. The goal is to determine whether alternative elasticity values significantly alter conclusions in this report.

9H.1.1 Alternative Supply and Demand Elasticity Parameters

The choice of supply and demand elasticities for the *engine and equipment market* is important because changes in quantities in the equipment markets are the key drivers in the derived demand functions used to link impacts in the engine and equipment markets. In addition, 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 if they are more responsive to price changes than producers.

Table 9H-1 reports the upper- and lower-bound values of the engine and equipment market elasticity parameters (supply and demand) used in the sensitivity analysis. The engine and equipment market supply elasticities are derived econometrically. Therefore, the upper and lower bound values were computed using the coefficient and standard error values associated with the econometric analysis and reflect a 95 percent confidence interval (see Appendix 9E).

Table 9H-1: Alternative Supply and Demand Elasticities Used in Sensitivity Analysis[a]

Parameter/Market	Upper Bound	Primary Case	Lower Bound
Supply Elasticities			
Engines			
Marine and Small SI	4.2	3.8	3.5
Equipment			
Marine SI			
All other vessel types	2.5	2.3	2.1
PWC	3.5	3.4	3.2
Small SI			
Small SI (handheld/nonhandheld)	3.9	3.4	3.0
Gensets/welders	3.6	3.3	2.9
Demand Elasticities			
Engines			
Marine and Small SI	Derived Demand	Derived Demand	Derived Demand
Equipment			
Marine SI			
All vessel types	–3.9	–2.0	–0.1
Small SI			
Handheld	–2.5	–1.9	–1.3
Lawn mowers	–0.3	–0.2	–0.1
Other lawn and garden	–1.5	–0.9	–0.3
Gensets/welders—Class I	–2.2	–1.4	–0.6
Gensets/welders—Class II	–1.4	–1.1	–0.8
All other handheld	–1.9	–1.0	–0.1

[a] EPA computed upper- and lower-bound estimates using the coefficient and standard error values associated with its econometric analysis and reflect a 95 percent confidence interval (Appendix 9E).

9H.1.2 Engines and Equipment Market (Supply Elasticity Parameters)

The results of the EIM using these alternative supply elasticity values for the Small SI and Marine SI engine and equipment markets are reported in Tables 9H-2. As can be seen in the table, projected changes in market prices are stable across the upper- and lower-bound sensitivity scenarios. The relative change in price is around the primary case by 0.1 percent. Absolute quantities vary but the percentage changes in output are negligible for the two scenarios. The change in total social surplus for 2013 also remains nearly unchanged across all scenarios and is approximately the same as for the rule ($507 million).

However, varying the supply elasticity changes the social impacts (how the burden is shared across markets). Manufacturers bear a *smaller* share of the social costs when they are more responsive to price changes (supply upper bound scenario). As shown for the Small SI market, engine and equipment manufacturers bear approximately 3.8 and 16.0 percent, respectively, in the supply upper bound scenario compared to 4.0 and 17.6 percent in the base case. In contrast, they bear a *higher* share of social cost when they are less responsive to price changes relative to the base case (the supply lower bound scenario). For the Marine SI market, engine and equipment manufacturers bear approximately 10.8 and 21.6 percent, respectively, in supply upper bound scenario compared to 11.4 and 22.4 percent in the base case. In contrast, they bear a *higher* share when they are less responsive to price changes relative to the base case (supply lower bound scenario).

Table 9H-2: Sensitivity Analysis for Engine and Equipment Market Supply Elasticities for 2013 [a,b]

Scenario	Primary Case Absolute	Primary Case Relative[b]	Supply Lower Bound Absolute	Supply Lower Bound Relative[b]	Supply Upper Bound Absolute	Supply Upper Bound Relative[b]
Marine						
Market-Level Impacts						
Price						
Engines	$256.8	2.3%	$255.1	2.3%	$259.3	2.3%
Equipment	$231.7	1.3%	$222.0	1.3%	$240.8	1.4%
Quantity						
Engines	–8,846	–2.0%	–8,406	–1.9%	–9,297	–2.1%
Equipment	–10,847	–2.7%	–10,443	–2.6%	–11,196	–2.8%
Welfare Impacts (million $)						
Change in engine manufacturers surplus	$21.5	11.4%	$22.3	11.8%	$20.4	10.8%
Change in equipment manufacturers surplus	$42.2	22.4%	$44.1	23.3%	$40.8	21.6%
Change in end user (households) surplus	$125.1	66.2%	$122.7	64.9%	$127.6	67.6%
Small SI						
Market-Level Impacts						
Price						
Engines	$22.3	11.7%	$22.2	11.7%	$22.3	11.8%
Equipment	$13.8	3.1%	$13.5	*3.1%*	$14.2	*3.2%*
Class I	$18.6	6.9%	$18.3	*6.9%*	$18.9	*7.0%*
Class II	$40.5	3.9%	$39.1	*3.8%*	$41.6	*4.0%*
HH	$0.3	0.3%	$0.3	*0.3%*	$0.3	*0.4%*
Quantity						
Engines	–371,097	–2.35	–361,097	–2.3%	–380,910	–2.4%
Equipment	–482,942	–1.9%	–467,931	*–1.8%*	–498,041	*–1.9%*
Class I	–219,400	–2.2%	–214,334	*–2.2%*	–224,691	*–2.3%*
Class II	–157,306	–4.3%	–152,207	*–4.1%*	–161,996	*–4.4%*
HH	–106,236	–0.6%	–101,390	*–0.6%*	–111,354	*–0.7%*
Welfare Impacts (million $)						
Change in engine manufacturers surplus	$18.4	4.0%	$19.4	*4.3%*	$17.1	*3.8%*
Change in equipment manufacturers surplus	$80.2	17.6%	$88.1	*19.4%*	$72.6	*16.0%*
Change in end user (households) surplus	$356.0	78.3%	$347.1	*76.4%*	$364.6	80.3%
Subtotal Social Costs (million $)	$643.4		$643.7		$643.1	
Fuel Savings (million $)	$136.5		$136.5		$136.5	
Total Social Costs (million $)	$506.9		$507.1		$506.6	

[a] Figures are in 2005 dollars.

[b] 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 distribution of total surplus changes among stakeholders (consumers and producers).

9H.1.3 Equipment Market (Demand Elasticity Parameters)

Sensitivity analysis was also conducted for the equipment market demand elasticities. The range of demand elasticity values evaluated for each market are provided in Table 9H-1. The demand elasticities for the engine markets are derived as part of the model, and therefore sensitivity analysis was not conducted on those parameters.[16] In other words, the change in the equipment market quantities determines the demand responsiveness in the engine market. As a result, the demand sensitivity analysis for engine markets is indirectly shown in Table 9H-2.

[16]For a discussion of the concept of derived demand, see Section 9.2.3.2 Incorporating Multimarket Interactions.

Table 9H-3: Sensitivity Analysis for Equipment Market Demand Elasticities for 2013 [a,b]

Scenario	Primary Case		Demand Lower Bound		Demand Upper Bound	
	Absolute	Relative[b]	Absolute	Relative[b]	Absolute	Relative[b]
Marine						
Market-Level Impacts						
Price						
Engines	$256.8	2.3%	$301.6	2.8%	$242.5	2.1%
Equipment	$231.7	1.3%	$448.4	2.5%	$157.4	0.9%
Quantity						
Engines	–8,846	–2.0%	–972	–0.2%	–11,205	–2.6%
Equipment	–10,847	–2.7%	–1,016	–0.2%	–14,646	–3.6%
Welfare Impacts (million $)						
Change in engine manufacturers surplus	$21.5	11.4%	$2.3	1.2%	$27.6	14.7%
Change in equipment manufacturers surplus	$42.2	22.4%	$4.0	2.1%	$56.2	30.0%
Change in end user (households) surplus	$125.1	66.2%	$185.7	96.7%	$103.8	55.3%
Small SI						
Market-Level Impacts						
Price						
Engines	$22.3	11.7%	$23.0	12.1%	$21.7	11.5%
Equipment	$13.8	3.1%	$16.4	3.5%	$12.1	2.8%
Class I	$18.6	6.9%	$20.4	7.6%	$17.1	6.4%
Class II	$40.5	3.9%	$46.4	4.4%	$36.3	3.6%
HH	$0.3	0.3%	$0.3	0.4%	$0.3	0.3%
Quantity						
Engines	–371,097	–2.35	–136,358	–0.9%	–542,349	–3.4%
Equipment	–482,942	–1.9%	–219,030	*–0.8%*	–676,766	*–2.6%*
Class I	–219,400	–2.2%	–78,053	*–1.0%*	–328,416	*–3.3%*
Class II	–157,306	–4.3%	–59,011	*–3.0%*	–222,780	*–5.2%*
HH	–106,236	–0.6%	–81,967	*–0.5%*	–125,569	*–0.8%*
Welfare Impacts (million $)						
Change in engine manufacturers surplus	$18.4	4.0%	$7.0	1.5%	$26.3	5.8%
Change in equipment manufacturers surplus	$80.2	17.6%	$26.1	5.7%	$116.1	25.7%
Change in end user (households) surplus	$356.0	78.3%	$424.9	92.8%	$309.6	68.5%
Subtotal Social Costs (million $)	$643.4		$650.0		$639.6	
Fuel Savings (million $)	$136.5		$136.5		$136.5	
Total Social Costs (million $)	**$506.9**		**$513.5**		**$503.1**	

[a] Figures are in 2005 dollars.
[b] 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 distribution of total surplus changes among stakeholders (consumers and producers).

As shown in Tables 9H-3, market prices are relative stable across the upper- and lower-bound sensitivity scenarios. The relative change in price is around the primary case by 0.5 percent. Absolute quantities vary and the percentage changes in output are small for the two scenarios. There is also a small change in total social surplus for 2013 compared to the primary case ($507 million) but this is negligible in terms of the percentage change.

In comparing Table 9H-3 with Table 9H-2 , all quantitative estimates for the market impacts (price and quantity changes) by the EIM model are a little more sensitive to the alternative demand elasticities than the alternative supply elasticities. However, theses changes remain in a reasonable range when compared with the rule, across both the upper and lower bound demand elasticity scenarios for the equipment markets.

It should be noted, varying the demand elasticity changes the social impacts (how the burden is shared across markets) as in the case of changing the supply elasticity. Manufacturers bear a *smaller* share of the social costs when consumers are less responsive to price changes (demand lower bound scenario). As shown for the Small SI market, engine and equipment manufacturers bear approximately 1.5 and 5.7 percent, respectively, in the demand lower bound scenario compared to 4.0 and 17.6 percent in the base case. In contrast, they bear a *higher* share of social cost when consumers are more responsive to price changes relative to the base case (the demand upper bound scenario). For the Marine SI market, engine and equipment manufacturers bear approximately 1.2 and 2.1 percent, respectively, in demand lower bound scenario compared to 11.4 and 22.4 percent in the base case. In contrast, they bear a *higher* share when consumers are more responsive to price changes relative to the base case (demand upper bound scenario).

9H.2 Engine and Equipment Variable Cost Shift Scenario

As discussed in Section 9.2, the total costs (fixed plus variable cost) are used to shift the supply curve in the engines and equipment markets. This is because Small SI and Marine SI engine and equipment manufacturers produce a product that changes very little over time. These manufacturers do not engage in research and development to improve their products on a continuous basis (as opposed to highway vehicles or nonroad engines and equipment). The product changes that would be required to comply with the proposed standards will require these manufacturers to devote new funds and resources to product redesign and facilities changes. Therefore, Small SI and Marine SI engine and equipment manufacturers are expected to increase their prices by the full amount of the compliance costs to recover those costs. This is in contrast to the nonroad diesel engine and equipment markets: manufacturers in those markets generally allocate redesign resources each year to accommodate a changing market. The sensitivity analysis was performed to investigate the impacts under the alternative scenario of shifting the supply curve by the variable costs only. The results of that analysis are shown at Table 9H-4.

In this scenario, engine and equipment manufacturers are able to pass along the variable compliance costs only rather than full costs including the fixed compliance costs. As expected, this scenario leads to a lower projected price increases for the engine and equipment markets (from 11.7 and 3.1 percent in the baseline case to 10.3 and 2.7 percent for Small SI engine and equipment markets; from 2.3 and 1.3 percent in the baseline case to 2.2 and 1.2 percent for Marine SI engine and equipment markets). The share of the social costs borne by Small SI engine and equipment manufacturers are increased by 10.4 and 5.9 percent, respectively. The share of the social costs borne by Marine SI engine and equipment manufacturers are also increased by 2.7 and 0.4 percent, respectively. However, the total social costs of the regulation are not expected to change measurably as the lower prices lead to almost no change in the demand for equipment and engines.

Table 9H-4: Variable Costs only to Shift Supply Curve in Engine and Equipment Markets for 2013 [a,b]

	Fixed and Variable Cost Supply Shift Scenario		Variable Cost Only Supply Shift Scenario	
Scenario	**Absolute**	**Relative[b]**	**Absolute**	**Relative[b]**
Marine				
Market-Level Impacts				
Price				
Engines	$256.8	2.3%	$245.0	2.2%
Equipment	$231.7	1.3%	$219.9	1.2%
Quantity				
Engines	–8,846	–2.0%	–8,264	–1.9%
Equipment	–10,847	–2.7%	–10,136	–2.5%
Welfare Impacts (million $)				
Change in engine manufacturers surplus	$21.5	11.4%	$26.7	14.1%
Change in equipment manufacturers surplus	$42.2	22.4%	$43.0	22.8%
Change in end user (households) surplus	$125.1	66.2%	$119.3	63.1%
Small SI				
Market-Level Impacts				
Price				
Engines	$22.3	11.7%	$19.3	10.3%
Equipment	$13.8	3.1%	$11.0	2.7%
Class I	$18.6	6.9%	$16.1	6.0%
Class II	$40.5	3.9%	$30.1	3.1%
HH	$0.3	0.3%	$0.3	0.3%
Quantity				
Engines	–371,097	–2.35	–309,280	–1.9%
Equipment	–482,942	–1.9%	–419,339	–1.6%
Class I	–219,400	–2.2%	–189,939	–1.9%
Class II	–157,306	–4.3%	–125,945	–3.3%
HH	–106,236	–0.6%	–105,454	–0.6%
Welfare Impacts (million $)				
Change in engine manufacturers surplus	$18.4	4.0%	$65.8	14.4%
Change in equipment manufacturers surplus	$80.2	17.6%	$107.1	23.5%
Change in end user (households) surplus	$356.0	78.3%	$283.6	62.1%
Subtotal Social Costs (million $)	$643.4		$645.5	
Fuel Savings (million $)	$136.5		$136.5	
Total Social Costs (million $)	**$506.9**		**$509.0**	

[a] Figures are in 2005 dollars

[b] 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 distribution of total surplus changes among stakeholders (consumers and producers).

9H.3 Alternative Baseline Prices for Lawn Mower & Tractor

As discussed in Section 9.3.2, the starting point for the economic impact analysis is initial market equilibrium conditions (prices and quantities) that exist prior to the implementation of new standards. At the 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. Since the lawn mower and tractor equipment are the most popular equipment in the Small SI market and their prices range widely, a sensitivity analysis was performed to examine how alternative baseline prices for lawn mower and tractor influence the EIM results.

Table 9H-5: Market Sensitivity Analysis for Alternative Baseline for Lawnmower & Tractor Prices in 2013 [a,b]

Scenario	Average Baseline Price	Market Results				Welfare Results		
		Change in Price (Absolute)	Change in Price (%)	Change in Quantity (Absolute)	Change in Quantity (%)	Change in End Users (Households) Surplus (Million $)	Change in Equipment Manufacturer Surplus (Million $)	Change in Total Surplus (Million $)
Lawn Mowers								
Primary scenario	$243	$14.38	5.9%	–90,263	–1.1%	–$115	–$6	–$121
Low price scenario	$181	$14.29	7.9%	–120,912	–1.5%	–$114	–$6	–$120
Tractors								
Primary scenario	$1,937	$35.15	1.8%	–35,706	–1.8%	–$69	–$20	–$89
Low price scenario	$928	$34.69	3.7%	–73,559	–3.7%	–$67	–$20	–$87

[a] Figures are in 2005 dollars.

We selected the lower end market prices as the alternative baseline prices for lawn mower and tractor in this sensitivity analysis. As shown in Table 9H-5, when these pre-control baseline prices are allowed to vary, the absolute change in market prices remains nearly unchanged when compared with the rule, although the relative price change and absolute quantity change are expected to be higher in the alternative baseline price case. This is because the change in absolute price is ultimately determined by the per unit compliance cost and market supply and demand elasticities. In contrast, the change in relative price is determined by the ratio between the per-unit compliance cost and the baseline price. The lower the initial baseline price, the higher the ratio is for a given per unit compliance cost. Therefore, the change in the relative price is higher. In this market, consumers are expected to response to the higher relative price change by purchasing less equipment. As a result, the expected change for quantity is higher in the lower baseline prices case. Also as seen in Table 9H-5, varying the baseline prices are not expected to substantially change the social cost estimates in these markets or alter the distribution of the social costs across the stakeholders.