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Regulatory Impact Analysis for the Automobile and Light Duty Vehicle NESHAP

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Regulatory Impact Analysis for the Automotive and Light Duty Vehicle NESHAP

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Strategies and Standards Division
Innovative Strategies and Economics Group
Research Triangle Park, NC

Disclaimer

This report is issued by the Air Quality Standards & Strategies Division of the Office of Air Quality Planning and Standards of the U.S. Environmental Protection Agency (EPA). It presents technical data on the National Emission Standard for Hazardous Air Pollutants (NESHAP)for Reciprocating Internal Combustion Engines, which is of interest to a limited number of readers. It should be read in conjunction with the Technical Support Document (TSD) for the NESHAP and other background material used to develop the rule, which are located in the public docket for the NESHAP rulemaking. Copies of these reports and other material supporting the rule are in Dockets OAR-2002-0093 and A-2001-22 at the EPA Docket Center, EPA West (6102T), 1301 Constitution Avenue, NW., Room B-102, Washington, DC 20460. The EPA may charge a reasonable fee for copying. Copies are also available through the National Technical Information Services, 5285 Port Royal Road, Springfield, VA 22161. Federal employees, current contractors and grantees, and nonprofit organizations may obtain copies from the Library Services Office (C267-01) , U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711; phone (919) 541-2777.

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LIST OF ABBREVIATIONS

AAMA	American Automobile Manufacturers Association
ABS	anti-lock braking systems
CAA	Clean Air Act
CPI	consumer price index
CR4s	four-firm concentration ratios
CR8s	eight-firm concentration ratios
EIA	economic impact analysis
EPA	U.S. Environmental Protection Agency
HAP	hazardous air pollutants
HHIs	Herfindahl-Hirschman indexes
ISEG	Innovative Strategies and Economics Group
LDT	light-duty truck
MACT	maximum achievable control technology
MSRP	Manufacturers Suggested Retail Price
NAFTA	North American Free Trade Agreement
NAICS	North American Industry Classification System
NESHAP	national emission standards for hazardous air pollutants
NUMMI	New United Motor Manufacturing, Inc.
OAQPS	Office of Air Quality Planning and Standards
SBA	Small Business Administration
SIC	Standard Industrial Classification
UMRA	Unfunded Mandates Reform Act
VOC	volatile organic compound

EXECUTIVE SUMMARY

Under the Clean Air Act (CAA), Congress gave the U.S. Environmental Protection Agency (EPA) broad authority to protect air resources throughout the nation. Under Section 112 of the CAA, EPA has prepared a National Emission Standard for Hazardous Air Pollutants (NESHAP) designed to reduce emissions generated during the automobile coating process. This report presents a regulatory impact analysis (RIA) to evaluate the economic impacts associated with the regulatory options under consideration for the final rule.

ES.1 Industry Profile

The domestic automobile and light duty truck (LDT) manufacturing industry is a large, mature industry spanning NAICS 336111 and NAICS 336112. In 1998 and 1999, this industry comprised 65 establishments, which were owned by 14 domestic and foreign companies and employed more than 160,000 workers. The industry operates in a global marketplace and competes with foreign producers of vehicles. Many of the companies that own these facilities are foreign-based companies.

Three companies supply the majority of automobile coatings used in vehicle assembly plants: DuPont Performance Coatings, PPG Industries, and BASF Coatings AG. Sherwin-Williams is also a major player in automobile coatings, but they tend to supply auto body shops and other aftermarket operations rather than assembly plants.

Market Structure

Within the United States, the market for automobiles and LDTs is considered an oligopolistic differentiated products market (Berry, Levinsohn, and Pakes, 1995) because the facilities that assemble these vehicles in the United States are owned by only 14 companies and because the products produced are highly differentiated by manufacturer. Entry and exit of companies in the industry are difficult because the capital outlays required to begin manufacturing cars are extremely large; thus, entry depends on the ability of a new manufacturer to secure outside funding. Entry is also difficult because brand name recognition is critical for establishing a market for a particular vehicle.

Market structure of the industry is particularly influenced by the high degree of product differentiation. Vehicles vary in their functions as sedans, coupes, wagons, pickups, and minivans, and in their characteristics such as carrying capacity, gas mileage, safety features, comfort features, visual aesthetics, and reliability ratings. Brand names are also important in this industry in that they embody consumers' perceptions of the characteristics and reliability of the vehicles. The prices for similar type vehicles across manufacturers can vary based on multiple characteristics; thus, nonprice competition, if it occurs, would be particularly difficult to discern.

Market Data

Over 12 million cars and LDTs were manufactured in the United States in 1999. LDT production accounted for approximately 55 percent of total production in 1999 and has shown strong growth over the past 5 years. In contrast, car production has shown small declines over the same period with an average annual growth rate of -2.6 percent. These trends reflect the growing consumer preference for SUVs and minivans (U.S. Department of Commerce, 1999c). Although Japan is the primary source of imported cars and trucks, the flow of imports has declined recently. Exports have remained relatively stable over the past 4 years with Canada accounting for half of all domestic exports.

Industry Trends

Domestic production of motor vehicles in the United States is projected to increase in the next 5 years primarily due to two factors. First, foreign automobile manufacturers, such as Honda and BMW, are locating more of their production facilities in the United States to serve the U.S. market. Second, the LDT market, in which U.S. manufacturers dominate, is surging especially as manufacturers are offering more car-like amenities in these vehicles. The U.S. Department of Commerce (1999c) projects that domestic automobile manufacturing facilities will have capacity utilization rates of 90 percent or more over the next few years.

Offsetting these increases in domestic production is the fact that U.S. manufacturers are expected to move some production facilities to locations with lower costs of production such as Mexico and Canada. Relocation to Mexico and Canada has become easier partly because of NAFTA. In addition to lower costs of production, other countries may have less stringent environmental regulations than the United States' regulations, which translates into lower costs as well. To serve the markets in other countries, however, U.S. manufacturers have developed and will continue to develop smaller, less costly models than those produced for the U.S. market. Most of the growth in the global vehicle market will be in less developed countries such as China, India, Latin America, and eastern Europe in which the typical U.S. automobile is overly equipped and prohibitively expensive.

ES.2 Regulatory Control Costs

For this analysis, EPA assumed that these facilities will adopt the following strategies to reduce their emissions and comply with the final NESHAP:

- Strategy 1: Facilities that do not presently have controls on the electrodeposition oven will add an oxidizer to control HAP emissions from the oven. This equates, on average, to about $8,200 per ton of HAP controlled.
- Strategy 2: If the HAP/VOC ratio for the primer-surfacer coating material exceeds 0.3, a modified surface coating material will be used to meet this ratio. This equates, on average, to about $540 per ton of HAP controlled.
- Strategy 3: If the HAP/VOC ratio for the topcoat material exceeds 0.3, a reformulated top coating material will be used to meet this ratio.
- Strategy 4: Any remaining HAP emissions in excess of the MACT floor will be reduced by introducing controls on the exhaust from automated zones of spray booths.

The associated abatement costs could include capital costs incurred to purchase or upgrade pollution control equipment, cost for operation and maintenance of this abatement equipment such as cost of energy needed to operate it and coating materials replacement costs, and other administrative costs associated with monitoring, reporting, and record keeping.

New facilities and new paint shops would incur little additional cost to meet the final emission limit. These facilities would already include bake oven controls and partial spray booth exhaust controls for VOC control purposes. New facilities might need to make some downward adjustment in the HAP content of their materials to meet the final emission limit.

The total annual capital cost estimate includes the annualized capital cost associated with all applicable strategies. Similarly, the total variable cost estimate includes the variable cost associated with all applicable strategies. The nationwide total cost is estimated at $154 million, with $75 million in annual capital costs, $76 million in operation and maintenance costs, and $3 million in administrative costs.[1] This equates, on average, to about $25,000 per ton of HAP controlled.

ES.3 Summary of EIA Results

Automobile/LDT manufacturers will attempt to mitigate the impacts of higher production costs by shifting as much of the burden on other economic agents as market conditions allow. Potential responses include changes in production processes and inputs, changes in output rates, or closure of the plant. This analysis focuses on the last two options because they appear to be the most viable for auto assembly plants, at least in the short term. We expect upward pressure on prices as producers reduce output rates. Higher prices reduce quantity demanded and output for each vehicle class, leading to changes in profitability of facilities and their parent companies. These market and industry adjustments determine the social costs of the regulation and its distribution across stakeholders (producers and consumers). We report key results below:

- *Price and Quantity Impacts*: The EIA model predicts the following:
  - The regulation is projected to increase the price of all vehicle classes by at most 0.01 percent (or at most $3.08 per vehicle). Similarly, the model projects small declines in domestic production across all vehicle classes (ranging from 17 to 384 vehicles).
  - Given the small changes in domestic vehicle prices projected by the economic model, EPA estimates foreign trade impacts associated with the rule are negligible.
- *Plant Closures and Changes in Employment:* EPA estimates that no automobile or LDT assembly plant is likely to prematurely close as a result of the regulation. However, employment in the automobile and LDT assembly industry is projected to decrease by 37 full-time equivalents (FTEs) as a result of decreased output levels. This represents a 0.02 percent decline in manufacturing employment at these assembly plants.
- *Small Businesses*: The Agency has determined that there are no small businesses within this source category that would be subject to this final rule. Therefore, because this final rule will not impose any requirements on small entities, EPA

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[1] All values are reported in 1999 constant dollars.

certifies that this action will not have a significant economic impact on a substantial number of small entities (SISNOSE).

- *Social Costs*: EPA estimates the total social cost of the rule to be $161 million. Note that social cost estimates exceeds baseline engineering cost estimates by $7 million. The projected change in welfare is higher because the regulation exacerbates a social inefficiency (see Appendix B). In an imperfectly competitive equilibrium, the marginal benefit consumers place on the vehicles, the market price, exceeds the marginal cost to producers of manufacturing the product. Thus, social welfare would be improved by increasing the quantity of the vehicles provided. However, producers have no incentive to do this because the marginal revenue effects of lowering the price and increasing output is lower than the marginal cost of these extra units.
  - Higher market prices lead to consumer losses of $9.1 million, or 6 percent of the total social cost of the rule.
  - Although automobile or LDT producers are able to pass on a limited amount of cost increases to final consumers, the increased costs result in a net decline in profits at assembly plants of $152 million.

ES.4 Summary of Benefit Analysis

The emission reductions achieved by the automobile and light-duty truck surface coating source category will provide benefits to society by improving environmental quality. In general, the reduction of HAP emissions resulting from the regulation will reduce human and environmental exposure to these pollutants and thereby reduce the likelihood of potential adverse health and welfare effects.

Seven HAP account for over 95 percent of the total HAP emitted in this source category. Those seven HAP are toluene, xylene, glycol ethers (including ethylene glycol monobutyl ether (EGBE)), MEK, MIBK, ethylbenzene, and methanol. According to baseline emission estimates, this source category will emit approximately 10,000 tons per year of HAPs at affected sources in the fifth year following promulgation. The regulation will reduce approximately 6,000 tons of emissions per year of the HAPs listed above.

Of the seven HAP emitted in the largest quantities by this source category, all can cause toxic effects following sufficient exposure. The potential toxic effects of these HAP include effects to the central nervous system, such as fatigue, nausea, tremors, and loss of motor coordination; adverse effects on the liver, kidneys, and blood; respiratory effects; and, developmental effects. In addition, one of the seven predominant HAP, EGBE, is a possible carcinogen, although information on this compound is not currently sufficient to allow us to quantify its potency. None of the seven predominant HAP are included in the list of 30 HAP posing the greatest health risk in urban areas which are being addressed in the EPA's Urban Air Toxics Program.

The rule will also achieve reductions of 12,000 to 18,000 tons of VOCs and hence may reduce ground-level ozone and particulate matter (PM). Major adverse health effects from ozone include alterations in lung capacity and breathing frequency; eye, nose and throat irritation; reduced exercise performance; malaise and nausea; increased sensitivity of airways; aggravation of existing respiratory disease; decreased sensitivity to respiratory infection; and extra pulmonary effects (CNS, liver, cardiovascular, and reproductive effects). Other welfare benefits associated with reduced ozone concentrations include the value of avoided losses in commercially valuable timber and aesthetic losses suffered by nonconsumptive users (EPA, 1995b). There are a number of benefits from reduced PM concentrations, including reduced soiling and materials damage, increased visibility, and reductions in cases of respiratory illness, hospitalizations, and deaths.

We are unable to provide a monetized estimate of the benefits from the reduction of HAP and VOC emissions associated with this rule due to a lack of scientific knowledge of the links between the reductions in incidence of the health and environmental effects listed and a value that can be placed on them. The Agency currently has research going on to develop methodologies for providing such benefit estimates.

SECTION 1

INTRODUCTION

In 1999, the automobile and LDT assembly industry was comprised of 65 establishments, which were owned by 14 domestic and foreign companies and employed more than 160,000 workers.[2] The coating operations of 59 of these facilities are major sources of hazardous air pollutant (HAP) emissions.[3] The majority of HAP emissions from the automobile coating process are released in the coating operations. Under Section 112 of the 1990 Clean Air Act (CAA) Amendments, the U.S. Environmental Protection Agency (EPA) is currently developing national emission standards for hazardous air pollutants (NESHAP) to limit these emissions. This report presents a regulatory impact analysis (RIA) to evaluate the economic impacts associated with the regulatory options under consideration.

1.1 Agency Requirements for Conducting an RIA

Congress and the Executive Office have imposed statutory and administrative requirements for conducting economic analyses to accompany regulatory actions. Section 317 of the CAA specifically requires estimation of the cost and economic impacts for specific regulations and standards promulgated under the authority of the Act. In addition, Executive Order (EO) 12866 and the Unfunded Mandates Reform Act (UMRA) require a more comprehensive analysis of benefits and costs for significant regulatory actions.[4] Other statutory and administrative requirements include examination of the composition and distribution of benefits and costs. For example, the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement and Fairness Act of 1996 (SBREFA), requires EPA to consider the economic impacts of regulatory actions on small

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[2] Automobiles are defined as vehicles designed to carry up to seven passengers but do not include sport utility vehicles (SUVs), vans, or trucks. Light duty trucks are defined as vehicles not exceeding 8,500 pounds that are designed to transport light loads of property and include SUVs and vans (AAMA/AIAM/NPCA, 2000).

[3] A major source of HAP emissions is defined as a facility that emits, or has the potential to emit, 10 or more tons of any HAP or 25 or more tons of any combination of HAPs.

[4] Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is required when the regulatory action has an annual effect on the economy of $100 million or more.

entities. The Agency's *Economic Analysis Resource Document* provides detailed instructions and expectations for economic analyses that support rulemaking (EPA, 1999).

1.2 Organization of the Report

This report is divided into five sections and two appendixes that describe the industry and economic methodology and present results of this RIA:

- Section 2 provides a summary profile of the automobile and light-truck industry. It describes the affected production process, inputs, outputs, and costs of production. It also describes the market structure and the uses and consumers of automobiles and light trucks.
- Section 3 reviews the regulatory control alternatives and the associated costs of compliance. This section is based on EPA's engineering analysis conducted in support of the final NESHAP.
- Section 4 outlines the methodology for assessing the economic impacts of the final NESHAP and the results of this analysis, including market, industry, and social welfare impacts.
- Section 5 addresses the final regulation's impact on small businesses, unfunded mandates, and new sources.
- Section 6 analyzes the benefits associated with the final regulation.
- Appendix A provides a detailed description of the Agency's economic model.
- Appendix B presents the methodology for estimating social costs under imperfect competition.

SECTION 2

INDUSTRY PROFILE

The domestic automobile and light duty truck (LDT) manufacturing industry is a large, mature industry spanning NAICS 336111 and NAICS 336112. In 1998 and 1999, this industry was comprised of 65 establishments, which were owned by 14 domestic and foreign companies and employed more than 160,000 workers. The industry's size is expected to increase as foreign producers locate additional production facilities in the United States and as the LDT market continues to grow. The final NESHAP will directly impact facilities that use coatings in their automobile and LDT assembly operations. This industry profile provides information that will be used in Section 4 to estimate the size and nature of these impacts.

This section is organized as follows. Section 2.1 describes the supply side including the affected production process, inputs, outputs, and costs of production. Section 2.2 describes the industry organization, including market structure, manufacturing plants, and parent company characteristics. Section 2.3 describes the demand side of the market including the uses and consumers of automobiles and light trucks. Finally, Section 2.4 provides market data on the automobile and light truck industry, including market volumes, prices, and projections. While the industry profile focuses largely on the automobile and light duty truck assembly industry, information is also provided when available on the indirectly affected coating manufacturing industry.

2.1 Supply Side Overview

Motor vehicle assembly plants combine automotive systems and subsystems to produce finished vehicles. Once the components of the vehicle body have been assembled, the body goes through a series of coating operations. In this section, the coating process and the characteristics of the coatings used are described.

2.1.1 Coating Process

As illustrated in Figure 2-1, the coating process for automobiles and LDTs consists of the following operations:

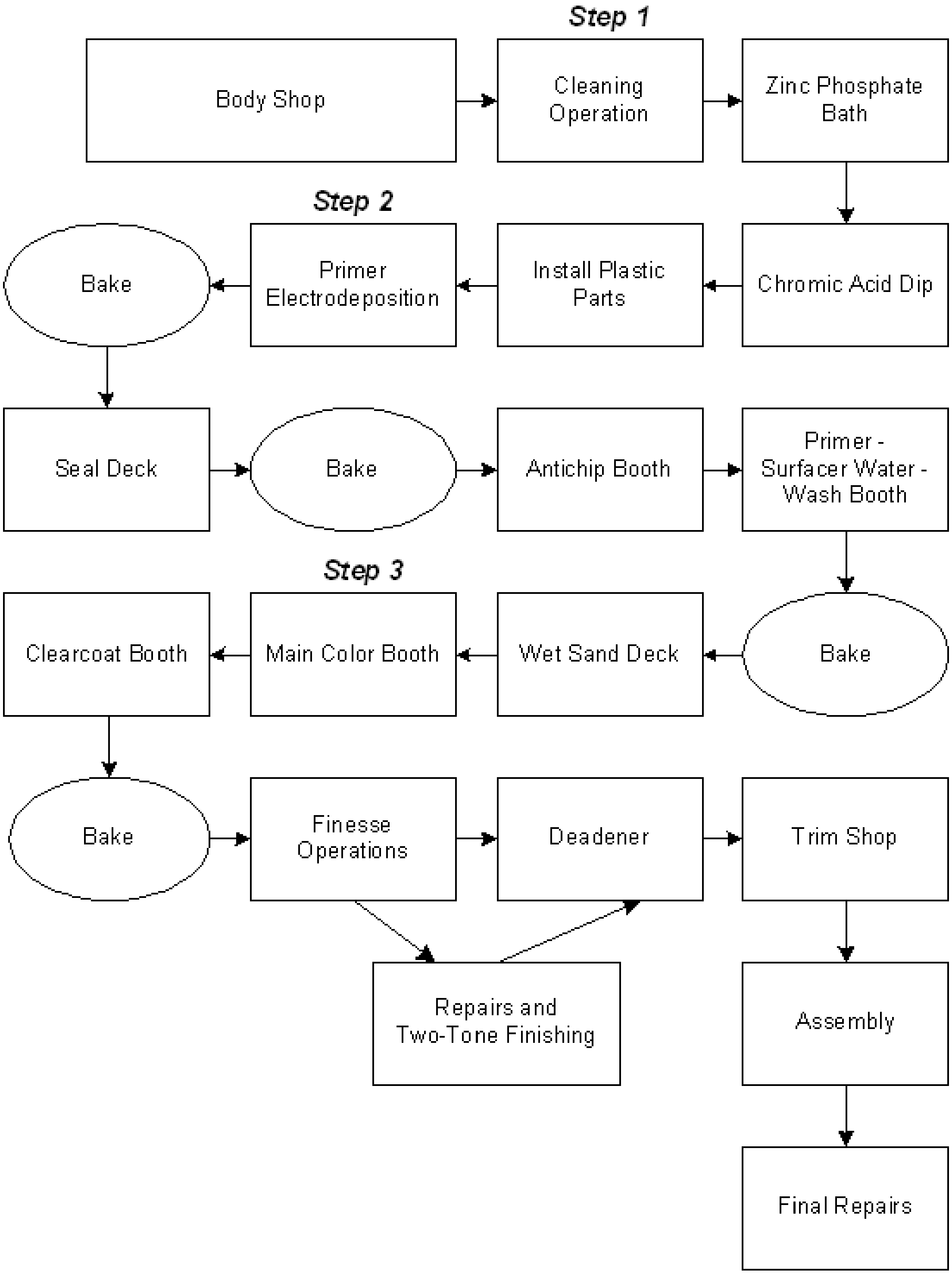

Figure 2-1. Car Painting Process

Sources: American Automobile Manufacturers Association. 1998. *Motor Vehicle Facts and Figures 1998.* Detroit: AAMA.

U.S. Environmental Protection Agency. September 1995a. *Profile of the Motor Vehicle Assemble Industry*. EPA 310-R-95-009. Washington, DC: U.S. Government Printing Office.

Step 1: Surface preparation operations—cleaning applications, phosphate bath, and chromic acid bath;

Step 2: Priming operations—electrodeposition primer bath, joint sealant application, antichip application, and primer surface application; and

Step 3: Finishing operations—color coat application, clearcoat application, and any painting necessary for two-tone color or touch-up applications (EPA, 1995a).

Most releases of HAPs occur during the priming operations (Step 2) and the finishing operations (Step 3); thus, these steps are described in more detail here, followed by a description of the final vehicle assembly activities. However, the order and the method by which these operations occur may vary for individual facilities. Once completed, the coating system typically is as shown in Figure 2-2.

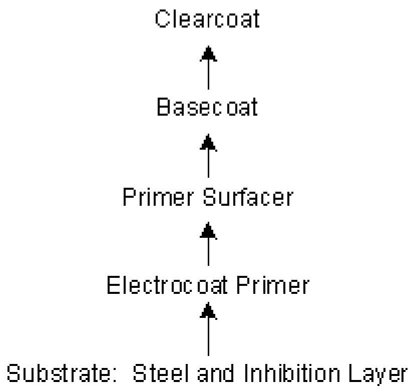

Figure 2-2. Priming Operations
Adapted from: Poth, U. 1995. "Topcoats for the Automotive Industry." *Automotive Paints and Coatings*, G. Fettis, ed. New York: VCH Verlagsgesellschaft mbH.

2.1.1.1 Priming Operations

After the body has been assembled, anticorrosion operations have been performed, and plastic parts to be finished with the body are installed, priming operations begin (Step 2). The purpose of the priming operations is to further prepare the body for finishing by applying various layers of coatings designed to protect the metal surface from corrosion and assure good adhesion of subsequent coatings.

First, a primer coating is applied to the body using an electrodeposition method in which a negatively charged auto body is immersed in a positively charged bath of primer for approximately 3 minutes (EPA, 1995a). The coating particles migrate toward the body and are deposited onto the body surface, creating a strong bond between the coating and the body to provide a durable coating (EPA, 1995a). Once deposition is completed, the body is rinsed in a succession of individual spray and/or immersion rinse stations and then dried with an automatic air blow-off (Vachlas, 1995). Following the rinsing stage, the deposited coating is cured in a electrodeposition curing oven for approximately 20 minutes at 350 to 380°F (EPA, 1995a).

Next, the body is further water-proofed by sealing spot-welded joints of the body. A sealant, usually consisting of polyvinyl chloride and small amounts of solvent, is applied to the joints. The body is again baked to ensure that the sealant adheres thoroughly to the spot-welded areas (EPA, 1995a).

After sealing, the body proceeds to the antichip booth. The purpose of antichip primers is to protect the vulnerable areas of the body, such as the door sills, door sides, under-body floor pan, and front and rear ends, from rocks and other small objects that can damage the finish. In addition, antichip primers allow for improved adhesion of the top coat. In the process, a substance usually consisting of a urethane or an epoxy ester resin, in conjunction with solvents, is applied locally to certain areas along the base and sill sections of the body (EPA, 1995a; Vachlas, 1995).

The final step in the priming operation is applying the primer-surfacer coating. The purpose of the primer-surfacer coating is to provide “filling” or hide minor imperfections in the body, provide additional protection to the vehicle body, and bolster the appearance of the topcoats (Ansdell, 1995). Unlike the initial electrodeposition primer coating, primer-surfacer coatings are applied by spray application in a water-wash spray booth. The primer-surfacer consists primarily of pigments, polyester or epoxy ester resins, and solvents. Because of the composition of this coating, the primer-surfacer creates a durable finish that can be sanded. Primer-surfacers can be color-keyed to specific topcoat colors and thus provide additional color layers in case the primary color coating is damaged. Since water-washed spray booths are usually used, water that carries the overspray is captured and processed for recycling (Poth, 1995; EPA, 1995a). Following application of the primer-surfacer, the body is baked to cure the film, minimize dirt pickup, and reduce processing time.

2.1.1.2 Finishing Operations

After the primer-surfacer coating is baked, the body is then sanded, if necessary, to remove any dirt or coating flaws. The next step of the finishing process is the application of the topcoat, which usually consists of a color basecoat and a clearcoat. This is accomplished in a manner similar to the application of primer-surfacer in that the coatings are sprayed onto the body. In addition to pigments and solvents, aluminum or mica flakes can be added to the color basecoat to create a finish with metallic or reflective qualities.

After the color basecoat is allowed to flashoff, the clearcoat is applied. The purpose of the clearcoat is to add luster and durability to the vehicle finish and protect the total coating system against solvents, chemical agents, water, weather, and other environmental effects. This coating generally consists of acrylic resins or melamine resins and may contain additives. Once the clearcoat is applied, the vehicle body is baked for approximately 30 minutes to cure the basecoat and clearcoat.

2.1.1.3 Final Assembly Activities

Once the clearcoat is baked, deadener is applied to certain areas of the automobile underbody to reduce noise. In addition, anticorrosion wax is applied to other areas, such as the inside of doors, to further seal the automobile body and prevent moisture damage. Hard and soft trim are then installed on the vehicle body. Hard trim, such as instrument panels, steering columns, weather stripping, and body glass, is installed first. The car body is then passed through a water test where, by using phosphorus and a black light, leaks are identified. Soft trim, including seats, door pads, roof panel insulation, carpeting, and upholstery, is then installed (EPA, 1995a).

Next, the automobile body is fitted with the gas tank, catalytic converter, muffler, tail pipe, bumpers, engine, transmission, coolant hoses, alternator, and tires. The finished vehicle is then inspected to ensure that no damage has occurred as a result of the final assembly stages. If there is major damage, the entire body part may be replaced. However, if the damage is minor, such as a scratch, paint is taken to the end of the line and applied using a hand-operated spray gun. Because the automobile cannot be baked at temperatures as high as in earlier stages of the finishing process, the paint is catalyzed prior to application to allow for faster drying at lower temperatures.

2.1.2 Coating Characterization

Automobile coatings enhance a vehicle’s durability and appearance. Coatings therefore add value to the vehicle. Some of the coating system characteristics that automotive assemblers test for include adhesion, water resistance, humidity resistance, salt spray resistance, color, gloss, acid etch resistance, and stone chip resistance.

Coatings inputs are combined with other inputs, such as labor, capital, and energy, to complete the coating process for automobiles and LDTs. The primary coatings used in vehicle assembly that the NESHAP will affect are the electrodeposition primer, the primer surfacer coating, and the topcoat (basecoat and clearcoat). Table 2-1 shows the coatings and their physical state, their purpose, and if they release HAPs.

As the table indicates, powder coatings used for primer surface coating do not release significant HAPs, but their liquid counterparts may (Green, 2000a); thus, automotive and LDT assembly plants may consider substituting powder coatings for liquid coatings in addition to installing control equipment to comply with the NESHAP. However, powder coatings tend to be more costly to use than liquid coatings because the technology has not been developed to allow powder to be applied as thinly as liquid coating. In particular, "the normal liquid film build-up for a clearcoat is 2 mils while for a powder clearcoat it takes 2.5 to 3 mils or more to make it look good" (Galvin, 1999). As a result, using powder means using a larger quantity of coating, thus an increased cost. However, some believe the cost difference between powder and liquid may be eliminated for applications such as automobile primers over the next 5 years (RTI, 2000). Already, one coating manufacturer, PPG, is experimenting with charging automotive manufacturers based on the number of vehicles coated rather than the units of coatings used (Galvin, 1999).

HAP emissions depend on HAP content, transfer efficiency, and the presence and extent of HAP control equipment. To reduce HAP content, liquid coatings can be reformulated. In addition, non-HAPs such as ethyl acetate and butyl acetate can substitute for HAPs such as toluene and xylene. It should also be noted that there are overlapping ranges of HAP contents and HAP emission rates for solventborne and waterborne materials.

Volatile organic compound (VOC) emissions depend on VOC content, transfer efficiency, and the presence and extent of VOC control equipment. Although most of the

HAPs in these coatings are also VOCs, there are non-HAP VOCs. To lower VOC content,

Table 2-1. Properties of Coatings Used in Automobile and LDT Assembly Facilities

Coating	Purpose	Physical State	Significant HAP Releases[a, b]
Cleaning agents	To clean spray booths and application equipment and purge lines between color changes	Solvent	Primarily specific aromatics (toluene and xylene), blends containing aromatics, MIBK
Electrodeposition primer	To prepare body for primer surface and for corrosion protection	Liquid—waterborne	Primarily glycol ethers, methanol, MIBK, xylene, MEK
Primer surfacer	To prepare body for paint	Liquid—solventborne or waterborne	Glycol ethers, methanol, xylene, ethylbenzene, formaldehyde, MEK
		Powder	None
Basecoat	To add color	Liquid—waterborne or solventborne	1,2,4 trimethyl benzene, ethylbenzene, xylene, toluene, aromatic 100, naptha, formaldehyde, mineral spirits, glycol ethers, MEK, methanol
Clearcoat	To protect the color coat	Liquid—solventborne	Ethyl benzene, xylene, 1,2,4 trimethyl benzene, aromatic solvent 100, napthol spirits, MIBK, aromatic solvent, formaldehyde
		Powder [c]	None

[a] Although liquid coatings may be associated with significant HAP releases, all can be reformulated using non-HAP chemicals.

[b] MIBK = methyl isobutyl ketone; MEK = methyl ethyl ketone.

[c] Powder clearcoats are currently not used in the United States.

Sources: Adapted from U.S. Environmental Protection Agency. September 1995a. *Profile of the Motor Vehicle Assembly Industry*. EPA310-R-95-009. Washington, DC: U.S. Government Printing Office.

Green, David, RTI. Email correspondence with Aaiysha Khursheed, EPA. November 8, 2000a.

liquid coatings can be reformulated. VOC contents and emission rates for solventborne and waterborne materials also have overlapping ranges.

2.1.3 Final Products

Motor vehicle assembly plants combine automotive parts from parts manufacturers to produce finished vehicles. There is a great diversity in the type of final vehicles available for sale to the consumer. Vehicles can vary in their functions such as sedans, pickup trucks, and minivans as well as in their characteristics such as fuel efficiency, carrying capacity, and comfort features. In this report, the Agency has categorized automobiles and light trucks into the eight vehicle classes listed below in Table 2-2.

Table 2-2. Finished Vehicle Categorization

Vehicle Class	Examples of Vehicle Models
Subcompact	Honda Civic, Nissan Sentra
Compact	Ford Focus, Toyota Corolla, Chevrolet Prizm
Intermediate/standard	Honda Accord, Dodge Stratus, Toyota Camry
Luxury	Cadillac Deville, Lincoln Towncar
Sports	Chevrolet Corvette, Dodge Viper
Pick-up	Dodge Ram, Ford F Series
Van	Dodge Caravan, Ford Windstar
Sports utility vehicle (SUV)	Jeep Grand Cherokee, Ford Explorer

2.1.4 Costs of Production

The overall costs of production for automobiles and LDTs include capital expenditures, labor, energy, and materials. The cost of coating a vehicle is only a subset of these overall costs. Costs of production, as reported by the Census Bureau for the relevant SIC and NAICS codes, include costs for automobile and LDT assemblers and for establishments that manufacture chassis and passenger car bodies. In addition, the relevant SIC code includes establishments that assemble commercial cars and buses and special-purpose vehicles for highway use, none of which are included in the NAICS code. In either case, the data presented here overstate the costs of production for plants that assemble vehicles. However, the hourly wages and the proportion of costs relative to the value of shipments provide us with information on relative costs in the industry.

Table 2-3 presents data on the value of shipments, payroll, cost of materials, and new capital expenditures for SIC 3711 and for NAICS 336111 (automobiles) and 336112 (LDTs). As indicated, payroll costs, which include wages and benefits, for these codes account for approximately 6 to 7 percent of the value of shipments. Materials account for a large portion of value of shipments at 64 to 73 percent. According to the Census definition, materials include parts used in the manufacture of finished goods (materials, parts, containers, and supplies incorporated into products or directly consumed in the process); purchased items later resold without further manufacture; fuels; electricity; and commission or fees to outside parties for contract manufacturing (U.S. Department of Commerce, 1996). The energy component of the materials cost averages less than 1 percent. Finally, new capital expenditures account for approximately 2 percent of the value of shipments.

Table 2-4 provides further detail on the labor component of production costs. Average hourly wages including benefits for production workers ranged from $21.66 per hour in 1992 to $26.30 per hour in 1997. However, real wages have been relatively constant over this time period.

2.1.5 Costs Associated with Coatings

According to the National Paint and Coatings Association (2000), the cost of paint on an average automobile accounts for approximately 1 percent of the showroom price. In addition to the costs of the coatings themselves, the total costs of coating a vehicle also include annualized capital expenditures for the "paint shop," labor, energy, and other material inputs. The costs associated with the coating process are described in more detail below.

2.1.5.1 Capital Costs for the Paint Shop

The capital costs associated with coating vehicles, or the "paint shop," include the cost of

- physical space within the assembly plant;
- conveyor system;

Table 2-3. Number of Establishments, Value of Shipments, and Production Costs for the SIC and NAICS Codes that Include Automobile and LDT Assemblers, 1992-1997

Industry Code	Number of	Value of		Cost of Materials	New Capital Expenditures % of VOS
					2%
					2%
					2%
					2%
Total NAICS 336111 and 336112					2%
					2%
(autos)					4%
(LDTs)					2%

.
NA = Not available

EC97M0-3361A. Washington, DC: Government Printing Office.

. EC97M-3361B. Washington, DC: Government Printing Office.

Table 2-4. Number of Establishments, Employment, and Payroll Costs for the SIC and NAICS Codes that Include Automobile and LDT Assemblers, 1992-1997

Industry Code	Number of	)	Average Hourly Wage
			1992$
			21.66
			22.67
			21.40
			22.54
			22.00
Total NAICS 336111 and 336112			22.99
336111 (autos)			22.99
336112 (LDTs)			22.98

NA = Not available

Office.

EC97M0-3361A. Washington, DC: Government Printing Office.

. EC97M-3361B. Washington, DC: Government Printing Office.

- sanding, paint spray, and demasking booths;
- vats for storing coatings;
- flash and cooling tunnels;
- electrocoat, sealer, and topcoat ovens;
- inspection and repair decks;
- pollution abatement system; and
- various other equipment (Graves, 2000).

Industry estimates that the capital costs for a new powder primer-surfacer system within an existing plant are $26 to $30 million (Praschan, 2000) and the total cost of removing and demolishing the previous equipment is in the range of $8 to $10 million. The expected life of a paint shop is approximately 15 years (Green, 2000b).

2.1.5.2 Variable Costs for the Paint Shop

The variable costs associated with coating vehicles include the coatings, labor, energy, and other material inputs. While specific information on the labor, energy, and other material input costs for the coating process could not be obtained, information on the costs of the coatings themselves is available. First, the relative size of the coating input cost can be estimated based on Census data. According to the 1997 Economic Census (U.S. Department of Commerce, Bureau of the Census, 1999a and 1999b), establishments classified in NAICS 336111 Automobile Manufacturing, which includes both assembly plants and chassis manufacturing, spent $605.8 million on materials purchased from establishments classified in NAICS 32551 Paints, Varnishes, Lacquers, Stains, Shellacs, Japans, Enamels, and Allied Products. This implies that the coatings themselves accounted for approximately 0.9 percent of the cost of materials ($66.5 billion) and 0.6 percent of the value of shipments ($95.4 billion) in 1997. Correspondingly, establishments classified in NAICS 336112 Light Truck and Utility Vehicle Manufacturing, which also include both assembly plants and chassis manufacturing, spent $969.8 million on materials purchased from establishments classified in NAICS 32551. Thus, coatings accounted for approximately 1.4 percent of the cost of materials ($137.5 billion) and 0.9 percent of the value of shipments ($205.8 billion) in 1997.

Table 2-5 provides a breakdown of automotive coatings usage for both motor vehicle assembly and parts manufacturing establishments in 5-year increments from 1989 with projections to 2008. In 1998, the majority of coatings were solvent-based (67.5 percent in

1998). Water-based coatings accounted for 19.8 percent of coating usage and powder coatings accounted for 7.1 percent. Over the next 10 years, Freedonia projects that the relative quantities of both water-based and powder coatings will increase relative to solvent-based coatings.

Table 2-5. Automotive Coatings Usage, 1989, 1993, and 1998 with Projections to 2008

Item	1989	1993	1998	2003	2008
Motor vehicle assembly and parts manufacturing shipments (10^9 \$1992)	\$246.1	\$255.1	\$337.6	\$388.0	\$448.2
Pounds of coatings per \$1,000 in shipments	3.69	3.32	2.70	2.44	2.19
Total automotive coating usage (10^6 pounds)	909	847	910	945	980
Coating weight by application (10^6 pounds)					
Solvent-based	765	675	615	560	505
Water-based	100	109	180	225	260
Powder	24	41	65	95	135
Other	20	22	50	65	80
Coating weight by resin (10^6 pounds)					
Acrylic	310	300	330	350	370
Urethane	285	280	290	305	320
Epoxy	89	90	110	115	120
Alkyd	150	110	100	90	80
Other	75	67	80	85	90

Source: Freedonia Group. September 1999. *Automotive Coatings, Sealants and Adhesives in the United States to 2003—Automotive Adhesives, Market Share and Competitive Strategies.*

When comparing liquid coatings to powder coatings, a general rule of thumb in the industry is to equate the cost of 3 pounds of powder, at a cost of $2.50 to $6.00 per pound, to 1 gallon of liquid coatings (RTI, 2000). One can also compare the cost of reformulated liquid coating materials that contain ethyl acetate and butyl acetate to those containing aromatics such as toluene and xylene. Inputs to coating, such as ethyl acetate and butyl acetate, cost about $0.40/lb, while toluene and xylene cost about $0.17/lb (Green, 2001). Overall coatings used in the automobile industry averaged $3.74 per pound in 1998. Table 2-6 shows an example of one private research firm's estimates of the pricing trends in automotive coatings, sealants, and adhesives in 5-year increments from 1989 with projections to 2008 (Freedonia Group, 1999).

Table 2-6. Pricing Trends in Automotive Coatings, Sealants, and Adhesives, 1989, 1993, and 1998 with Projections to 2008 (Dollars per Pound)

Item	1989	1993	1998	2003	2008
Weighted average	2.48	2.60	2.59	2.69	2.76
Coatings	3.36	3.66	3.74	3.92	4.08
Sealants	1.09	1.17	1.23	1.31	1.39
Adhesives	1.18	1.20	1.33	1.41	1.48

Source: Freedonia Group. September 1999. *Automotive Coatings, Sealants and Adhesives in the United States to 2003—Automotive Adhesives, Market Share and Competitive Strategies.*

2.2 Industry Organization

This subsection describes the market structure of the automobile and LDT assembly industries, the characteristics of the assembly facilities, and the characteristics of the firms that own them. In addition, we provide information on the market structure of the automotive coatings industry and the characteristics of the firms that manufacture the coatings used at the assembly facilities.

2.2.1 Market Structure

Market structure is important because it determines the behavior of producers and consumers in the industry. If an industry is perfectly competitive, then individual producers are not able to influence the price of the output they sell or the inputs they purchase. This condition is most likely to hold if the industry has a large number of firms, the products sold and the inputs purchased are undifferentiated, and entry and exit of firms are unrestricted.

Product differentiation can occur both from differences in product attributes and quality and from brand name recognition of products. Entry and exit are unrestricted for most industries except, for example, in cases where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market.

The automobile and LDT assembly industry operates in a global marketplace and competes with foreign producers of vehicles. Many of the companies that own these facilities are foreign-based companies. Within the United States, the market for automobiles and LDTs is considered an oligopolistic differentiated products market (Berry, Levinsohn, and Pakes, 1995) because the facilities that assemble these vehicles in the United States are owned by only 14 companies and because the products produced are highly differentiated by manufacturer. Entry and exit of companies in the industry are difficult because the capital outlays required to begin manufacturing cars are extremely large; thus, entry depends on the ability of a new manufacturer to secure outside funding. Entry is also difficult because brand name recognition is critical for establishing a market for a particular vehicle.

Market structure of the industry is particularly influenced by the high degree of product differentiation. Vehicles vary in their functions as sedans, coupes, wagons, pickups, and minivans, and in their characteristics such as carrying capacity, gas mileage, safety features, comfort features, visual aesthetics, and reliability ratings. Brand names are also important in this industry in that they embody consumers' perceptions of the characteristics and reliability of the vehicles. The prices for similar type vehicles across manufacturers can vary based on multiple characteristics; thus, nonprice competition, if it occurs, would be particularly difficult to discern.

In addition to evaluating the factors that affect competition in an industry, one can also evaluate four-firm concentration ratios (CR4s), eight-firm concentration ratios (CR8s), and Herfindahl-Hirschmann indexes (HHIs). These values are reported at the four-digit SIC level for 1992, the most recent year available, in Table 2-7. Also included in the table are the same ratios independently calculated from sales data for 1998/1999 for the 14 companies that own vehicle assembly plants. Comparing these two sets of numbers provides some insights into how the companies owning assembly plants differ from the rest of the SIC 3711 companies.

Table 2-7. Measures of Market Concentration for Automobile Manufacturers, 1992 and 1998–1999

Description	CR4	CR8	HHI	Number of Companies	Number of Establishments
SIC 3711 (1992)[a]	84	91	2,676	398	465
Companies that own assembly plants (1998/99)[b]	72	94	1,471	14	65

[a] Concentration ratios, as calculated by the Department of Commerce, are based on value added for the SIC code.

[b] Independently calculated concentration ratios were based on overall sales for the companies that own assembly plants.

Sources: U.S. Department of Commerce. 1992. *Concentration Ratios in Manufacturing.* Washington, DC: Government Printing Office.
Hoover's Online. Company capsules. <http://www.hoovers.com>. As obtained on January 13, 2000.

Table 2-7 suggests that companies that own assembly plants have similar concentration ratios compared to all companies in SIC 3711 based on the CR4s and CR8s. The values for both of these measures are high relative to other industries. The criteria for evaluating the HHIs are based on the 1992 Department of Justice's Horizontal Merger Guidelines. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive). The HHI as calculated by the Department of Commerce indicates that SIC 3711 is considered highly concentrated, whereas the HHI calculated based on the sales of companies that own assembly plants indicates that the industry is moderately concentrated. In general, firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. While the concentration measures are high for the automobile and LDT industries, the high degree of product differentiation is likely a more important determinant of the industry's structure.

As with the assembly industry, the automotive coatings industry is oligopolistic in that three companies provide nearly all of the coatings used by vehicle assemblers. These multinational companies—Dupont, BASF, and PPG Industries—provide coatings to a variety of industries. The coatings they provide to the vehicle assemblers are differentiated based on their uses and specific formulations. Because little information is available on how they market their products to the automotive industry, the degree of competition in the automotive coatings industry is not known.

2.2.2 *Automobile and LDT Assembly Facilities*

Facilities comprise a site of land with a plant and equipment that combine inputs (raw materials, fuel, energy, and labor) to produce outputs (in this case, automobiles and light trucks, and coatings). The terms facility, establishment, and plant are synonymous in this report and refer to the physical locations where products are manufactured. As of 1999, there were 65 facilities that assemble autos and LDTs. This section provides information on their characteristics, the vehicles manufactured at these facilities, and trends for these facilities.

2.2.2.1 Characteristics of Automobile and LDT Assembly Plants

As shown in Figure 2-3, most automobile and LDT facilities are located in Michigan (30 percent of plants) and six Midwestern and Southern states south of Michigan (50 percent of plants). The remaining plants are located primarily in California and on the Eastern seaboard. Most assembly plants employ from 2,000 to 3,999 workers (see Table 2-8). However, the largest plant, a Honda plant in Marysville, Ohio, employs 13,000 people.

Capacity utilization indicates how well the current facilities meet current demand. For the years 1988-1997 the automobile industry capacity utilization was lower than the manufacturing sector (see Table 2-9). However, capacity utilization is highly variable from year to year depending on economic conditions. In comparison to the data in Table 2-9, capacity utilization for automotive manufacturers, including those that make medium- and heavy-duty trucks, reached 91 percent in 1997 (U.S. Department of Commerce, 1999c) and nearly 100 percent in 1999 (Tables 2-10 and 2-11).

Tables 2-10 and 2-11 provide detailed information on automobile and LDT assembly facilities by company, including the location of each facility, production volume, capacity, utilization rate, and the class of vehicles produced at the plant in 1999. As these tables illustrate, a variety of vehicle classes can be produced at a single plant. Car companies engage in joint ventures since several models can be produced with one plant. Generally models that are produced within one plant are similar (i.e., Prizm and Corolla). The New United Motor Manufacturing, Inc. (NUMMI) facility is owned and used for manufacture by both Toyota and General Motors (GM). In other cases, the facility may be wholly owned by

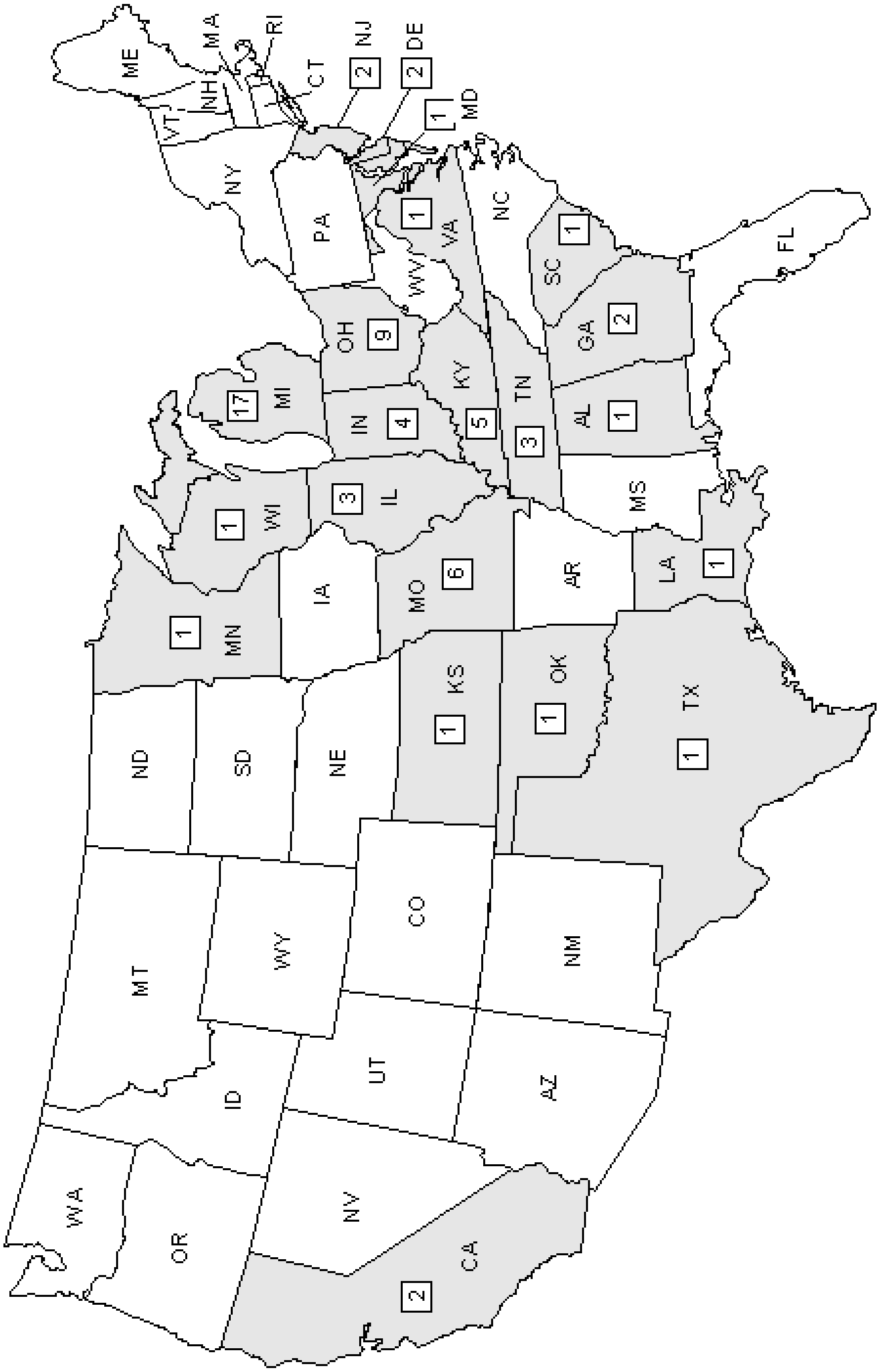

Figure 2-3. Map of Facility Locations

Source: Harris Info Source. Selected Online Profiles. As obtained January 2000.

Table 2-8. Number of Automobile and LDT Assembly Plants by Employment Range, 1998-1999

Employment Range	Number of Plants
<1,000	1
1,000 to 1,999	6
2,000 to 2,999	13
3,000 to 3,999	14
4,000 to 4,999	5
5,000 to 5,999	5
6,000 or greater	3
Not available	18
Total plants	65

Source: Harris Info Source. 2000. Selected Online Profiles. As obtained on January 2000.

Table 2-9. Capacity Utilization

Year	All Manufacturing	Percent Change	Motor Vehicle and Parts Mfg.	Percent Change
1988	83.8	3.1	81.2	5.7
1989	83.6	–0.2	79.5	–2.1
1990	81.4	–2.6	71.6	–9.9
1991	77.9	–4.3	64.0	–10.6
1992	79.4	1.9	69.9	9.2
1993	80.5	1.4	77.3	10.6
1994	82.5	2.5	83.5	8.0
1995	82.8	0.4	76.9	–7.9
1996	81.4	–1.7	72.4	–5.9
1997	81.7	0.4	73.4	1.4
Average	81.5	0.1	75.0	–0.2

Source: American Automobile Manufacturers Association. 1998. *Motor Vehicle Facts and Figure 1998*. Detroit: AAMA.

Table 2-10. Facility-Level Car Production Data by Market: 1999

Plant ID	City	State	Market	Capacity	Production	Utilization Rate
Daimler-Chrysler						
010A	Belvidere	IL	Compact	244,160	232,134	0.951
010B	Detroit	MI	Sports	5,712	4,468	0.782
010E	Sterling Heights	MI	Intermediate/Standard	258,944	195,231	0.754
				508,816	**431,833**	**0.849**
Ford						
012A	Atlanta	GA	Intermediate/Standard	247,520	243,842	0.985
012N	Chicago	IL	Intermediate/Standard	247,520	245,443	0.992
012M	Dearborn	MI	Sports	186,592	191,432	1.026
012C	Kansas City	MO	Compact	239,904	152,918	0.637
012K	Wayne	MI	Compact	285,600	243,544	0.853
012L	Wixom	MI	Luxury	198,016	147,938	0.747
				1,405,152	**1,225,117**	**0.872**
GM						
013A	Bowling Green	KY	Sports	28,560	33,243	1.164
015A	Flint	MI	Luxury	190,400	66,759	0.351
016A	Detroit-Hamtramck	MI	Luxury	228,480	214,375	0.938
017A	Fairfax	KS	Luxury	228,480	272,368	1.192
018A	Lake Orion	MI	Luxury	228,480	143,223	0.627
030B	Lansing (C)	MI	Compact	160,320	212,804	1.327
030A	Lansing (M)	MI	Subcompact and Compact	210,240	192,996	0.918
035A	Lansing (Craft Center)	MI	Compact	NR	318	NR
031A	Lordstown	OH	Subcompact and Compact	388,960	385,754	0.992
019A	Oklahoma City	OK	Intermediate/Standard	247,520	249,413	1.008
032A	Spring Hill	TN	Compact	288,200	238,140	0.826
033A	Wilmington	DE	Intermediate/Standard	122,080	83,942	0.688
				2,321,720	**2,093,335**	**0.902**
Auto Alliance						
005A	Flat Rock	MI	Compact and Intermediate/Standard	178,976	165,143	0.923
				178,976	**165,143**	**0.923**

(continued)

Table 2-10. Facility-Level Car Production Data by Market: 1999 (continued)

Plant ID	City	State	Market	Capacity	Production	Utilization Rate
BMW						
007A	Spartanburg	SC	Sports	50,000	48,393	0.968
				50,000	**48,393**	**0.968**
Honda						
034A&B	Marysville	OH	Intermediate/Standard and Luxury	383,040	448,140	1.170
002A	East Liberty	OH	Subcompact and Compact	220,864	237,760	1.076
				603,904	**685,900**	**1.136**
Mitsubishi						
001A	Normal	IL	Intermediate/Standard, Sports	228,480	161,931	0.709
				228,480	**161,931**	**0.709**
NUMMI						
009A	Fremont	CA	Compact	228,480	210,726	0.922
				228,480	**210,726**	**0.922**
Nissan						
004A	Smryna	TN	Subcompact	224,672	167,742	0.747
				224,672	**167,742**	**0.747**
Subaru-Isuzu						
003A	South Bend	IN	Intermediate/Standard	106,624	93,070	0.873
				106,624	**93,070**	**0.873**
Toyota						
008A	Georgetown	KY	Intermediate/Standard	357,952	356,840	0.997
				357,952	**356,840**	**0.997**
			Total:	**6,214,776**	**5,640,030**	**0.908**

NR = Not reported

Sources: Crain Automotive Group. 2000. Automotive News Market Databook—2000. Detroit, MI: Crain Automotive Group.

U.S. Environmental Protection Agency (EPA). 2000. Fuel Economy Guide Data—1999. [computer file]. <http://www.epa.gov/otaq/feddata.htm>. As obtained December 13, 2000.

Edmunds.com. 2001. "New and Used Vehicles." <http://www.Edmunds.com>. As obtained January 2001.

Table 2-11. Plant-Level Truck Production Data by Market: 1999

Plant ID	City	State	Market	1999 Capacity	1999 Production	1999 Utilization Rate
DaimlerChrysler						
010J	Warren	MI	Pickup	236,096	256,955	1.09
010C	Detroit	MI	SUV	324,870	343,536	1.06
010F	St. Louis (N)	MO	Pickup	133,280	160,162	1.20
010G	St. Louis (S)	MO	Van	285,600	260,471	0.91
010H&I	Toledo	OH	SUV	266,560	287,062	1.08
010D	Newark	DE	SUV	171,360	220,097	1.28
006A	Vance	AL	SUV	72,352	77,696	1.07
				1,490,118	**1,605,979**	**1.08**
Ford						
012I	Avon Lake	OH	Van	110,880	94,658	0.85
012B	Edison	NJ	Pickup	152,320	169,024	1.11
012D	Kansas City	MO	Pickup	182,784	224,637	1.23
012O	Louisville	KY	Pickup and SUV	301,400	392,701	1.30
012E	Lorain	OH	Van	213,248	233,178	1.09
012F	Louisville	KY	Pickup and SUV	312,256	331,161	1.06
012G	Wayne	MI	SUV	286,000	299,251	1.05
012H	Norfolk	VA	Pickup	182,784	237,142	1.30
012J	St. Louis	MO	SUV	190,400	249,700	1.31
012P	St. Paul	MN	Pickup	159,936	213,836	1.34
				2,092,008	**2,445,288**	**1.17**
GM						
021A	Baltimore	MD	Van	190,400	168,057	0.88
020A	Arlington	TX	SUV	190,400	123,593	0.65
014A	Doraville	GA	Van	239,904	285,872	1.19
022A	Flint	MI	Van and Pickup	66,640	120,558	1.81
023A	Fort Wayne	IN	Pickup	201,600	257,574	1.28
024A	Janeville	WI	Pickup and SUV	201,824	242,581	1.20
025A	Linden	NJ	Pickup and SUV	190,400	202,513	1.06
026A	Moraine	OH	SUV	285,600	303,312	1.06
027A	Pontiac (E)	MI	Pickup	252,000	309,775	1.23
028A	Shreveport	LA	Pickup	190,400	219,741	1.15
029A	Wentzville	MO	Van	152,320	173,221	0.88
				2,161,488	**2,406,797**	**1.11**

(continued)

Table 2-11. Plant-Level Truck Production Data by Market: 1999 (continued)

Plant ID	City	State	Market	1999 Capacity	1999 Production	1999 Utilization Rate
BMW						
007A	Spartanburg	SC	SUV	NR	2,413	NR
				NR	**2,413**	NR
NUMMI						
009B	Fremont	CA	Pickup	152,320	156,395	1.03
				152,320	**156,395**	**1.03**
Nissan						
004B	Smryna	TN	Pickup and SUV	217,056	155,398	0.72
				217,056	**155,398**	**0.72**
Subaru-Isuzu						
038A	Lafayette	IN	SUV	103,680	99,130	0.96
				103,680	**99,130**	**0.96**
Toyota						
008B	Georgetown	KY	Van	121,856	120,686	0.99
NA	Princeton	IN	Pickup	102,816	56,176	0.55
				224,672	**176,862**	**0.55**
			Total:	**6,441,342**	**7,048,262**	**1.09**

NR = Not reported

Sources: Crain Automotive Group. 2000. Automotive News Market Databook—2000. Detroit, MI: Crain Automotive Group.

U.S. Environmental Protection Agency (EPA). 2000. Fuel Economy Guide Data—1999. [computer file]. <http://www.epa.gov/otaq/feddata.htm>. As obtained December 13, 2000.

Edmunds.com. 2001. "New and Used Vehicles." <http://www.Edmunds.com>. As obtained January 2001.

one company, while another company contracts with them to have their vehicles produced there. For instance, DaimlerChrysler contracts with Mitsubishi to produce its Sebring and Avenger models at Mitsubishi's Illinois facility. In this relationship, Mitsubishi assembles the vehicles for DaimlerChrysler based on Mitsubishi components (U.S. Department of Commerce, 1999c).

2.2.2.2 Trends in the Automobile and LDT Assembly Industries

Because of the large capital outlays necessary to build a new plant, new plants come online on average less than one per year. Most recently, Toyota finished construction of a new plant in 1999 to produce its new Toyota Tundra, which is a LDT. In 2000, GM announced that it will open two new plants near Lansing, Michigan. Honda is currently building a new auto and engine plant in Lincoln, AL (Honda, 2000). Both Nissan and Hyundai are also considering new facilities in the United States.

Although new plants are not built often, companies are constantly revamping old equipment in existing plants to replace aging equipment, upgrade to new technologies, and switch to new car models. The paint shops within assembly plants are refitted every 10 to 15 years. When refitted with new equipment, new technologies have allowed for lower pollutant emissions than the replaced equipment. The innovations for these new technologies come from both the coatings manufacturers as well as automobile assembly company engineers. Examples of paint shop innovations include lower VOC and lower HAP content materials, electrostatic spray equipment, robotic spray equipment, waterborne coatings, and powder coatings.

2.2.3 Companies that Own Automobile and LDT Assembly Facilities

Companies that own individual facilities are legal business entities that have the capacity to conduct business transactions and make business decisions that affect the facility. The terms "company" and "firm" are synonymous, and refer to the legal business entity that owns one or more facilities. This subsection presents information on the parent companies that own automobile and LDT assembly plants.

2.2.3.1 Company Characteristics

The 65 automobile and LDT assembly facilities listed in Tables 2-10 and 2-11 are owned by 14 domestic and foreign companies (see Table 2-12). The largest number of facilities is operated by GM—23 facilities or 35 percent of the total—and by Ford Motor Company—16 facilities or 25 percent of the total. The foreign-based companies—BMW, DaimlerChrysler, Mitsubishi Motors Corporation, Honda, Nissan, and Toyota—own between one and 11 facilities in the United States. Isuzu and Subaru jointly operate one facility as do Mazda and Ford. NUMMI, which is wholly owned through a joint partnership between Toyota and GM, is not individually publicly traded; all of the remaining companies are publically traded.

Sales in the 1998 and 1999 time period for all lines of business at companies that own automobile and LDT facilities range from $4.7 billion for the jointly owned Toyota and GM company, NUMMI, to $161.3 billion for GM itself. With the exception of Nissan Motors, which generated a loss of $229 million in 1999, all of these companies generated positive returns ranging from $43 million for Mitsubishi to $22.1 billion for Ford. Profit-to-sales ratios ranged from 0.2 percent for Mitsubishi Motors Corporation to 15.3 percent for Ford.

Employment for all lines of business at companies that own automobile and LDT assembly facilities ranges from 4,800 workers for NUMMI to 594,000 for GM. The Small Business Administration (SBA) defines a small business in this industry as follows:

- NAICS 33611 (Automobile Manufacturing)—1,000 employees or less
- NAICS 336112 (Light Truck and Utility Vehicle Manufacturing)—1,000 employees or less.

Based on these size standards and company employment data presented in Table 2-12, there are no small businesses within this industry.

2.2.3.2 Vertical and Horizontal Integration

Companies within the automotive industry may be horizontally and/or vertically integrated. Vertical integration refers to the degree to which firms own different levels of production and marketing. Vertically integrated firms may produce the inputs used in their production processes and own the distribution network to sell their products to consumers. These firms may own several plants, each of which handles these different stages of production. For example, a company that owns an automobile assembly plant may also own a plant that molds the dashboard or makes the seat coverings. An automotive company may be integrated as far back as the foundry that makes parts for an automobile, as in the cases of Ford, GM, and DaimlerChrysler. However, it may not be integrated into retail dealership operations because of various state franchise laws.

Vertical integration within the automotive industry has been decreasing as competition has increased and outsourcing has become a more attractive option. Outsourcing refers to hiring an outside company to produce some of the materials necessary for manufacture. As a result, companies may not produce a number of the inputs used in their automobiles. In 1997, Ford outsourced 50 percent of its vehicle content. GM was expected to have similar levels after it spun off Delphi automotive systems, a subsidiary of GM. And, finally, before Chrysler merged with Daimler-Benz, it outsourced 70 percent of its inputs (Brunnermeier and Martin, 1999). “Reduced vertical integration allows vehicle makers to buy parts from the best suppliers. The spun-off parts companies are assumed to operate more efficiently and become more competitive (and thus yield lower unit costs) as independent entities” (U.S. Department of Commerce, 1999c).

Table 2-12. Financial Data for Companies that Own Automobile and LDT Assembly Facilities, 1998–1999

	Joint Ownership	Number of Assembly Plants	Company)	Company Profits)	Profit/Sales Ratio	Company	Year
AAI (Auto Alliance International)							NA
Company							
							1998
							1998
Fuji Heavy Industries (owns Subaru)							1998
							1999
							1998
							1999
							1999
							1999
							1999
	GM-Toyota (50-50)						1999
							1998
Renco Group Inc. (AM c							1999

1999

Source: Hoover's Online. 2000. Company Capsules. <http://www.hoovers.com>. As obtained on January 13, 2000.

Horizontal integration refers to a company that produces a diversity of products. The companies may be directly integrated by direct ownership of additional facilities or indirectly integrated by owning additional facilities through affiliations with other companies and subsidiaries. Several of the automobile manufacturers have high degrees of horizontal integration. First, most of the companies are horizontally integrated within their own industry in that they own multiple assembly plants and produce multiple automobile and LDT models. Second, most companies are also involved in other activities including automobile rentals, automobile and other credit financing, and electronics manufacturing. Table 2-13 provides examples of the subsidiaries and affiliates associated with companies that assemble automobiles and LDTs (Hoover's, 2000).

2.2.4 Companies that Manufacture Automotive Coatings

Three companies supply the majority of automobile coatings used in vehicle assembly plants: DuPont Performance Coatings, PPG Industries, and BASF Coatings AG. Sherwin-Williams is also a major player in automobile coatings, but they tend to supply auto body shops and other aftermarket operations rather than assembly plants. Other minor suppliers may supply adhesives and sealers to the vehicle assembly industry (Green, 2000c). In total, the industry had estimated sales of $3.4 billion in 1998 (Freedonia, 1999). Table 2-14 lists the market shares of U.S. automotive coating manufacturers, including both sales to assembly plants and to aftermarket users.

The parent companies for DuPont, PPG, and BASF, are all large with 1998 sales ranging from $7.5 billion for PPG to $32.4 billion for BASF (Hoover's, 2000). Table 2-15 shows sales, income, and employment for these three coating manufacturers. Based on the SBA definition of a small company for NAICS 32551 (paint and coating manufacturing) (i.e., 500 or fewer employees), none of these companies are small.

2.3 Demand Side Overview Characteristics

Individual consumers, companies, and the government lease or purchase automobiles and LDTs. Over the past several years, consumption by individual consumers, which accounted for 47 percent of 1997 sales, has decreased, while consumption by businesses, which accounted for 51 percent of 1997 sales, has increased (see Table 2-16). Government purchases make up 1 to 2 percent of consumption. While individuals generally purchase automobiles and LDTs for personal use, companies purchase automobiles so their employees

Table 2-13. Examples of Subsidiaries and Affiliates Partially or Wholly Owned by Automotive Companies

DaimlerChrysler AG	
Detroit Diesel Corporation	DaimlerChrysler Rail Systems GmbH
DaimlerChrysler Canada Inc.	Freightliner Corporation
Ford Motor Company	
Automobile Protection Corporation	Kwik-Fit Holdings PLC
Ford Motor Company of Canada, Ltd.	Mazda Motor Corporation
Ford Motor Credit Company	Visteon Automotive Systems
The Hertz Corporation	Ford Motor Company/Buffalo Stamping Division
General Motors Corporation	
Adam Opel AG	GM Corporation/Allison Transmission Divisions
GM Acceptance Corporation	GM Corporation/Powertrain
GM of Canada Ltd.	HRL Laboratories, LLC
Hughes Electronics Corporation	Hughes Network Systems
Integon Corporation	Hughes Space and Communications Company
Isuzu Motors Ltd.	Lexel Imaging Systems, Inc.
Saab Automobile AB	Packard Hughes Interconnect
AMI instruments, Inc.	Rockwell Collins Passenger Systems
Delco Defense Systems Operations	Spectrolab, Inc.
Delphi Harrison Thermal Systems	
Isuzu Motors Limited	
American Isuzu Motors Inc.	Tri Petch Isuzu Sales Company, Ltd.
Toyota Motor Corporation	
Daihatsu Motor Company, Ltd.	Toyota Motor Sales, USA, Inc.
New United Motor Manufacturing, Inc.	Toyota Motor Thailand Company Ltd.
Toyota Motor Credit Corporation	

Source: Hoover's Online. 2000. Company Capsules. <http://www.hoovers.com>. As obtained January 13, 2000.

may use them on work-related business or so their customers may use them, as in the case of automobile rental companies. Federal, state, and local governments purchase automobiles for use during government-related work, including military operations, escorting officials, and site visits. In general, government-purchased vehicles are more utilitarian than vehicles purchased by individual consumers and companies.

Table 2-14. Market Shares in the Automotive Coatings Industry, 1998

Company	Percent
DuPont	29.4
PPG Industries	28.8
BASF	15.9
Sherwin-Williams	8.8
Others	17.1

Source: Freedonia Group. September 1999. *Automotive Coatings, Sealants and Adhesives in the United States to 2003—Automotive Adhesives, Market Share and Competitive Strategies.*

Table 2-15. Company Data for Coatings Manufacturers, 1998

Company	Location of HQ	Sales (10^6)	Income (10^6)	Employment
BASF Aktiengesellschaft	Germany	$32,439	$1,994	105,945
E.I du Pont de Nemours and Co.	Wilmington, DE	$24,767	$4,480	101,000
PPG Industries	Pittsburgh, PA	$7,510	$801	32,500

Source: Hoover's Online. Company Capsules. <http://www.hoovers.com>. As obtained on January 13, 2000.

In 1997, sales of passenger cars and LDTs were approximately equal (AAMA, 1998). However, the individual consumers who purchase new passenger cars differ somewhat from those who purchase new LDTs. As shown in Table 2-17, purchasers of new passenger cars are fairly evenly split between male and female, but men make up three-quarters of the LDT purchasers. New passenger car purchases are greatest for the 45 to 54 age range, but LDT purchases are high for the broader 35 to 54 age range. The highest education level for vehicle purchases is similar for both vehicle types, with the high percentages for the categories of some college and college graduates. Passenger car purchases are higher than LDT purchases in the Northeast and lower than LDT purchases in the North Central. Differences in these purchases are minor in the South and West. Finally, median household income for passenger car purchasers is lower at $59,900 compared to $68,000 for LDT purchasers.

Table 2-16. U.S. Car Sales by Market Sector, 1980–1997

	Units by Consuming Sector (10^3)				% of Total Sales		
Year	Consumer	Business	Government	Total	Consumer	Business	Government
1980	6,062	2,791	126	8,979	67.5%	31.1%	1.4%
1985	7,083	3,822	134	11,039	64.2%	34.6%	1.2%
1986	7,658	3,666	127	11,450	66.9%	32.0%	1.1%
1987	6,748	3,395	135	10,278	65.7%	33.0%	1.3%
1988	6,802	3,699	138	10,639	63.9%	34.8%	1.3%
1989	6,375	3,402	136	9,913	64.3%	34.3%	1.4%
1990	5,768	3,567	149	9,484	60.8%	37.6%	1.6%
1991	4,538	3,752	97	8,387	54.1%	44.8%	1.2%
1992	4,558	3,683	113	8,354	54.6%	44.1%	1.4%
1993	4,669	3,941	108	8,718	53.6%	45.2%	1.2%
1994	4,612	4,255	124	8,991	51.3%	47.3%	1.4%
1995	4,313	4,211	162	8,686	49.7%	48.5%	1.9%
1996	4,065	4,328	134	8,527	47.4%	50.7%	1.6%
1997	3,880	4,233	131	8,245	47.1%	51.3%	1.6%

Source: U.S. Department of Commerce, Bureau of Economic Analysis, as reported in American Automobile Manufacturers Association (AAMA). 1998. *Motor Vehicle Facts and Figure 1998*. Detroit: AAMA.

When choosing an automobile or LDT to purchase or lease, consumers consider the following characteristics:

- function of the vehicle (e.g., sedan, coupe, wagon, pickup truck, minivan, SUV);
- performance characteristics, such as capacity, mileage per gallon, horsepower, four-wheel drive versus two-wheel drive;
- aesthetic characteristics, such as design and visual appeal;
- comfort characteristics, such as seating, equipment adjustments, and air conditioning;
- safety characteristics, such as air bags and advanced braking systems (ABS);

Table 2-17. Demographics of New Automobile and LDT Buyers, 1998

Characteristic	New Passenger Car Buyers Total	New Light Truck Buyers Total
Gender		
Male	51.6%	71.2%
Female	43.1%	24.3%
No Answer	5.3%	4.5%
Total	100.0%	100.0%
Age of Principal Purchaser (in years)		
Under 25	7.0%	4.0%
25–29	7.7%	7.4%
30–34	8.3%	10.0%
35–39	8.0%	12.7%
40–44	9.3%	13.3%
45–49	11.5%	12.7%
50–54	11.0%	12.3%
55–59	7.6%	8.5%
60–64	6.7%	6.2%
65 and over	17.3%	8.7%
No Answer	5.6%	4.1%
Total	100.0%	100.0%
Highest Education Level		
8th grade or less	0.6%	1.1%
Some high school	2.1%	3.0%
High school/no college	15.5%	18.1%
Some college	23.5%	23.9%
College graduate	28.7%	25.5%
Post graduate	20.2%	16.1%
Trade/technical	4.7%	8.3%
Other	1.3%	1.0%
No answer	3.3%	3.1%
Total	100.0%	100.0%
Census Region		
Northeast	21.8%	17.2%
North central	28.4%	32.4%
South	31.6%	32.0%
West	18.2%	18.4%
Total	100.0%	100.0%
Median Household		
Income	$59,900	$68,000

Source: J.D. Power and Associates, *1998 Vehicle Quality Survey* as reported in American Automobile Manufacturers Association (AAMA). 1998. *Motor Vehicle Facts and Figure 1998*. Detroit: AAMA.

- perceived reliability and durability; and
- price, including financing and leasing options.

According to a survey conducted by Consumers Union, reliability, price, and appearance are the top three reasons why a consumer chooses a particular vehicle (*Consumer Reports,* 2000c).

Coatings obviously affect the appearance of a vehicle, but they also affect its durability since they provide protection from rust, acid rain, chipping, and scratching. A consumer can readily observe the appearance characteristics of coatings, including, most obviously, its color and gloss. For the year 2000, metallic silver is expected to make up 22 percent of car sales, followed by black at 17 percent, white at 15 percent, blue at 12 percent, and green at 11 percent (*Consumer Reports*, 2000a). In the future, metallic paints on vehicles are expected to remain popular and special effects coatings are expected to increase.

While the benefits of coatings for the appearance of vehicles are easily observable when a consumer purchases a car, the durability aspects of the coatings are only observable over time. The average age of a passenger vehicle on the road in 1997 was 8.7 years and has been increasing over time from an average age of 5.6 years in the 1970s (AAMA, 1998). As the vehicle ages, coatings that rust, chip, and scratch easily greatly diminish the appearance and, hence, value of the vehicle. Thus, because the quality of the coating cannot be entirely observed at the time of purchase, the reputation of the company that manufactures the cars is important.

2.3.1 Substitution Possibilities in Consumption

The possibilities for substitution in the automobile and LDT industries arise from the choices among different makes and models of vehicles, between purchasing a vehicle versus leasing, between new versus used vehicles, and among different forms of alternative transportation. The quality of the coatings on a vehicle may subtly affect these choices. As described above, a company with a history of problems with its coatings may lose market share over time to companies that manufacture vehicles with durable coatings. The market for used vehicles may also be potentially affected by the quality of coatings because consumers would be more willing to purchase a used vehicle if its appearance is satisfactory but less willing if the coatings are declining as the vehicle ages. Thus, the market for used vehicles may affect manufacturers of new vehicles in two opposite directions. If good quality used vehicles are available for purchase, consumers may purchase used vehicles as a substitute for new vehicles, thus reducing the size of the market for new vehicles. However, if the resale market for a particular model is good (i.e., the model retains its value over time), then the manufacturer may be able to obtain a higher price for the same model when it is new. The last possibility for substitution, the use of alternative forms of transportation such as buses, subways, and bicycles, is likely much less affected by appearance and quality of coatings because these forms of transportation tend to be lifestyle choices for particular individuals.

2.3.1.1 Demand Elasticity

Estimates of own-price elasticity of demand for vehicles are available at different levels of aggregation from a number of sources in the economics literature. Trandel (1991) estimates an overall own-price elasticity of –2.42 by aggregating data for 210 models from 1983-1985. Berry, Levinsohn, and Pakes (1995) report own-price elasticities of demand for vehicles ranging from -3.515 to -6.358 for individual models. Aggregate elasticity estimates for domestic, European, and Asian vehicles of -1.06, -1.85 and -1.42 respectively are reported in McCarthy (1996). One of the most disaggregated sets of elasticity estimates is available from Goldberg (1995). She estimates own price elasticities for different vehicle classes using micro data on transaction prices and make/models from the Consumer Expenditure Survey and the Automotive News Market Data Book. Her estimates of average own price elasticities by vehicle class are reported in Table 2-18. All estimates are greater than one in absolute value, but vary in an intuitive manner across vehicle classes. For example, the demand for intermediate and standard automobiles is highly elastic, while that for sports and luxury cars is the least price elastic.

Cross-price semi-elasticities refer to the percentage change in quantity demanded of model j when price of model i changes, but all other model prices remain unchanged. Goldberg (1995) estimates cross price semi-elasticities of demand for some specific vehicle models and finds that these semi-elasticities are low if the models belong to different classes. For example, the cross price semi-elasticity between a Honda Civic and a Honda Accord is only 14.9E-07. McCarthy (1996) also finds that the cross-price elasticities of demand are relatively inelastic.

2.4 Market Data

EPA collected the market information to characterize the baseline year of the regulatory impact analysis and identify trends in production, consumption, prices, and international trade. The primary sources of this data are the Automotive News Market Data Book, U.S. International Trade Commission's trade data base, and the Commerce Department's U.S. Industry and trade

Table 2-18. Own Price Elasticities of Demand by Vehicle Class

Vehicle Class	Elasticity
Subcompact	–3.286
Compact	–3.419
Intermediate	–4.179
Standard	–4.712
Luxury	–1.912
Sports	–1.065
Pick-up	–3.526
Van	–4.363
Other	–4.088

Sources: Goldberg, Pinelopi K. 1995. "Product Differentiation and Oligopoly in International Markets: The Case of the U.S. Automobile Industry." *Econometrica* 63(4): 891-951.

outlook. The following section provides a discussion of these data, with emphasis on the baseline data set used to develop an economic model of the industry.

2.4.1 Domestic Production and Consumption

Over 12 million cars and LDTs were manufactured in the United States in 1999. As shown in Table 2-19, this was an increase of 8 percent from 1998. LDT production accounted for approximately 55 percent of total production in 1999 and has shown strong growth over the past 5 years. The average annual growth rate for trucks is 5.3 percent between 1995 and 2000. In contrast, car production has shown small declines over the same period with an average annual growth rate of -2.6 percent. These trends reflect the growing consumer preference for SUVs and minivans (U.S. Department of Commerce, 1999c).

Table 2-19. Domestic Car and Truck Production: 1995–1999 (10^3 Units)

Year	Cars	Trucks[a]	Total
1995	6,327	5,392	11,719
1996	6,056	5,488	11,544
1997	5,922	5,958	11,880
1998	5,550	6,163	11,713
1999	5,640	7,048	12,688
2000	5,543	6,949	12,492
Average annual growth rate	–2.6%	5.3%	1.4%

[a] Excludes other medium/heavy trucks.

Sources: Crain Automotive Group. 2000. Automotive News Market Databook—2000. Detroit, MI: Crain Automotive Group.
Crain Automotive Group. 2001. Automotive News Market Databook—2001. Detroit, MI: Crain Automotive Group.

Industry data and forecasts show North American sales[1] of cars and trucks peaked in 1999–2000 with sales reaching 19 million (see Table 2-20). Total annual sales are projected to be 18.1 and 19 million between 2001 and 2005. Truck sales are projected to grow, increasing from 9.1 million in 1999 to 9.7 million in 2005, or 6.6 percent. However, cars sales are projected to decline from 10.0 million in 1999 to 9.3 million in 2005, or 7 percent. Again, this reflects the growing use of LDTs for personal transportation.

2.4.2 International Trade

Although Japan is the primary source of imported cars and trucks, the flow of imports has declined recently (see Table 2-21). Levy (2000) attributes this decline to currency fluctuations that have encouraged the production of foreign models in North America. He notes Japanese and European automakers are increasing their U.S. production capacity, suggesting additional future declines in imports.

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[1] Includes the United States, Canada, and Mexico.

Table 2-20. North American Consumption of Cars and Trucks: 1997–2000[a] (10^3 Units)

Year	Cars	Trucks[b]	Total
1997	9,333	7,710	17,043
1998	9,353	8,275	17,628
1999	10,017	9,111	19,128
2000	10,453	9,361	19,814
2001[c]	9,575	8,782	18,357
2002[c]	9,363	8,811	18,174
2003[c]	9,319	9,208	18,527
2004[c]	9,224	9,604	18,828
2005[c]	9,336	9,703	19,039

[a] North American sales (includes the United States, Canada, and Mexico).

[b] Excludes other medium/heavy trucks.

[c] Forecast.

Source: Crain Automotive Group. 2001. Automotive News Market Databook—2001. Detroit, MI: Crain Automotive Group.

Table 2-21. Imports for Consumption for NAICS 336111 (Automobiles and Light Duty Motor Vehicles, Including Chassis) by Country of Origin: 1997-2000 (10^3 units)

Country	1997	1998	1999	2000
Japan	3,763	3,490	3,431	2,941
Canada	1,726	1,839	2,170	2,139
Mexico	778	594	640	934
Germany	707	844	974	611
Other	522	421	736	942
Total	7,495	7,188	7,953	7,567

Source: U.S. International Trade Commission. 2001. ITC Trade Dataweb. http://205.197.120.17/. Obtained May 31, 2001.

Exports have remained relatively stable over the past 4 years (see Table 2-22) with Canada accounting for half of all domestic exports. As a result of NAFTA, the Mexican export market has recently expanded. U.S. vehicles are typically equipped with bigger engines and more accessories relative to other vehicles produced overseas. This limits demand from countries with lower incomes and higher fuel prices (Levy, 2000). As a result, U.S. companies will increasingly have to consider development of manufacturing operations in foreign countries where production costs are lower. This will likely further limit growth in exports of U.S. manufactured vehicles (Levy, 2000).

Table 2-22. Domestic Exports for NAICS 336111 (Automobiles and Light Duty Motor Vehicles, Including Chassis) by Country of Origin: 1997-2000 (10^3 units)

Country	1997	1998	1999	2000
Canada	633	608	637	666
Mexico	68	97	135	190
Germany	64	57	53	55
Japan	84	53	48	39
Other	386	329	226	221
Total	1,236	1,144	1,099	1,171

Source: U.S. International Trade Commission. 2001. ITC Trade Dataweb. http://205.197.120.17/. Obtained May 31, 2001.

2.4.3 *Market Prices*

The relationship between the prices paid by consumers for cars and the wholesale prices received by car manufacturers is not readily known. The Manufacturers Suggested Retail Price (MSRP) is usually above the price that consumers actually pay for a vehicle and includes the markup received by the dealership that sells the vehicle. Invoice prices, which would appear to be a wholesale price, are readily available from automobile pricing services, such as Autobytel.com, nadaguides.com, and Edmunds.com, but do not reflect the actual prices received by manufacturers (*Consumer Reports*, 2000b). The prices they receive may be below the invoice base price because of dealer holdbacks, dealer incentives, and rebates (Edmunds, 2000a). Dealer holdback is a percentage of the MSRP that the manufacturer pays the dealer to assist with the dealer's financing of the vehicle while it is on the dealer's lot (Edmunds.com, 2000b).

EPA collected price information by vehicle class using the following methodology. First, EPA identified car and truck models produced in 1999.[2] Models were assigned a vehicle class using EPA's Fuel Economy Guide data (EPA, 2000), car buyers guides such as Edmunds.com (Edmunds, 2001), and the Automotive News Market Data Book (Crain Automotive Group, 2000). Next, the Agency collected base price data for the low and high values for these models reported in the Automotive News Market Data Book (Crain, 2000). The prices includes the MSRP and destination price. Finally, EPA computed a sales-weighted average price for each vehicle class using the median base price for each model and 1999 model sales. Prices for each class are reported in Table 2-23.

In addition to 1999 price data, the Agency collected data on price trends from the U.S. Bureau of Labor Statistics. As shown in Figure 2-4, the consumer price index (CPI) for new cars rose more slowly than the CPI for all items, even while new cars improved and added safety and emissions equipment. In comparison, the CPI for new truck rose slightly faster than the CPI for all items.

2.4.4 Industry Trends

The motor vehicle industry in the United States is a large, mature market in which most of the vehicles produced are geared toward the preferences of U.S. consumers. U.S. consumers generally prefer larger, more powerful vehicles than consumers in other parts of the world, in part because gas prices are significantly lower in the United States relative to other countries.

Domestic production of motor vehicles in the United States is projected to increase in the next 5 years primarily due to two factors. First, foreign automobile manufacturers, such as Honda and BMW, are locating more of their production facilities in the United States to serve the U.S. market. Automobiles produced from these facilities would previously have been classified as imports, but after relocation of production facilities, they are considered domestic production. Second, the LDT market, in which U.S. manufacturers dominate, is surging especially as manufacturers are offering more car-like amenities in these vehicles.

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[2] For LDTs, we selected sample of top sales models (with price data) in each market class reported by Crain Automotive Group 2000. pp. 50-51.

Table 2-23. Average Vehicle Prices by Class[a]

Vehicle Class	Price ($/unit)
Compact	$16,487
Intermediate/standard	$21,155
Luxury	$33,587
Pick-up	$22,126
Sports	$25,797
Subcompact	$15,522
SUV	$27,694
Van	$22,910

[a] Includes the MSRP and destination price reported by the Automotive News Market Data Book (Crain, 2000; p: 75). Prices current as of April 2000 and were considered representative of 1999 prices.

Sources: Crain Automotive Group. 2000. Automotive News Market Databook—2000. Detroit, MI: Crain Automotive Group.
Edmunds.com. 2001. "New and Used Vehicles." <http://www.Edmunds.com>. As obtained January 2001.
U.S. Environmental Protection Agency (EPA). 2000. Fuel Economy Guide Data—1999. [computer file]. <http://www.epa.gov/otaq/feddata.htm>. As obtained December 13, 2000.

The U.S. Department of Commerce (1999c) projects that domestic automobile manufacturing facilities will have capacity utilization rates of 90 percent or more over the next few years.

Offsetting these increases in domestic production is the fact that U.S. manufacturers are expected to move some production facilities to locations with lower costs of production such as Mexico and Canada. Relocation to Mexico and Canada has become easier partly because of NAFTA. In addition to lower costs of production, other countries may have less-stringent environmental regulations than the United States' regulations, which translates into lower costs as well. When production facilities are relocated to other countries, what was formerly considered domestic production becomes imports if the vehicles are delivered to the U.S. market. However, if the vehicles are intended for the domestic country in which they are produced, they are no longer considered either "domestic production" or "imports." To serve the markets in other countries, however, U.S. manufacturers have developed and will

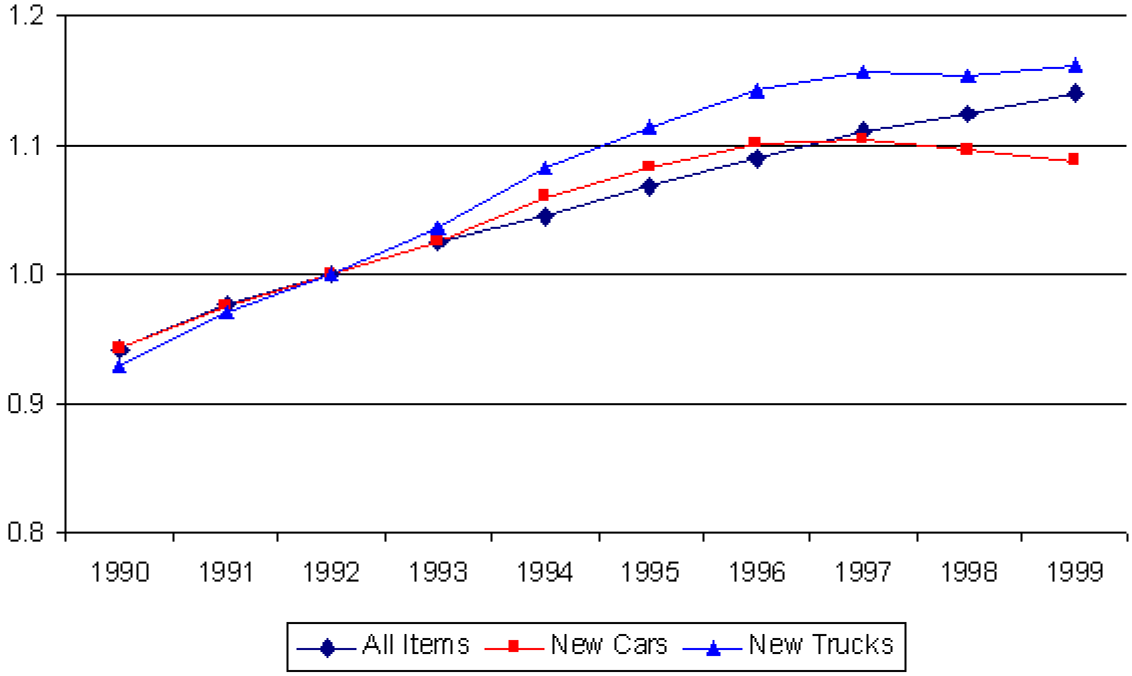

Figure 2-4. Consumer Price Indexes for All Items Compared to New Cars and Trucks (1992 = 100), 1990–1999

Sources: U.S. Bureau of Labor Statistics (BLS). Consumer Price Index—All Urban Consumers: CUUR0000SA0, All Items: 1990-1999. <http://www.bls.gov>. As obtained on September 9, 2000.
U.S. Bureau of Labor Statistics (BLS). Consumer Price Index—All Urban Consumers: CUUR0000SS45011, New Cars: 1990-1999. <http://www.bls.gov>. As obtained on January 3, 2001a.
U.S. Bureau of Labor Statistics (BLS). Consumer Price Index—All Urban Consumers: CUUR0000SS45021, New Trucks: 1990-1999. <http://www.bls.gov>. As obtained on January 3, 2001b.

continue to develop smaller, less costly models than those produced for the U.S. market. Most of the growth in the global vehicle market will be in less-developed countries such as China, India, Latin America, and eastern Europe in which the typical U.S. automobile is overly equipped and prohibitively expensive.

Over time, automobile manufacturers are adopting a more global approach to automobile manufacturing. This change in approach comes as the industry continues to consolidate and foreign and domestic firms merge or form joint ventures (e.g., Mazda and Ford, Daimler-Benz and Chrysler). In the more global approach, automobile manufacturers are reducing the number of unique automobile platforms and using them throughout the world. This approach allows them to reduce product development costs and spread the development costs over a greater number of vehicles. In addition, under the global approach, automobile manufacturers can locate plants in the countries in which production costs are lowest.

Overall, the U.S. Department of Commerce (1999c) projects that the U.S. share of the world motor vehicle markets, including cars, trucks, and buses, will increase from 22 percent in 1997 to 27 percent in 2003. U.S. output in these markets is projected to rise an average of 4.6 percent per year from 1997 to 2003 with a corresponding net increase of 25 percent in value of shipments.

SECTION 3

ENGINEERING COSTS

This section presents the Agency's estimates of the compliance costs associated with the regulatory alternatives developed to reduce HAP emissions during automobile and light-truck coating operations. These engineering costs are defined as the annual capital, operation and maintenance, and monitoring costs assuming no behavioral market adjustment by producers or consumers. An overview of the methodology used to develop these engineering cost estimates is provided below. A more detailed discussion of this methodology can be found in docket A-2001-22.

3.1 Methodology

As indicated in Tables 2-10 and 2-11, there were 65 facilities operating in the U.S. automobile and LDT assembly industry in our baseline year of 1999. The final regulation will affect 60 of those assembly facilities.[1] It is assumed that these facilities will adopt the following strategies to reduce their emissions and comply with the NESHAP:

- Strategy 1: Facilities that do not presently have controls on the electrodeposition oven will add an oxidizer to control HAP emissions from the oven. This equates, on average, to about $8,200 per ton of HAP controlled.
- Strategy 2: If the HAP/VOC ratio for the primer-surfacer coating material exceeds 0.3, a modified surface coating material will be used to meet this ratio. This equates, on average, to about $540 per ton of HAP controlled.
- Strategy 3: If the HAP/VOC ratio for the topcoat material exceeds 0.3, a reformulated top coating material will be used to meet this ratio.
- Strategy 4: Any remaining HAP emissions in excess of the MACT floor will be reduced by introducing controls on the exhaust from automated zones of spray booths.

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[1] Five facilities would not incur significant costs under the final regulation because they only assemble vehicles and do not paint them. One of these facilities, AM General, is not subject to the final rule because it is no longer producing or planning to produce vehicles classified as autos or LDTs. Hence, it is more appropriately regulated under the Miscellaneous Metal Parts Subcategory.

As part of this discussion of regulatory strategies, it should be noted that the Agency examined regulatory options beyond the MACT floor for existing and new sources as part of the analyses completed for the proposal. The process for doing this involves identification and consideration of reasonable and technically achievable regulatory alternatives that provide emissions control beyond the MACT floor. It also takes into account cost and economic impacts (including small business), non-air quality health and enviromental impacts, and energy requirements. These alternatives may be different for existing and new sources because different MACT floors and separate standards may be established for existing and new sources.

The floor for existing electrodeposition primer, primer-surfacer, topcoat, final repair, glass bonding primer and glass bonding adhesive operations was based on the performance of the best eight facilities. These facilities employed a combination of various organic HAP emission reduction techniques, including the use of lower organic HAP content coatings, improved transfer efficiency, control of bake oven exhaust streams, and control of the exhaust streams from automated zones of spray booths where solvent-borne coatings are used. However, no single technology or combination of technologies representing a beyond-the-floor MACT was identified, nor did we identify any other available technologies which are not presently in use with the potential to decrease organic HAP emissions beyond-the-floor for either new or existing sources.

We selected MACT floor level standards for electrodeposition primer, primer-surfacer, topcoat, final repair, glass bonding primer and glass bonding adhesive operations because we were unable to identify any specific technologies that would result in a lower level of emissions for existing sources. We will require in the final rule a more stringent emission limit for electrodeposition primer, primer-surfacer, topcoat, final repair, glass bonding primer and glass bonding adhesive operations for new sources. This more stringent limit applied to new sources as compared to existing sources is not appropriate for existing sources because of the difficulty, uncertainty, and in some cases, impossibility of retrofitting the best combination of emission limitation techniques to existing facilities, as well as the high incremental cost associated with what would be a beyond-the-floor limit for existing facilities.

We expect that most existing plants will control the exhaust streams from the automated zones of spray booths where solvent-borne coatings are used to achieve the MACT floor level of control. Control options beyond-the-floor would involve additional control of the exhaust streams from automated zones of spray booths, if they have not already been controlled to achieve the MACT floor level of control, and control of the exhaust streams from manual zones of spray booths. The cost of such a beyond-the-floor limit would exceed $40,000 per ton of incremental organic HAP controlled through additional control of the exhaust streams from automated zones of spray booths and would exceed $80,000 per ton of incremental organic HAP controlled through control of the exhaust streams from manual zones of spray booths. This incremental cost of control is much higher than that from baseline to the MACT floor alternative (roughly $25,000 per ton of organic HAP controlled). Therefore, the limits in the final rule are based on the MACT floor. Following a future analysis of residual risk for this source category, EPA may propose a beyond-the-floor emission limit, if it is found to be justified at that time.

We believe this analysis of beyond the floor options done for the proposed rule is sufficient to satisfy the guidance in OMB Circular A-4 (September 17, 2003) calling for analysis of multiple regulatory alternatives in an RIA. Therefore, only one alternative is assessed in this RIA.

The associated abatement costs could include capital costs incurred to purchase or upgrade pollution control equipment, cost for operation and maintenance of this abatement equipment such as cost of energy needed to operate it and coating materials replacement costs, and other administrative costs associated with monitoring, reporting and record keeping. The following assumptions were used to estimate the engineering costs associated with each of the strategies listed above:

- All capital costs are annualized over the equipment's expected lifetime of 15 years at a 7 percent discount rate in accordance with OMB guidelines (OMB, 1996).
- For Strategy 1, Vatavuk (1999) estimates that a regenerative thermal oxidizer of 15,000 standard cubic feet per minute (scfm) capacity with 95% heat recovery costs approximately $1.08 million. This equipment is associated with annualized capital costs of $117, 967 and annual operating costs of $127,000.
- Strategies 2 and 3 essentially involve the purchase of reformulated coating materials that contain ethyl acetate and butyl acetate instead of coating materials containing aromatics such as toluene and xylene. Ethyl acetate costs about $0.40/lb while xylene costs about $0.17/lb (Green, 2001). No new capital equipment is required to apply these reformulated coatings.
- The Agency estimates that it costs $10,000/ton to reduce VOC emissions from automated zones of spray booths. For Strategy 4, it is assumed that annual VOC control costs of $10,000/ton imply annual HAP control costs of $40,000 per ton. This cost is split evenly between annual capital and operating expenses.

- Monitoring, reporting and record keeping activities will involve professional, technical, and clerical labor at an hourly wage rate of $40, $30, and $18 respectively.
- The Agency assumes that a performance test is required if a facility installs or upgrades a control system but not if it merely switches to a reformulated coating input. Facilities that adopt both Strategy 1 and Strategy 4 are required to perform two performance tests. Testing is assumed to take 280 technical hours per system; once every 15 years; plus 10 percent for repeat tests. These performance test costs are amortized over the life of the control system.
- All plants have in place elaborate record keeping programs to demonstrate compliance with existing VOC regulations. These programs will have to be modified to accommodate the tracking of HAP emissions. The Agency assumes that this modification will require 500 professional hours and these costs are amortized over the life of the system.
- Record keeping is estimated to take 1 technical hour per shift for 10 shifts per week.
- Monitoring activities are also estimated to take 1 technical hour per shift for 10 shifts per week.
- Finally, reporting is assumed to take 40 technical hours per year plus 40 clerical hours per year.

New facilities and new paint shops would incur little additional cost to meet the final emission limit. These facilities would already include bake oven controls and partial spray booth exhaust controls for VOC control purposes. New facilities might need to make some downward adjustment in the HAP content of their materials to meet the final emission limit.

3.2 Results

The Agency's facility level engineering cost estimates are summarized in Table 3-1. The total annual capital cost estimate includes the annualized capital cost associated with all applicable strategies. Similarly, the total variable cost estimate includes the variable cost associated with all applicable strategies. The nationwide total cost is estimated at $154 million, with $75 million in annual capital costs, $76 million in operation and maintenance costs, and $2 million in administrative costs.[2] This equates, on average, to about $25,000 per ton of HAP controlled.

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[2] All values are reported in 1999 constant dollars.

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State	Total Annualized Capital Costs	Total Annual Operating and Maintenance Costs	Total Monitoring, Recordkeeping, and Reporting Costs	Total Annual Costs
				$20
				$21
				$20
				$0
				$20
				$20
				$20
				$20
				$20
				$1,555
				$0
				$20
				$369
				$3,896
				$3,625
				$5,838
				$4,102
				$2,660
				$4,491
				$4,013
				$3,651
				$12,974
				$0
			$20	$61

(Continued)

State	Total Annualized Capital Costs	Total Annual Operating and Maintenance Costs	Total Monitoring, Recordkeeping, and Reporting Costs	Total Annual Costs
				$1,543
				$6,852
				$668
				$1,855
				$186
				$3,129
				$5,662
				$3,129
				$1,863
				$9,473
				$4,224
				$846
				$4,601
				$3,566
				$3,663
				$713
				$587
				$1,511
				$0
				$3,287
				$288
				$1,408
				$3,891
				$3,107

(Continued)

	State	Total Annualized Capital Costs	Total Annual Operating and Maintenance Costs	Total Monitoring, Recordkeeping, and Reporting Costs	Total Annual Costs
					$7,585
					$20 $4,842
					$751 $4,012
					$1,289
					$3,060
					$3,893
Nissan Motor Manfacturing Corp., USA– Line HF					$1,426 $4,016
Nissan Motor Manufacturing Corp. USA– Line IV					
New United Motor Mfg. Inc. NUMMI– Car Line					$20 $2,572
New United Motor Mfg. Inc. NUMMI– Truck Line					$989
Toyota Motor Manufacturing Kentucky Inc. Paint #1					$0 $43 $4,109
Toyota Motor Manufacturing Kentucky Inc. Paint #2					$1,580
					$153,661

model pertains to final vehicles and not to parts, TABC Inc. compliance costs will be assigned to NUMMI—Truck Line in the subsequent analysis.

SECTION 4

ECONOMIC IMPACT ANALYSIS

Congress and the Executive Office have imposed statutory and administrative requirements for conducting economic analyses to accompany regulatory actions. Section 317 of the CAA specifically requires estimation of the cost and economic impacts for specific regulations and standards promulgated under the authority of the Act. In addition, Executive Order (EO) 12866 requires a more comprehensive analysis of benefits and costs for significant regulatory actions. Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is only required when a regulatory action has an annual effect on the economy of $100 million or more. Other statutory and administrative requirements include examination of the composition and distribution of benefits and costs. For example, the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement and Fairness Act of 1996 (SBREFA), requires EPA to consider the economic impacts of regulatory actions on small entities. The *OAQPS Economic Analysis Resource Document*, which can be found at http://www.epa.gov/ttn/ecas/econdata/Rmanual2/index.html , provides detailed instructions and expectations for economic analyses that support rulemaking (EPA, 1999).

The engineering analysis described in Section 3 provides estimates of the total annual costs associated with the abatement strategies that bring each facility into compliance with the final standards. Note, however, that these engineering cost estimates do not account for behavioral responses by facilities, such as changes in output quantities and prices. In this section, engineering cost estimates are used as inputs to an economic model of the automobile and LDT assembly industry to predict market, industry and social welfare impacts of the final regulation. Small business impacts are addressed in Section 5 and a benefits analysis is presented in Section 6 of this report.

4.1 Methodology

This analysis will address several special characteristics of the automobile industry. First, the industry's products are highly differentiated with vehicles varying along dimensions such as their functions, carrying capacity, fuel efficiency, and comfort features. Second, the market for automobiles within the United States may be characterized as imperfectly competitive. Only 14 companies operate in this market. In 1998-1999, the Herfindahl-Hirschmann Index for the industry was 1,471, and the four-firm concentration ratio (CR4) was 72 percent. Third, exclusive dealerships play an intermediary role between manufacturers and final consumers.[1] Finally, international trade is a major component of the U.S. market for automobiles. In 1999, imports accounted for approximately 20 percent of car sales in the United States (Crain Automotive Group, 2000). Given the data available, we will evaluate the economic effects of the final regulation at the facility level within the context of the overall industry conditions. This approach is consistent with accepted economic logic and provides consistent estimates for the impacts on all the required variables.

4.1.1 Product Differentiation

To address the high degree of product differentiation in this industry, the Agency has segmented the market into eight vehicle classes: subcompacts, compacts, intermediate/ standard, luxury, sports, pickups, vans, and other.[2] Separate demand and cost curves are developed for each of these market segments.

Since all domestic vehicle categories are subject to price changes due to the final regulation, we will estimate the consumer response to these price changes *within* each vehicle class. However, we will not estimate spillover impacts *between* domestic vehicle classes because available estimates of the cross-price elasticities of demand suggest that consumers rarely substitute between vehicle classes in response to relatively small price changes. In particular, Goldberg (1995) estimates cross price semi-elasticities of demand for some specific vehicle models and finds that these semi-elasticities are low if the models belong to different classes.[3] For example, the cross price semi-elasticity between a Honda Civic and a Honda Accord is only 14.9×10^{-7}. Furthermore, our priors suggest that the tendency to switch between vehicle categories will be low given the relatively small magnitude of price changes expected for this NESHAP. Therefore, our basic market segmented model is designed to capture the within-segment, first order impacts of the regulation.

4.1.2 Imperfect Competition

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[1] Exclusive dealership arrangements are also found in the sewing machine, agricultural machinery and gasoline markets.

[2] EPA's 1999 Fuel Economy Guide Data (EPA, 2000), car buyers guides such as Edmunds.com (Edmunds, 2001), and the Automotive News Market Databook (Crain Automotive Group, 2000) were used to assign vehicle models to the appropriate market segments.

[3] Recall that a semi-elasticity refers to the percentage change in quantity demanded of model j when price of model i changes by $1 but all other model prices remain unchanged.

Although the U.S. automobile industry comprises 14 firms, a smaller subset of these firms operates within each vehicle category segment. Given our assumption of imperfect competition in the industry as a whole and within each segment in particular, we will use a Cournot model to characterize the market for each vehicle category. The implicit assumption is that vehicles within a given category are close substitutes. In the Cournot model, one of several models of oligopoly, firms are modeled as choosing production quantities. Unlike a competitive market, in which the price equals the marginal cost of production and firms take the price as given, the Cournot model reflects the fact that automobile manufacturers may have market power and thus charge a price in excess of marginal cost by producing a quantity that is less than in a competitive equilibrium.

4.1.3 Role of Dealerships

Manufacturers in the U.S. automobile industry do not actually set final consumer prices. Instead, they set wholesale prices for dealers which are then marked up to form retail or list prices. The final transaction price paid by the consumer can also differ from these retail prices because of dealer-specific rebates, local and state taxes, and individual bargaining power. This pricing scheme is summarized in Figure 4-1. Note that manufacturer decisions are based on wholesale prices, while consumer decisions are based on transaction prices.

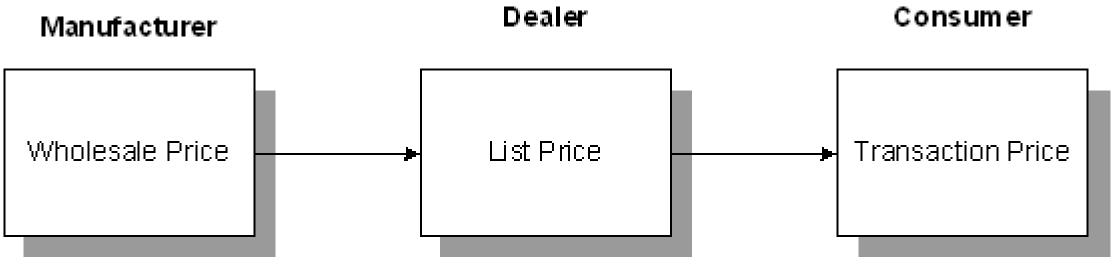

Figure 4-1. Pricing in Automobile Markets

This relationship can be viewed as a successive oligopoly game, with the manufacturer adding a markup over the marginal cost of production, and the dealer adding his own markup. In stage 1, the manufacturer maximizes his profits by comparing his marginal costs to his marginal revenues. His marginal revenue depends on the wholesale price and the wholesale price elasticity of demand. In the second stage, the dealer maximizes her profits by comparing her own marginal costs to her marginal revenue, which depends on the transaction price and the transaction price elasticity of demand.

If the marginal cost of production increases, the impacts can be borne by the manufacturer who changes input-output quantities, the dealer who earns a reduced markup, or the consumer who faces a higher list price. Gron and Swenson (2000) examine the degree of cost pass-through to final consumers in the U.S. automobile market. They find that cost shocks common to all manufacturers have a greater effect on list price than do model-specific cost shocks. This is consistent with the theoretical predictions of Dornbusch (1987) who showed in the context of exchange rate shocks that firms competing in a Cournot game will increase the level of cost pass-through as the proportion of the market that is exposed to the cost increase grows.

Because the final regulation covers all facilities assembling vehicles in the United States, we have made the simplifying assumption that the dealer can charge the same percentage markup as before the regulation. Assuming that the percentage markup (including discounts, taxes, etc.) between the wholesale price (P^W) and the transaction price (P^T) is constant, i.e. $P^W = \lambda P^T$, the demand elasticity with respect to wholesale prices coincides with the transaction price elasticity. Thus we can collapse the two-stage game between the manufacturer, dealer, and consumer to a one-stage game between the manufacturer and a "composite customer" (dealer/consumer).

4.1.4 Foreign Trade

While the final NESHAP will directly affect domestic facilities that use coatings in automobile and LDT assembly operations, the rule can also have indirect foreign trade implications.[4] On the import side, the demand for imported cars could increase if they become inexpensive relative to domestic cars that are affected by the coating process standard. We will assume that foreign firms can meet this spillover demand by using excess capacity in their existing plants. On the export side, foreign demand for vehicles produced in the United States can decrease if they become relatively more expensive because of the regulation. Finally, domestic facilities could relocate to foreign countries with laxer environmental regulations if domestic production costs increase. However, given the small size of the compliance costs relative to company sale it is unlikely that the final regulations will trigger industrial flight at least in the short run. This assumption is consistent with empirical studies in the literature that have found little evidence of environmental regulations affecting industry location decisions (Levinson, 1996). This discussion illustrates the theory

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[4] All production facilities located within the United States are subject to the final NESHAP regardless of whether they are owned by domestic or foreign companies. For the purposes of this analysis, imports refers to vehicles produced outside of the United States.

underlying estimation of the economic impacts of the final MACT standard. The next task is to operationalize this model to calculate the impacts.

4.2 Operational Model

The final regulation will increase the cost of production for existing vehicle assembly plants. The regulated facilities may alter their current levels of production or even close a plant in response to the increased costs. These responses will in turn determine the impact of the regulation on total market supply and ultimately on the equilibrium price and quantity. To determine the impact on equilibrium price and quantity, we will

- characterize the demand for each domestic vehicle type;
- characterize the costs of production for classes of domestic vehicles at the individual facility and at the market level;
- develop the solution algorithm to determine the new with-regulation equilibrium;
- characterize spillover impacts on the demand for imported and exported cars and LDTs; and
- compute the values for all the impact variables.

An intuitive overview of our economic model is presented below. Details of the modeling exercise and its implementation are relegated to Appendix A.

The Agency has modeled separate markets for each of the eight vehicle categories: subcompacts, compacts, intermediate/standard, luxury, sports, pickups, vans, and other. Given the imperfect competition observed within each market segment, Cournot models are used to reflect the fact that oligopolistic manufacturers can charge a price in excess of marginal cost by producing a quantity that is less than the competitive optimum.

U.S. demand for domestic vehicles in each category is characterized by a downward-sloping demand curve, which implies that the quantity demanded is low when prices are high and quantity demanded is high when prices are low due to the usual income and substitution effects. The demand curve for each vehicle category is constructed using baseline quantity and retail price data and available estimates of own price elasticities of demand.

Given the capital in place, each automobile and LDT assembly facility will be assumed to face an upward-sloping marginal cost function. In addition, it is assumed that if revenue falls below its minimum average variable costs, then the firm's best response is to cease production because total revenue does not cover total variable costs of production. In this scenario, producers lose money on operations as well as capital. By shutting down, the firm avoids additional losses from operations.

Figure 4-2 shows how the market prices and quantities are determined by the intersection of the marginal revenue and marginal cost curves in a concentrated market model. The baseline consists of a market price and quantity (P_0, Q_0) that is determined by the downward-sloping market demand curve (D) and the upward-sloping marginal cost curve (MC_0) that reflects the sum of the individual marginal cost curves of the assembly facilities. Any individual supplier would produce amount Q_0 (at price P_0) and the facilities would collectively produce amount Q_0.

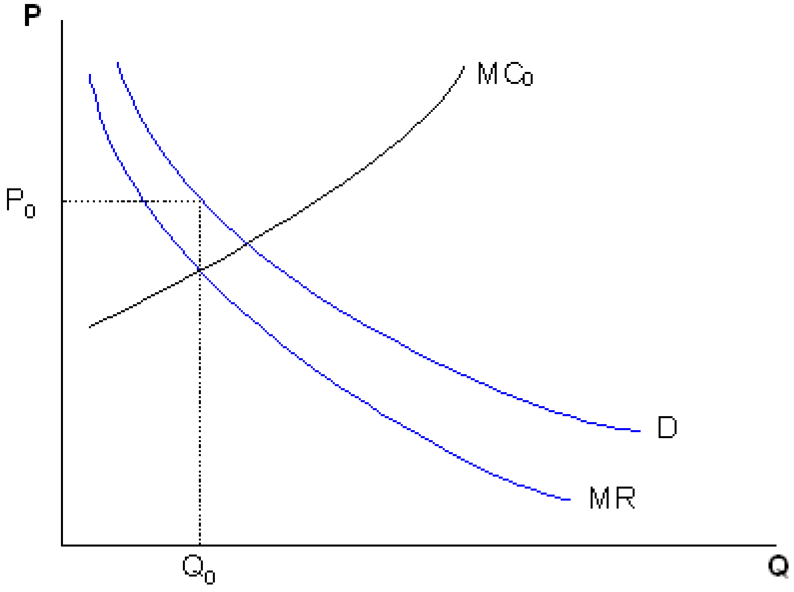

Figure 4-2. Baseline Equilibrium

Now consider the effect of the regulatory control costs (see Figure 4-3). Incorporating the regulatory control costs will involve shifting the marginal cost curve upward for each regulated facility by the per-unit variable compliance cost. As a result, the market output declines from Q_0 to Q_1 and the market price (as determined from the market demand curve, D_M) increases from P_0 to P_1.

Because the final coating standard will only be binding on automobile and LDT assembly facilities operating within the U.S., the Agency has also modeled the impact of the predicted domestic price increase on foreign trade. Imports of foreign vehicles into the U.S. could increase because they become cheap relative to domestic vehicles. The ratio between quantities of imported versus domestic vehicles purchased by U.S. consumers is modeled as a function of their relative prices and the ease of substitution between these vehicles. Exports of U.S.-made vehicles can also decline if their price increases while other exogenous determinants of foreign demand are held constant. Foreign demand is modeled as a downward sloping function that depends on average price of exported U.S. vehicles and the export elasticity of demand.

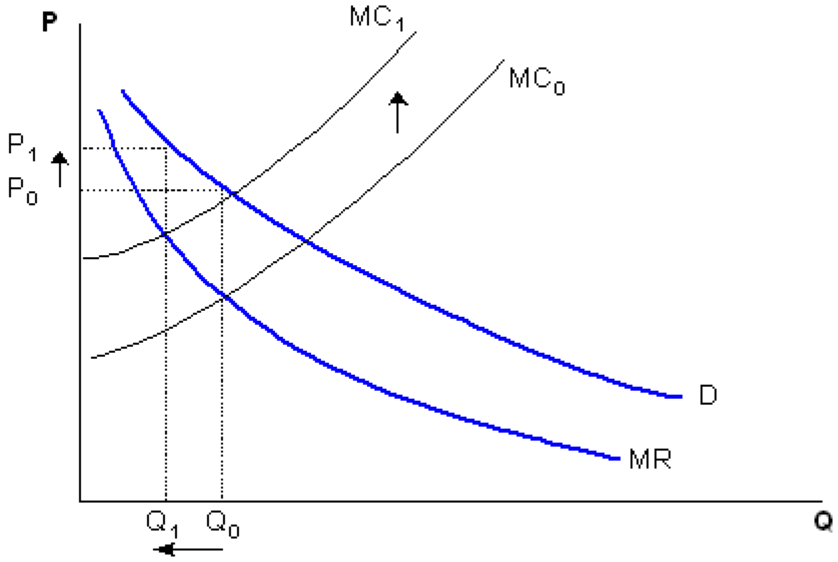

Figure 4-3. With-Regulation Equilibrium

4.3 Economic Impact Results

Based on the simple analytics presented above, automobile/LDT manufacturers will attempt to mitigate the impacts of higher production costs by shifting as much of the burden on other economic agents as market conditions allow. Potential responses include changes in production processes and inputs, changes in output rates, or closure of the plant. This analysis focuses on the last two options because they appear to be the most viable for auto assembly plants, at least in the short term. We expect upward pressure on prices as producers reduce output rates. Higher prices reduce quantity demanded and output for each vehicle class, leading to changes in profitability of facilities and their parent companies. These market and industry adjustments determine the social costs of the regulation and its distribution across stakeholders (producers and consumers).

4.3.1 Market-Level Impacts

The increased costs of production due to the regulation are expected to slightly increase the price of automobiles/LDT and reduce their production and consumption from 1999 baseline levels. As shown in Table 4-1, the regulation is projected to increase the price of all vehicle classes by at most 0.01 percent (or at most $3.08 per vehicle). Similarly, the model projects small declines in domestic production across all vehicle classes (ranging from 17 to 384 vehicles).

4.3.2 Industry-Level Impacts

Industry revenue, costs, and profitability change as prices and production levels adjust in response to the increased compliance costs. These impacts are described in detail below.

4.3.2.1 Changes in Profitability

As shown in Table 4-2, the economic model projects that pre-tax earnings for assembly plants will decrease by $152 million, or 1.1 percent. This is the net result of three effects, the first two of which partially offset each other:

- Decrease in revenue ($21 million): Revenue decreases as a result of reductions in output. However, these losses were mitigated by increased revenues as a result of small increases in vehicle prices.
- Decrease in production costs ($22.5 million): Production costs decline as output declines.

Table 4-1. Market-Level Impacts by Vehicle Class: 1999

Vehicle Class	Baseline	Absolute Change	Relative Change
Subcompacts			
Wholesale Price ($/unit)	$15,522	$0.40	0.00%
Domestic Production (10^3/yr)	586,257	–50	–0.01%
Compacts			
Wholesale Price ($/unit)	$16,487	$1.05	0.01%
Domestic Production (10^3/yr)	1,766,657	–384	–0.02%
Intermediate/Standard			
Wholesale Price ($/unit)	$21,155	$0.61	0.00%
Domestic Production (10^3/yr)	2,187,415	–280	–0.01%
Luxury			
Wholesale Price ($/unit)	$33,587	$3.08	0.01%
Domestic Production (10^3/yr)	749,746	–131	–0.02%
Sports			
Wholesale Price ($/unit)	$25,797	$1.21	0.00%
Domestic Production (10^3/yr)	349,955	–17	0.00%
Pickups			
Wholesale Price ($/unit)	$22,126	$0.23	0.00%
Domestic Production (10^3/yr)	2,908,018	–106	0.00%
Vans			
Wholesale Price ($/unit)	$22,910	$0.80	0.00%
Domestic Production (10^3/yr)	1,447,482	–220	–0.02%
SUV			
Wholesale Price ($/unit)	$27,694	$0.41	0.00%
Domestic Production (10^3/yr)	2,692,763	–163	–0.01%

Table 4-2. National-Level Industry Impacts: 1999

	Baseline	Absolute Change	Relative Change
Revenues ($\$10^6$/yr)	\$290,789	–\$20.7	–0.01%
Costs ($\$10^6$/yr)	\$276,746	\$131.1	0.05%
Compliance	\$0	\$153.6	NA
Production	\$276,746	–\$22.5	–0.01%
Pre-Tax Earnings ($\$10^6$/yr)	\$14,043	–\$151.8	–1.08%
Plants (#)	65	0	0.00%
Employment (#)	219,817	–37	–0.02%

- Increase in control costs ($154 million): Costs associated with coating operation HAP controls increase.

Although aggregate industry pre-tax earnings decline, the regulation creates both winners and losers based on the distribution of compliance costs across facilities. As shown in Table 4-3, 18 of the 65 plants (28 percent) are projected to become more profitable with the regulation with a total gain of $2 million. These plants are either not subject to additional controls or have lower per-unit control costs (less than $1 per vehicle) relative to other assembly plants. The remaining 47 plants are projected to experience a total loss of $154 million. These plants have higher per-unit costs ($16 per vehicle on average). This results in an average loss of $3.3 million and represents a 1.5 percent decline in the average pre-tax profit of these plants.

4.3.2.2 Facility Closures and Changes in Employment

Economic theory suggests that a facility will cease production if market prices fall below the minimum average variable cost. EPA estimates that no automobile or LDT assembly plant is likely to prematurely close as a result of the regulation. However, employment in the automobile and LDT assembly industry is projected to decrease by 37 full-time equivalents (FTEs) as a result of decreased output levels. This represents a 0.02 percent decline in manufacturing employment at these assembly plants.

Table 4-3. Distributional Impacts Across Facilities: 1999

	Pre-Tax Earnings		
	Loss	Gain	Total
Assembly Plants (#)	47	18	65
Baseline Production			
Total (units/yr)	9,642,611	3,045,681	12,688,292
Average (units/facility)	205,162	169,205	195,204
Baseline Compliance Costs			
Total ($\$10^6$/yr)	\$153.2	\$0.5	\$153.66
Average (\$/unit)	\$15.89	\$0.16	\$12.11
Change in Pre-Tax Earnings ($\$10^6$/yr)	–\$153.6	\$1.7	–\$151.8
Change in Employment (#)	–37	1	–37

4.3.3 Foreign Trade

Given the small changes in domestic vehicle prices projected by the economic model, EPA estimates foreign trade impacts associated with the rule are negligible. The price of domestic vehicles, averaged across all eight vehicle categories, is expected to rise by 0.003 percent as a result of the final regulation, while the price of imported cars will remain unchanged. The Agency computed two quantitative measures of foreign trade impacts based on this predicted price impact. As shown in Table 4-4, the ratio of imports to domestic sales is expected to rise by approximately 0.01 percent. Furthermore, export sales are predicted to decline by approximately 0.01 percent.

4.3.4 Social Costs

The social impact of a regulatory action is traditionally measured by the change in economic welfare that it generates. The social costs of the final rule will be distributed across consumers and producers alike. Consumers experience welfare impacts due to changes in market prices and consumption levels associated with the rule. Producers experience welfare

Table 4-4. Foreign Trade Impacts: 1999

	% change
Ratio of imports-to-domestic vehicles	0.01%
Exports	–0.01%

impacts resulting from changes in profits corresponding with the changes in production levels and market prices. However, it is important to emphasize that this measure does not include benefits that occur outside the market, that is, the value of reduced levels of air pollution due to the regulation.[5]

The national baseline compliance cost estimates are often used as an approximation of the social cost of the rule. The engineering analysis estimated annual costs of $154 million (1999$). In this case, the burden of the regulation falls solely on the affected facilities that experience a profit loss exactly equal to these cost estimates. Thus, the entire loss is a change in producer surplus with no change (by assumption) in consumer surplus. This is typically referred to as a "full-cost absorption" scenario in which all factors of production are assumed to be fixed and firms are unable to adjust their output levels when faced with additional costs.

In contrast, the economic analysis conducted by the Agency accounts for behavioral responses by producers and consumers to the regulation (i.e., shifting costs to other economic agents). This approach results in a social cost estimate that may differ from the engineering estimate and also provides insights on how the regulatory burden is distributed across stakeholders.

Higher market prices lead to consumer losses of $9.1 million, or 6 percent of the total social cost of the rule. Although automobile or LDT producers are able to pass on a limited amount of cost increases to final consumers, the increased costs result in a net decline in profits at assembly plants of $152 million. As shown in Table 4-5, EPA estimates the total social cost of the rule to be $161 million. Note that social cost estimates exceeds baseline engineering cost estimates by $7 million. The projected change in welfare is higher because the regulation exacerbates a social inefficiency (see Appendix B). In an imperfectly competitive equilibrium, the marginal benefit consumers place on the vehicles, the market price, exceeds the marginal cost to producers of manufacturing the product. Thus, social

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[5] Those impacts are the focus of the benefits analysis presented in Section 6 of this report.

Table 4-5. Distribution of Social Costs: 1999$

	Value ($\$10^6$/yr)
Change in Consumer Surplus	**–$9.1**
Subcompacts	–$0.2
Compacts	–$1.9
Intermediate/Standard	–$1.3
Luxury	–$2.3
Sports	–$0.4
Pickups	–$0.7
Vans	–$1.2
SUV	–$1.1
Change in Producer Surplus	**–$151.8**
Total Social Cost	**–$160.9**

welfare would be improved by increasing the quantity of the vehicles provided. However, producers have no incentive to do this because the marginal revenue effects of lowering the price and increasing output is lower than the marginal cost of these extra units.

4.4 Energy Impacts

Executive Order 13211 "Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use" (66 Fed. Reg. 28355, May 22, 2001) requires federal agencies to estimate the energy impact of significant regulatory actions. The final NESHAP will trigger both an increase in energy use due to the operation of new abatement equipment as well as a decrease in energy use due to a small decline in automobile production. The net impact will be an overall increase in the automobile industry's energy costs by about $26.41 million per year. These impacts are discussed below in greater detail.

4.4.1 Increase in Energy Consumption

As described earlier in Section 3 of this report, automobile and LDT coating facilities can adopt multiple strategies to reduce their HAP emissions in compliance with the final regulation. Input substitution strategies 2 and 3 will not require significant amounts of extra energy because they only involve the application of modified coating materials. However, adoption of strategy 1 and/or strategy 4 will necessitate extra fan horsepower to convey additional air streams to add-on control devices, as well as additional natural gas and electricity for operating these devices (which are assumed to be regenerative thermal oxidizers). The operation of such abatement equipment is estimated to require an additional 4.9×10^9 standard cubic feet per year of natural gas and 1.8×10^8 kilowatt hours per year of electricity nationwide at a cost of $3.20 per thousand cubic feet of natural gas and $0.06 per kilowatt hour of electricity (Green, 2002). Therefore, the nationwide cost of the energy needed to operate the control equipment required by strategies 1 and 4 is estimated at $26.48 million per year. This incremental energy cost was included in the operation and maintenance component of the engineering cost estimates presented in Section 3.

4.4.2 Reduction in Energy Consumption

The economic model described in Section 4.2 predicts that increased compliance costs will result in an annual production decline of approximately 1,300 vehicles valued at $21 million collectively. This production decline will lead to a corresponding decline in energy usage by automobile manufacturers. EPA has computed an average "energy per unit output ratio" and multiplied it by the decline in production to quantify this impact.

Census data presented in Table 4-6 indicates that the U.S. automobile and LDT industry incurred energy costs of $669 million to produce $205.8 billion worth of vehicles in 1997. This translates into an energy consumption per unit of output ratio of about 0.3 percent for the automobile and LDT industry. Therefore, energy costs are estimated to decline by approximately $0.07 million per year if the industry's production declines by 1,300 vehicles valued at $21 million per year.

4.4.3 Net Impact on Energy Consumption

The operation of additional abatement capital is estimated to result in an increase in energy use worth $26.48 million per year, while the decline in automobile production will result in a decrease in energy use worth $0.07 million per year. These competing factors will result in a net increase in annual energy consumption by the automobile industry of approximately $26.41 million, on balance.

The total electricity generation capacity in the U.S. was 785,990 Megawatts in 1999 (DOE, 1999a). Thus, the electricity requirements associated with the additional abatement capital represent a small fraction of domestic generation capacity. Similarly, the natural gas requirements associated with the final NESHAP are insignificant given the 23,755 billion

Table 4-6. Energy Usage in Automobile and LDT Production (1997)

Industrial Sector	NAICS	Value of Shipments ($\$10^6$)	Fuel & Electricity Costs ($\$10^6$)
Automobile Mfg.	336111	$95,385	$339
Light Truck and Utility Vehicle Mfg.	336112	$110,400	$330
Total		$205,785	$669

Source: U.S. Department of Commerce, Census Bureau. October 1999a. "Automobile Manufacturing." *1997 Economic Census Manufacturing Industry Series.* EC97M0-3361A. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Census Bureau. October 1999b. "Light Truck and Utility Vehicle Manufacturing." *1997 Economic Census Manufacturing Industry Series.* EC97M-3361B. Washington, DC: Government Printing Office.

cubic feet of natural gas produced domestically in the U.S. in 1999 (DOE, 1999b). Hence, the final NESHAP is not likely to have any significant adverse impact on energy prices, distribution, availability, or use.

SECTION 5

OTHER IMPACT ANALYSES

The economic- and energy-impacts associated with the final NESHAP were described in the previous section. Statements discussing additional impacts on small businesses, unfunded mandates, and new sources are presented below.

5.1 Small Business Impacts

The Regulatory Flexibility Act (RFA) of 1980 as amended in 1996 by the Small Business Regulatory Enforcement Fairness Act (SBREFA) generally requires an agency to prepare a regulatory flexibility analysis of a rule unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impacts of the final rule on small entities, a small entity is defined as: (1) a small business that is a parent company according to Small Business Administration (SBA) size standards for NAICS codes 336111 (automobile manufacturing) and 336112 (light truck and utility vehicle manufacturing) with 1,000 or fewer employees; (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

Based on the above definition of small entities and data reported in Section 2 of this report, the Agency has determined that there are no small businesses within this source category that would be subject to this final rule. Therefore, because this final rule will not impose any requirements on small entities, EPA certifies that this action will not have a significant economic impact on a substantial number of small entities.

5.2 Unfunded Mandates

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104-4, establishes requirements for federal agencies to assess the effects of their regulatory actions on state, local, and tribal governments and on the private sector. Under Section 202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules that includes any federal mandate that may result in expenditures to state, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. As indicated below, EPA is responsive to all required provisions of UMRA.

Section 202(a)(1) requires EPA to identify the relevant statutory authority. The final standard to limit emissions of HAPs associated with the automobile and LTD coating process is being developed under Section 112 of the CAA of 1990.

Section 202(a)(2) requires a quantitative and qualitative assessment of the anticipated costs and benefits of the regulation. Section 3 of this report provides detailed estimates of the costs incurred by the private sector to comply with the final NESHAP. The estimated effects of the regulation on the national economy are described in Section 4. Section 6 of this report provides a qualitative assessment of the benefits of reducing HAP emissions, as well as the additional benefits of reducing VOC emissions due to HAP controls.

Before EPA establishes any regulatory requirement that significantly or uniquely affects small governments, including tribal governments, it must develop a small government agency plan under Section 203 of UMRA. The final automobile and LDT coating NESHAP does not impose an unfunded mandate on state, local, and tribal governments; the cost of the regulation is borne by industry. Thus, Section 203 of UMRA does not apply to the current rule.

Section 205 of UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule. For reasons discussed in the preamble of the rule, EPA has determined that the current rule constitutes the least burdensome alternative consistent with the CAA.

5.3 Impact on New Sources

There is a potential that new sources such as new paint shops at existing plants or new plants will operate in the automobile industry in the future. The final rule imposes more stringent limits on emissions from these new sources. If control costs for new sources and facilities are sufficiently higher than that for current producers, new source performance standards can raise the cost of entry in the automobile market. Thus, EPA has analyzed the relative effect of new source controls to determine whether they are likely to impose significant entry barriers.

It is difficult to predict which of the 65 facilities that currently operate in the U.S. automobile and LDT assembly industry will replace their existing paint shops in the future. The engineering cost analysis presented in Section 3 of this report assumes that all existing plants will keep their current paint shops and make the necessary material changes and control equipment additions to meet the final Maximum Achievable Control Technology (MACT) rule. This is a conservative (higher MACT-specific compliance cost) assumption compared to assuming that only some of these paint shops will be replaced.

The construction of greenfield facilities is also difficult to predict. EPA examined the list of current facilities and determined that over the past 23 years there has been about one new greenfield plant per year, on average. These were more frontloaded in the earlier years for many reasons including the industry-wide change to basecoat/clearcoat from single coating topcoats, "retooling" to take advantage of new production strategies and technologies, and the arrival of non-U.S. manufacturers such as Honda, Nissan, and Toyota. Thus, the assumption of one new greenfield plant per year in the future would be an overly generous one. The engineering analysis does not explicitly include greenfield facilities because they are difficult to predict, the number is both absolutely and relatively small compared to the existing facility population, and the cost and economic impacts are likely to be very small.

Even though the number of affected entities cannot be predicted, the impact of new source controls can be estimated qualitatively. The additional MACT-specific compliance costs for a new source (greenfield plant or new paint shop at an existing plant) would be very low because these new sources will comply with existing VOC regulations and already have all of the control equipment needed to meet the final MACT rule. The only incremental costs for new sources would be the small cost of lower HAP coating materials and some MACT-specific monitoring, reporting, and record keeping costs that they would not have incurred in the absence of the final rule. However, these costs are in line with the costs incurred by existing facilities and thus do not impose any barriers to entry into the industry. Overall, given the minimal impacts on price and production described in Section 4 of this report, it is very unlikely that a substantial number of firms who may consider entering the industry will be significantly affected.

SECTION 6

BENEFITS ANALYSIS

The emission reductions achieved by this environmental regulation will provide benefits to society by improving environmental quality. This section provides information on the types and levels of social benefits anticipated from the automobile and LDT NESHAP. This section discusses the health and welfare effects associated with the HAPs and other pollutants emitted by automobile and LDT coating operations.

In general, the reduction of HAP emissions resulting from the regulation will reduce human and environmental exposure to these pollutants and thereby reduce the likelihood of potential adverse health and welfare effects. This section provides a general discussion of the various components of total benefits that may be gained from reducing HAPs through this NESHAP. The rule will also achieve reductions of VOCs and hence may reduce ground-level ozone and particulate matter (PM), the benefits of which are presented separately from the benefits associated with reductions in HAPs. We do not present a monetized benefits estimate for the HAP and other emission reductions associated with this final rule for reasons discussed later in the section. We do provide a qualitative treatment of the benefits of this final rule in this section.

6.1 Identification of Potential Benefit Categories

The benefit categories associated with the emission reductions predicted for this regulation can be broadly categorized as those benefits that are attributable to reduced exposure to HAPs and those attributable to reduced exposure to other pollutants. Benefit categories include reduced incidence of neurological effects, respiratory irritation, and eye, nose, and throat irritation associated with exposure to noncarcinogenic HAPs and VOCs. In addition to health impacts occurring as a result of reductions in HAP and VOC emissions, welfare impacts can also be identified. Each category is discussed separately below.

6.1.1 Benefits of Reducing HAP Emissions

The HAP emissions reductions achieved by this rule are expected to reduce exposure to ambient concentrations of ethylbenzene, EGBE, methanol, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), toluene, and xylenes. According to baseline emission estimates, this source category in the absence of rulemaking will emit approximately 10,000 tons per year of HAPs at affected sources in the fifth year following promulgation. The regulation will reduce total HAP emissions by approximately 6,000 tons of emissions per year. Human exposure to these HAPs is likely to occur primarily through inhalation, but people may also be exposed indirectly through ingesting contaminated food or water or through dermal contact. These substances may also enter terrestrial and aquatic ecosystems through atmospheric deposition or may be deposited on vegetation and soil. These HAPs may also enter the aquatic environment from the atmosphere via gas exchange between surface water and the ambient air or by wet or dry deposition of particles to which they adsorb. This analysis is focused only on the air quality benefits of HAP reduction.

6.1.1.1 Health Benefits of Reduction in HAP Emissions

The HAP emissions resulting from automobile and LDT coating operations are associated with a variety of adverse health effects. Acute (short-term) exposure to relatively high levels of ethylbenzene in humans results in respiratory effects such as throat irritation and chest constriction, and irritation of the eyes. Chronic (long-term) exposure of humans to ethylbenzene may cause eye and lung irritation, with possible adverse effects on the blood. Animal studies have reported effects on the blood, liver, and kidneys from chronic inhalation exposure to ethylbenzene. No information is available on the developmental or reproductive effects of ethylbenzene in humans, but animal studies have reported developmental effects, including birth defects in animals exposed via inhalation. EPA has established a reference concentration (RfC)[1] of 1 mg/m^3 to protect against adverse health effects other than cancer. The RfC is based on the critical effect[2] of developmental toxicity observed in studies with rats and rabbits. EPA has characterized ethylbenzene as in Group D, not being classifiable as to human carcinogenicity due to inadequate data.

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[1] In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

[2] The critical effect is the first adverse effect, or its known precursor, that occurs to the most sensitive species as the dose rate of an agent increases.

EGBE is a member of the glycol ethers HAP category, a large group of related compounds. Acute exposure in humans to high levels of glycol ethers results in narcosis, pulmonary edema, and liver and kidney damage. Chronic exposure to glycol ethers may result in neurological and blood effects, including fatigue, nausea, tremor, and anemia. No information is available on the reproductive or developmental effects of glycol ethers in humans, but animal studies have reported such effects, including testicular damage, reduced fertility, maternal toxicity, early embryonic death, birth defects, and delayed development. EPA has established an RfC of 13 mg/m^3 for EGBE to protect against adverse health effects other than cancer based on the critical effect of decreases in red blood cell count observed in studies with rats.

No reliable human epidemiological studies are available that address the potential carcinogenicity of EGBE, but a draft report of a 2-year rodent inhalation study reported equivocal evidence of carcinogenic activity in female rats and male mice. Because of the uncertain relevance of these tumor increases to humans, the fact that EGBE is generally negative in genotoxic tests, and the lack of human data to support the findings in rodents, the human carcinogenic potential of EGBE cannot be determined at this time. In response to a petition, EPA has proposed removing EGBE from the list of HAP, however, no final action has yet been taken.

Acute inhalation exposure to MEK in humans results in irritation to the eyes, nose, and throat. Little information is available on the chronic effects of MEK in humans, but inhalation studies in animals have reported slight neurological, liver, kidney, and respiratory effects. No information is available on the developmental, reproductive, or carcinogenic effects of MEK in humans. Developmental effects, including decreased fetal weight and fetal malformations, have been reported in mice and rats exposed to MEK via inhalation and ingestion. EPA has established an RfC of 5 mg/m^3 to protect against adverse health effects other than cancer based on the critical effect of decreased birth weight observed in studies with mice. With regard to cancer, EPA has determined that available data are inadequate to assess the human carcinogenic potential for MEK. EPA has classified MEK in Group D, not classifiable as to human carcinogenicity. In response to a petition, EPA has proposed removing MEK from the list of HAP, however, no final action has yet been taken.

Acute or chronic exposure of humans to high levels of methanol by inhalation or ingestion may result in blurred vision, headache, dizziness, and nausea. No information is available on the reproductive, developmental, or carcinogenic effects of methanol in humans. Birth defects have been observed in the offspring of rats and mice exposed to methanol by inhalation. A methanol inhalation study using rhesus monkeys reported a decrease in the length of pregnancy and limited evidence of impaired learning ability in offspring. EPA has not established an RfC for methanol or classified methanol with respect to carcinogenicity. The California Environmental Protection Agency has developed a reference exposure level (similar in concept to an RfC) of 4 mg/m^3 based on the critical effect of birth defects observed in studies with mice.

Acute exposure to high levels of MIBK may irritate the eyes and mucous membranes and cause weakness, headache, and nausea. Chronic exposure to workers has been observed to cause nausea, headache, burning eyes, insomnia, intestinal pain, and slight enlargement of the liver. No information is available on reproductive or developmental effects of MIBK in humans, but studies with rats and mice have reported neurological effects and increased liver and kidney weights. EPA has not established an RfC for MIBK or classified it with respect to carcinogenicity. Animal studies are currently underway that are expected to provide the foundation for an EPA assessment.

Acute inhalation to high levels of toluene by humans may cause effects to the central nervous system (CNS), such as fatigue, sleepiness, headache, and nausea, as well as irregular heartbeat. Chronic inhalation exposure of humans to lower levels of toluene also causes irritation of the upper respiratory tract, eye irritation, sore throat, nausea, dizziness, headaches, and difficulty with sleep. Studies of children whose mothers were exposed to toluene by inhalation or mixed solvents during pregnancy have reported CNS problems, facial and limb abnormalities, and delayed development. However, these effects may not be attributable to toluene alone. EPA has established an RfC of 0.4 mg/m^3 to protect against adverse health effects other than cancer. The RfC is based on the critical effect of decreased neurological performance in workers exposed to toluene emitted from glue. EPA has characterized toluene in Group D, as not classifiable as to human carcinogenicity.

Acute inhalation to high levels of mixed xylenes (a mixture of three closely related compounds) in humans may cause irritation of the nose and throat, nausea, vomiting, gastric irritation, mild transient eye irritation, and neurological effects. Chronic inhalation of xylenes in humans may result in nervous system effects such as headache, dizziness, fatigue, tremors, and incoordination. Other reported effects include labored breathing, heart palpitation, severe chest pain, abnormal electrocardiograms, and possible effects on the blood and kidneys. EPA has not developed an RfC for xylenes. The Agency for Toxic Substances and Disease Registry has published a minimum risk level (similar to an RfC) for xylenes of 0.43 mg/m^3 based on CNS effects in rodents. EPA has characterized xylenes as in Category D, not classifiable with respect to human carcinogenicity.

For the HAPs covered by the automobile and LDT NESHAP, evidence on the potential toxicity of the pollutants varies. However, given sufficient exposure conditions, each of these HAPs has the potential to elicit adverse health or environmental effects in the exposed populations.

EPA prepared a relative ranking evaluation for all HAPs for the purpose of selecting 30 HAPs posing the greatest health risk in urban areas (Smith et al., 1999). This evaluation combined all available data on toxic potential with nationwide emission and ambient concentration information (i.e., not just urban) for all 188 HAPs, considering both cancer and noncancer end points and both inhalation and ingestion exposures. The available database supported quantitative ranks for more than 150 HAPs, including the seven HAPs most commonly used in (or emitted by) this source category. None of these seven HAPs were found to present a hazard sufficient to justify including them on the list of urban air toxics.

EPA prepared a draft national-scale assessment as part of its National Air Toxics Assessment activities (EPA, 2001). This draft assessment estimates human inhalation exposures to the urban HAPs selected based on the ranking study described above. To the extent that EPA's ranking analysis was effective, the 30 HAPs included in the urban list were likely to present greater health risks than those that were not listed. Less than one-third of the noncarcinogens evaluated by the national-scale assessment were judged likely to have human exposure exceeding the RfC anywhere in the U.S.

It is important to note that the national-scale assessment did not include ingestion exposures or acute time-scales and used simplified models that were not efficient at estimating hot spots or maximum individual exposures. However, the results suggest that most of the noncarcinogens included in this assessment do not present national concerns. Because the HAPs in the national-scale assessment arguably present greater potential hazards than the seven HAPs most commonly used in (or emitted by) this source category, EPA has no information that suggests there is presently any widespread overexposure to these seven HAPs. Nevertheless, given the limitations of the national-scale assessment, this may not be true in all areas or for all receptors.

6.1.1.2 Welfare Benefits of Reducing HAP Emissions

The welfare effects of exposure to HAPs have received less attention from analysts than the health effects. However, this situation is gradually changing, as over the past 10 years, ecotoxicologists have started to build models of ecological systems that focus on interrelationships in function, the dynamics of stress, and the adaptive potential for recovery. This perspective is reflected in Table 6-1 where the end points associated with ecosystem functions describe structural attributes rather than species-specific responses to HAP exposure. This development is consistent with the observation that chronic sublethal exposures may affect the normal functioning of individual species in ways that make them less than competitive and therefore more susceptible to a variety of factors including disease, insect attack, and decreases in habitat quality (EPA, 1991). All of these factors may contribute to an overall change in the structure (i.e., composition) and function of the ecosystem.

The overall environmental behavior of these HAPs can be evaluated using fugacity models. Fugacity is a thermodynamic property and is equal to the partial pressure of a substance in compartment. Thus the fugacity of a substance in an environmental medium (e.g., air, water, soil, or sediment) is a measure of the substance’s tendency to escape that medium and enter another medium. The Mackay Level III model is a relatively rigorous representation of multiple environmental compartments and the fate and transport process through which chemicals are moved through them (Mackay, 1991).

The Level III model indicates that the HAPs released from automobile and LDT coating operations once emitted to the ambient air as vapors are likely to remain in the vapor phase as VOCs. Model estimates of HAPs remaining in the air compartment range from greater than 99 percent of the ethyl benzene, xylenes, and toluene to approximately 85 percent of methanol emissions.

The median half-lives for these HAPs in the vapor phase range from 23 hours for xylenes to 57 hours for toluene. As VOCs, they under go various chemical reactions that contribute to the formation of other atmospheric pollutants that can affect welfare. For example, these VOCs can contribute to ozone in the environment. EPA has previously stated (59 FR 1788, January 12, 1994) that ozone's effects on green plants include injury to foliage, reductions in growth, losses in yield, alterations in reproductive capacity, and alterations in susceptibility to pests and pathogens. Based on known interrelationships of different components of ecosystems, such effects, if of sufficient magnitude, may potentially lead to irreversible changes of a sweeping nature to ecosystems.

In addition to directly contributing to ozone formation, the reaction of methanol with nitrogen dioxide in a smog chamber has been shown to yield methyl nitrite and nitric acid. The reaction of methanol with nitrogen dioxide may be the major source of methyl nitrite that has the potential to cause allergic responses in polluted atmospheres. However, methyl nitrite is short lived in the atmosphere. It is rapidly photolyzed by sunlight, with a mean lifetime of about 10 to 15 minutes. The result is the production of NO_x, which contributes to an increase in ozone.

Beyond photochemical removal processes, a relatively small portion of these vapor-phase HAPs, as well as some of the particulates, leave the ambient air via removal processes such as wet or dry deposition. Compounds such as methanol, EGBE, and MIBK are slightly miscible in water and can therefore be physically removed from the air by rain. The other HAPs (i.e, toluene, xylenes, ethyl benzene) are less soluble but can be deposited on surfaces via processes such as dry deposition or impaction.

In water, the HAPs released from automobile and LDT coating operations exhibit low to moderate acute aquatic toxicity. Methanol, EGBE, and MIBK represent the low side and MEK, xylenes, toluene, and ethyl benzene are considered to present moderate acute toxicity. All of these HAPs exhibit low persistence and low bio-accumulation potential. The persistence, as indicated by median half-lives in water, range from a low of 96 hours for methanol to a maximum of 312 hours for toluene. The bio-accumulation factor (BAF) is defined as the concentration of a substance in an organism divided by the concentration of the chemical in the surrounding medium measured in an intact ecosystem. As such, the BAF takes into account accumulation through ingested food, as well as the concentration from the surrounding medium.

A low bio-accumulation potential indicates that they are not likely to bio-concentrate through the food chain. However, substances that do not tend to readily bio-accumulate or bio-concentrate may be taken up by biota and still exert a deleterious effect. These effects could potentially include such impacts as lethality or reproductive impairment to vulnerable species resulting in impacts to recreational or commercial fishers, as well as the ecosystems supporting these fisheries. This not only has potential adverse implications for individual wildlife species, (including threatened or endanger species) and ecosystems as a whole, but also to humans who may depend on contaminated fish and waterfowl.

Once deposited on soil or sediments these HAPs are subject to a variety of competing removal mechanisms including evaporation, mobility, bio-transformation, and chemical reactions. Xylenes deposited on soil can vaporize or, if contained on sediment, be buried. Methanol and ethyl benzene demonstrate high mobility in soil and can end up in ground water, and EGBE and MIBK are readily subject to aerobic and anaerobic bio-transformation. The estimated median half-lives for these HAPs in soil ranges from 96 hours for MIBK and methanol to 420 hours for xylenes. In sediment, the estimated median half-lives are 384 hours for MIBK and methanol to 1,248 hours for toluene. Once deposited on soil or in sediments, these HAPs can enter into terrestrial biota through diet or directly from the surrounding media. The potential for this uptake of HAPs to adversely affect individual wildlife species (including threatened or endangered species) as well as ecosystems as a whole is not understood.

In summary, the potential for adverse effects of these HAPs on individual wildlife species or aquatic terrestrial ecosystems have not been characterized. However, HAP emission reductions achieved through the automobile and LDT NESHAP should reduce the associated potential for adverse environmental impacts.

6.1.2 Benefits of Reducing VOC Emissions due to HAP Controls

VOCs are a precursor to tropospheric (ground-level) ozone, and exposure to ground-level ozone has been linked to acute and chronic effects on human health and welfare. This section addresses these effects.

Human exposure to elevated concentrations of ozone primarily results in respiratory-related impacts such as coughing and difficulty in breathing. Eye irritation is another frequently observed effect. These acute effects are generally short-term and reversible. Nevertheless, a reduction in the severity or scope of such impacts may have significant economic value.

Recent studies have found that repeated exposure to elevated concentrations of ozone over long periods of time may also lead to chronic, structural damage to the lungs (EPA, 1995b). To the extent that these findings are verified, the potential scope of benefits related to reductions in ozone concentrations could be expanded significantly.

Major ozone adverse health effects are alterations in lung capacity and breathing frequency; eye, nose and throat irritation; reduced exercise performance; malaise and nausea; increased sensitivity of airways; aggravation of existing respiratory disease; decreased sensitivity to respiratory infection; and extra pulmonary effects (CNS, liver, cardiovascular, and reproductive effects). It is expected that VOC reductions through the automobile and LDT coatings rule will lead to a reduction in ambient ozone concentrations and, in turn, reduce the incidence of the adverse health effects of ozone exposure.

Major ozone adverse welfare effects are reduction in the economic value of certain agricultural crops and ornamental plants and materials damage. Over the last decade, a series of field experiments has demonstrated a positive statistical association between ozone exposure and yield reductions as well as visible injury to several economically valuable cash crops, including soybeans and cotton. Damage to selected timber species has also been associated with exposure to ozone. The observed impacts range from foliar injury to reduced growth rates and premature death. Benefits of reduced ozone concentrations include the value of avoided losses in commercially valuable timber and aesthetic losses suffered by nonconsumptive users (EPA, 1995b).

There are some benefits from reduced VOC emissions beyond merely a reduction in ozone concentration. Approximately 1 to 2 percent of VOCs precipitate in the atmosphere to form particulate matter (PM) with an aerodynamic diameter at or below 10 micrometers (called PM-10). There are a number of benefits from reduced PM concentration, including reduced soiling and materials damage, increased visibility, and reductions in excess deaths and morbidity. However, the focus of this part of the benefits section is on the benefits from reduced ozone concentrations because they are greater than those from reduced PM-10 concentrations. PM-10 control is already prescribed by primary and secondary National Ambient Air Quality Standards (NAAQS) promulgated by EPA, which are now under review. For more information on ozone health and welfare effects, refer to the 1996 Ozone NAAQS Staff Paper developed by the Agency.

Sizable uncertainties exist in any risk estimates, including these. Emissions estimates can be off by a factor of two or more one time out of three, and air dispersion models can have a similar uncertainty. Consideration of actual exposures also adds uncertainty. Estimates of the total burden of disease associated with air pollution and air toxics are rough. Cancer potency factors contribute additional uncertainty of often greater magnitude. Although we did not formally estimate the combined uncertainties for these risk estimates, it is very likely that the uncertainty around these estimates is at least a factor of 10 above or below the stated values.

We did not quantify the benefits from VOC reductions for this rule because available methods are not consistent with guidance from the Science Advisory Board (SAB) and National Academy of Sciences (NAS) on the estimation of health benefits for air pollution regulations. In other benefits analyses for MACT standards (e.g., industrial boilers and process heaters MACT), we have generated benefits estimates for precursor emissions of ozone and PM by scaling results for similar scenarios with supporting air quality modeling. For this final rule, we were unable to identify existing air quality modeling runs that covered similar source categories and emissions types. As such, we were not confident in the transfer of benefit per ton of VOC based on dissimilar scenarios to auto and light duty MACT. EPA is working with the SAB to develop better methods for analyzing the benefits of reductions in VOCs.

6.2 Lack Of Approved Methods To Quantify HAP Benefits

There are both cancer and non-cancer health effects associated with the HAPs that are controlled under this rule. In previous analyses of the benefits of reductions in HAPs, EPA has quantified and monetized the benefits of reduced incidences of cancer. (EPA, 1995b). In some cases, EPA has also quantified (but not monetized) reductions in the number of people exposed to non-cancer HAP risks above no-effect levels. (EPA, 1996).

Monetization of the benefits of reductions in cancer incidences requires several important inputs, including central estimates of cancer risks, estimates of exposure to carcinogenic HAPs, and estimates of the value of an avoided case of cancer (fatal and non-fatal). In the above referenced analyses, EPA relied on unit risk factors (URF) developed through risk assessment procedures. The unit risk factor is a quantitative estimate of the carcinogenic potency of a pollutant, often expressed as the probability of contracting cancer from a 70 year lifetime continuous exposure to a concentration of one $\mu g/m^3$ of a pollutant. These URFs are designed to be conservative, and as such, are more likely to represent the high end of the distribution of risk rather than a best or most likely estimate of risk.

In a typical analysis of the expected health benefits of a regulation (see for example, "Regulatory Impact Analysis: Heavy-Duty Engine and Highway Diesel Fuel Sulfur Control Requirements", December 2000, EPA 420-R-00-026), health effects are estimated by applying changes in pollutant concentrations to best estimates of risk obtained from epidemiological studies. As the purpose of a benefit analysis is to describe the benefits most likely to occur from a reduction in pollution, use of high-end, conservative risk estimates will lead to a biased estimate of the expected benefits of the regulation.

However the methods to conduct a risk analysis of HAP reductions produces high-end estimates of benefits due to assumptions required in such analyses. While we used high-end risk estimates in past analyses, recent advice from the EPA SAB and internal methods reviews have suggested that we avoid using high-end estimates in current analyses. This advice, as taken from the Workshop on the Benefits of Reductions in Exposure to Hazardous Air Pollutants (EPA, 2002), has been to prefer central estimates to upper bound risk estimates because cost-benefit analysis is focused on the expected values of costs and benefits. In addition, the SAB stated (EPA, 2000b) to conduct an accurate benefit-cost analysis of a regulation that alters cancer and/or noncancer health risks requires risk assessment information of the following form: (1) the proposed regulation and associated standard need to be clearly identified; (2) the most accurate and realistic estimates of the expected change in exposure resulting from the standard, including any potential behavioral adjustments (which can increase or decrease exposure) need to be determined; and (3) the most accurate and realistic estimate of the expected cancer-related consequences resulting from the change in exposure need to be provided. Again, the estimates of exposure and resulting cancer cases avoided need to be as realistic as possible, employing neither particularly conservative nor optimistic assumptions.

In order to develop unit risks, EPA has generally made a conservative assumption of no threshold and used a linear extrapolation approach. In order to protect public health with a substantial margin of safety, EPA has extrapolated the upper 95th percent confidence band of the dose-response data rather than its central tendency. While this conservative approach may be required for regulatory purposes, it does not necessarily provide realistic, best estimates for the purposes of benefit-cost analysis.

Also, limited input data on non-cancer effects associated with exposure to these HAPs does not allow us to quantify the benefits from risk reductions of these effects. The input data is limited in the sense that we do not have sufficient data to produce a dose-response relationship. The RfC does not say anything about the effects of changes in concentrations of toxics on changes in different non-cancer health effects. All it provides is a reference concentration where a particular sensitive non-cancer health effect is unlikely to occur. Therefore, the RfC is not generally useful for benefits analyses which require changes in incidence of the full suite of effects. For these reasons, we will not attempt to quantify the health benefits of reductions in HAPs unless best estimates of risks are available. EPA is working with the SAB to develop better methods for analyzing the benefits of reductions in HAPs. While not appropriate as part of a primary estimate of benefits to estimate the potential baseline risks posed by the Auto and Light-Duty Truck source category, EPA performed a "rough" risk assessment, described below. There are large uncertainties regarding all components of the risk quantification step, including location of emission reductions, emission estimates, air concentrations, exposure levels and dose-response relationships. However, if these uncertainties are properly identified and characterized, it is possible to provide estimates of the reduction in inhalation cancer incidence associated with this rule. Also, since conservative assumptions were generally made where site-specific data were unavailable, overall risk estimates from the rough assessment can be characterized as health protective; that is, actual risks in the population are likely to be lower. This rough analysis considered what is likely to be the predominant pathway for the HAPs emitted by these facilities. Other routes of exposure could add to overall exposures.

6.2.1 Characterization of Industry Emissions and Potential Baseline Health Effects

For the automobile and light-duty truck surface coating source category, seven HAP account for over 95 percent of the total HAP emitted. Those seven HAP are toluene, xylene, glycol ethers (including ethylene glycol monobutyl ether (EGBE)), MEK, MIBK, ethylbenzene, and methanol. Additional HAP which may be emitted by some automobile and light-duty truck surface coating operations are: ethylene glycol, hexane, formaldehyde, chromium compounds, diisocyanates, manganese compounds, methyl methacrylate, methylene chloride, and nickel compounds.

Of the seven HAP emitted in the largest quantities by this source category, all can cause toxic effects following sufficient exposure. The potential toxic effects for high doses of these seven HAP include effects to the central nervous system, such as fatigue, nausea, and mild tremors; adverse effects on the liver, kidneys, and blood; respiratory effects; and, developmental effects.

In accordance with section 112(k), EPA developed a list of 33 HAP which present the greatest threat to public health in the largest number of urban areas. None of the predominant seven HAP that represent 95% of the emissions of HAP for this category is included on this list for the EPA's Urban Air Toxics Program, although three of the other emitted HAP (formaldehyde, manganese compounds, and nickel compounds) appear on the list. In November 1998, EPA published "A Multimedia Strategy for Priority Persistent, Bioaccumulative, and Toxic (PBT) Pollutants." None of the predominant seven HAP emitted by automobile and light-duty truck surface coating operations appears on the published list of compounds referred to in the EPA's PBT strategy.

To estimate the potential baseline risks posed by the source category , EPA performed a "rough" risk assessment for 56 of the approximately 60 facilities in the source category by using a model plant placed at the actual location of each plant and simulating impacts using air emissions data from the 1999 EPA Toxics Release Inventory (TRI). In addition to the seven predominant HAP, the following additional HAP were included in this rough risk assessment because they were reported in TRI as being emitted by facilities in the source category: ethylene glycol, hexane, formaldehyde, diisocyanates, manganese compounds, nickel compounds and benzene. The benzene emissions and some of the nickel emissions are from non-surface coating activities which are not part of the source category. Of the HAP reported in TRI which are emitted from automobile and light-duty truck surface coating operations, three (formaldehyde, nickel compounds, and EGBE) are carcinogens that, at present, are not considered to have thresholds for cancer effects. Most facilities in this source category emit some small quantity of formaldehyde. In the 1999 TRI, however, only two facilities in this source category reported formaldehyde emissions. No other facilities exceeded the TRI reporting threshold for formaldehyde in 1999.

6.2.2 Results of Rough Risk Assessments of Alternative Control Options Under CAA Sections 112 (d)4 and 112(c)(9)

The results of the human health risk assessments described below are based on approaches for quantifying exposure, risk, and cancer incidence that carry significant assumptions, uncertainties, and limitations. For example, in conducting these types of analyses, there are typically many uncertainties regarding dose-response functions, levels of exposure, exposed populations, air quality modeling applications, emission levels, and control effectiveness. The risk estimates from this rough assessment are also based on typical facility configurations (i.e., model plants). As such, they are subject to significant uncertainties. The actual risks at any one facility could be significantly higher or lower. Because the estimates derived from the various scoping approaches are necessarily rough, we are concerned that they not convey a false sense of precision. Any point estimates of risk reduction or benefits generated by these approaches should be considered as falling within the upper range of potential estimates.

If this final rule is implemented at all automobile and light-duty truck surface coating facilities, the number of people exposed to hazard index (HI) values equal to, or greater than, 1 was estimated to be reduced from about 100 to about 10. The emissions of manganese, MIBK, and xylenes contributed most to non-cancer risk estimates. (Details of these analyses are available in the docket.)

The baseline cancer risk and subsequent cancer risk reductions were estimated to be minimal for this source category. The rough risk assessment indicated that currently no one would be exposed to a lifetime cancer risk above 10 in a million and perhaps 6,000 people would be exposed to a lifetime cancer risk above 1 in a million as a result of emissions from these facilities. Of the three carcinogens included in the assessment, emission reductions attributable to the final rule could be estimated for only EGBE. The cancer risk for EGBE, however, cannot currently be quantified. As a result, we were not able to estimate whether or not this rule would have any significant effect on cancer risks.

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Appendix A

Economic Model for Automobile and LDT Market Under Imperfect Competition

The final regulation will increase the cost of production for existing vehicle assembly plants. The regulated facilities may alter their current levels of production or even close the facility in response to the increased costs. These responses will in turn determine the impact of the regulation on total market supply and ultimately on the equilibrium price and quantity. The economic analysis described below employs standard concepts of microeconomics to model these impacts.

A.1 U.S. Demand for Domestic Vehicles

The Agency has modeled separate markets for eight domestic vehicle categories: subcompacts, compacts, intermediate/standard, luxury, sports, pickups, vans, and other. Domestic demand for each vehicle category i can be expressed by the following constant elasticity demand function:

$$Q_i^d = A_i[p_i]^{\epsilon_i^d}$$

where p_i is the average price of vehicle category i, ϵ_i^d is the own-price demand elasticity for vehicle category i, and A_i is a multiplicative demand parameter that calibrates the demand equation given data on price and the demand elasticity to replicate the observed baseline year (1999) level of domestic consumption of vehicles of class i.

Estimates of average retail prices and own-price elasticities by vehicle class are presented in Table A-1. The average retail price for each of the eight vehicle classes is derived from the Automotive New Market Data Book, as described previously in Section 2.4.3. The own-price elasticity of demand for each vehicle class is taken from Goldberg (1995) who estimates them using micro data on transaction prices and make/models from the Consumer Expenditure Survey and the Automotive News Market Data Book. Note that these demand elasticity estimates are all greater than one in absolute value but vary across vehicle classes in an intuitive manner. For example, the demand for intermediate and standard automobiles is highly elastic, while that for sports and luxury cars is the least price elastic.

A.2 U.S. Supply of Domestic Vehicles

Given the capital in place, each facility is assumed to face an upward sloping curve for a particular vehicle class. The Generalized Leontief profit function is used to

Table A-1. Retail Prices and Own-Price Elasticities of Demand by Vehicle Class

Vehicle Class	Average Retail Price[a]	Elasticity[b]
Subcompact	$15,522	–3.286
Compact	$16,487	–3.419
Intermediate	$21,155	–4.179
Standard		–4.712
Luxury	$33,587	–1.912
Sports	$25,797	–1.065
Pick-up	$22,126	–3.526
SUV	$27,694	
Van	$22,910	–4.363
Other		–4.088

[a] Includes the MSRP and destination price reported by the Automotive News Market Data Book (Crain, 2000; p: 75). Prices current as of April 2000 and were considered representative of 1999 prices.

[b] Goldberg, Pinelopi K. 1995. "Product Differentiation and Oligopoly in International Markets: The Case of the U.S. Automobile Industry." *Econometrica* 63(4):891-951, Table II.

characterize the facility supply function under perfect competition. Under this assumption, the supply function for facility j for producing vehicles of class i would take the form:

$$q_{ij} = \gamma_{ij} + \frac{\beta_{ij}}{2}\left[\frac{1}{p_i}\right]^{\frac{1}{2}} \tag{A.2}$$

where p_i is the average price for vehicle class i, and γ_{ij} and β_{ij} are model parameters. The theoretical restrictions on the model parameters that ensure upward-sloping supply curves are $\gamma_{ij} \geq 0$ and $\beta_{ij} < 0$. Figure A-1 illustrates the theoretical supply function represented by Eq. (A.2). As shown, the upward-sloping supply curve is specified over a productive range with a lower bound of zero that corresponds with a shutdown price equal to $\frac{\beta_{ij}^2}{4\gamma_{ij}^2}$ and an upper bound given by the production capacity of q_j^M that is approximated by the supply parameter γ_{ij}. The curvature of the supply function is determined by the β_{ij} parameter.

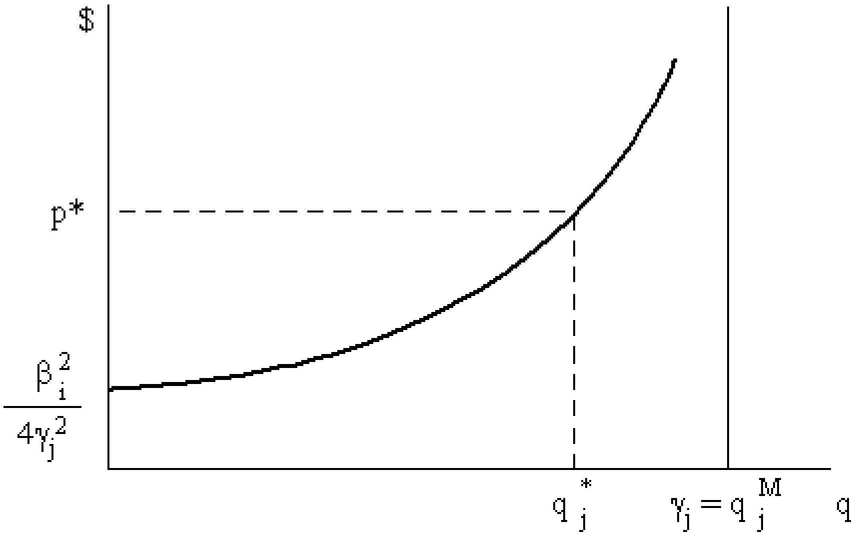

Figure A-1. Facility-Level Marginal Cost Function

The β parameter is related to the facility's supply elasticity which can be expressed as:

$$\xi_{ij} = \frac{\partial q_{ij}}{\partial p_i} \cdot \frac{p_i}{q_{ij}} \tag{A.3}$$

Taking the derivative of the facility supply function (equation A-2) with respect to price and multiplying this expression by p_i/q_{ij} results in the following expression for the supply elasticity:

$$\xi_{ij} = -\left[\frac{\beta_{ij}}{4q_{ij}}\right] \cdot \left[\frac{1}{p_i}\right]^{\frac{1}{2}} \tag{A.4}$$

By rearranging terms, β can be expressed as follows:

$$\beta_{ij} = -4q_{ij}\xi_{ij}\left[\frac{1}{p_i}\right]^{-\frac{1}{2}} . \qquad (A.5)$$

Under perfect competition,[3] EPA estimated the β parameter by substituting an assumed supply elasticity for the vehicle class (ξ_{ij}), the baseline production level by facility j of vehicle class i (q_{ij}), and the average market price for the vehicle class (p_i). EPA assumed that a facility's ability to respond to small price changes depends on its current capacity utilization rate, as outlined in Table A-2. The remaining supply function parameter, γ_{ij}, does not influence the facility's production responsiveness to price changes as does the β parameter. Thus, the parameter γ_j is used to calibrate the model so that each facility's supply equation replicates the baseline production data.

Table A-2. Supply Elasticity Assumptions

Capacity Utilization Rate (R)	**Supply Elasticity (ξ)**
$R > 1$	0.10
$0.9 < R < 1$	0.50
$R < 0.9$	1.00

A.3 Baseline Equilibrium

The facility's optimization problem with respect to vehicle class i is then given by:

$$\max \Pi_{i,j} = P(Q_i)^{*}q_{i,j} - C(q_{i,j}) \qquad (A.6)$$

where Q_i is the total number of vehicles of class i available in the market, and $P(Q_i)$ is the average price in this vehicle category. In the short-run, a facility owner will be willing to supply vehicles at a markup over marginal cost as long as the market price is high enough to cover average variable costs. If revenue falls below average variable costs, then the facility's best response is to shut down production because total revenue does not cover total variable costs of production. In this scenario, producers lose money on operations as well as capital. By shutting down, the facility

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[3] The calibration method is modified for the basic oligopoly model described in Section A.3 where the marginal revenue term in Eq. A.8 is substituted for p_i.

avoids additional losses from operations. The sufficient condition for production at facility j is non-negative profits (Π_j):

$$\Pi_j = TR_j - TC_j \geq 0 \tag{A.7}$$

where TR_j is the total revenue earned from the sale of all vehicles assembled at facility j and TC_j is the sum of the variable production costs (production and compliance) and total avoidable fixed costs (annualized expenditure for compliance capital) incurred by facility j for all vehicles that it produces. The underlying assumption is that if a facility produces multiple models, these models share some fixed costs that cannot be separated. Thus the facility need not shut down if one product line is unprofitable. It will only shut down if the aggregate profits from *all* models are negative on balance.

To model each vehicle category as a concentrated market, we have used a Cournot model in which facilities exercise some control over the wholesale price of the vehicle. In these noncompetitive models, each supplier recognizes its influence over the market price and chooses a level of output that maximizes its profits, given the output decisions of the others. Employing a Cournot model assumes that suppliers do not cooperate. Instead, each supplier evaluates the effect of its output choice on price and does the best it can given the output decision of its competitors. Thus, given any output level chosen by other suppliers there will be a unique optimal output choice for a particular supplier.

The basic oligopoly model we consider is the "Many Firm Cournot Equilibrium" described in Varian (1993, page 290). As is the case in all imperfectly competitive models of profit-maximizing behavior, each oligopolist chooses an output level where marginal revenue equals marginal cost. In the Cournot model, marginal revenue is a fraction, $Z_{i,j}$, of the market price: $Z_{i,j} = (1 + s_{i,j}/\epsilon_i)$, where $s_{i,j} = q_{i,j}/Q_i$. If we optimize Eq. (A.7)with respect to $q_{i,j}$ we can derive the following first-order condition:

$$P(Q_i)\bullet(1 + s_{ij}/\epsilon_i) = MC_{ij}. \tag{A.8}$$

If facility j's market share of vehicle category i (s_{ij}) is 1, the demand curve facing it is the market demand curve. In that case, Eq. (A.8) reduces to the profit maximization condition facing a monopolist where marginal revenue equals marginal cost, and the marginal revenue is only a function of the demand elasticity. On the other extreme, if the producer is a very small part of a large market, its market share is near zero, and Eq. (A.8) reduces to the profit maximization condition under perfect competition: price equals marginal cost.

Using data on the approximated market price of vehicle by type ($P(Q_i)$), total quantity produced for the domestic market (Q_i), the amount produced by each affected facility (q_{ij}), and the price elasticity of demand ($\epsilon_{i,}$) for vehicle class i, the baseline equilibrium can be established as depicted in Figure A-2. For each of the affected facilities, the baseline automobile production quantities are provided in Tables 2-11 and 2-12 of Section 2. Some facilities produce vehicles in more than one market segment. In these cases, the Agency treated each market segment for a facility as a separate product line thus, a facility may have multiple product lines for the purposes of the economic impacts model.

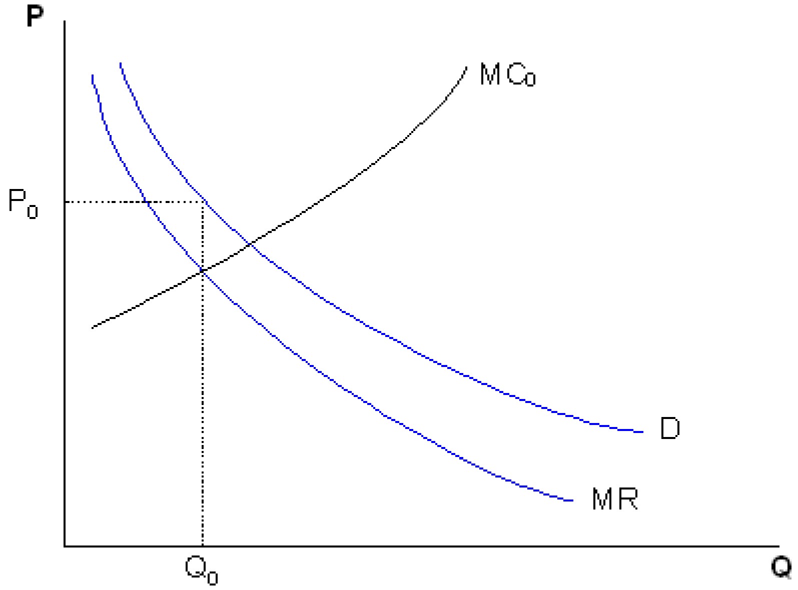

Figure A-2. Baseline Equilibrium

A.4 With-Regulation Market Equilibrium

The production decision at assembly facility j is affected by the variable compliance costs, $c_{i,j}$, which are expressed in dollars per vehicle.[4] Each marginal cost equation is directly affected by the regulatory control costs. Dropping subscripts henceforth for convenience, the profit maximizing solution for each existing facility becomes:

$$\frac{\beta^2}{4\cdot(q-\gamma)} + c = p\cdot\left[1 + \frac{s}{\varepsilon}\right] \qquad (A.9)$$

Incorporating the regulatory control costs (c) will involve shifting the marginal cost curve upward for each regulated facility by the per-unit variable compliance cost, as shown in Figure A-3. The marginal cost of the affected facilities shifts upward, causing the market cost curve to shift upward to MC_1. At the new with-regulation equilibrium, the market price increases from P_0 to P_1 and market output (as determined from the market demand curve, D_M) declines from Q_0 to Q_1.

Facility responses and market adjustments can be conceptualized as an interactive feedback process. Facilities face increased production costs due to compliance, which causes facility-specific production responses (i.e., output reduction). The cumulative effect of these responses leads to an increase in the market price that all producers and consumers face. This increase leads to further responses by all producers and consumers and, thus, new market prices. The new with-regulation equilibrium is the result of a series of these iterations between producer and consumer responses and market adjustments until a stable market price equilibrium is reached where total market supply equals total market demand. A spreadsheet nonlinear solution algorithm was used to compute the with-regulation equilibrium price and quantities in each market.

A.5 Impact on Foreign Trade

The final coating regulation will only be binding on facilities that assemble vehicles in the United States. The consequent change in relative prices of domestic versus

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[4] The variable compliance costs per vehicle were calculated given the annual production per facility and the variable cost component of the total compliance cost estimate for each facility. These latter cost estimates were provided by the engineering analysis and include annual operating and maintenance costs and monitoring and record keeping costs.

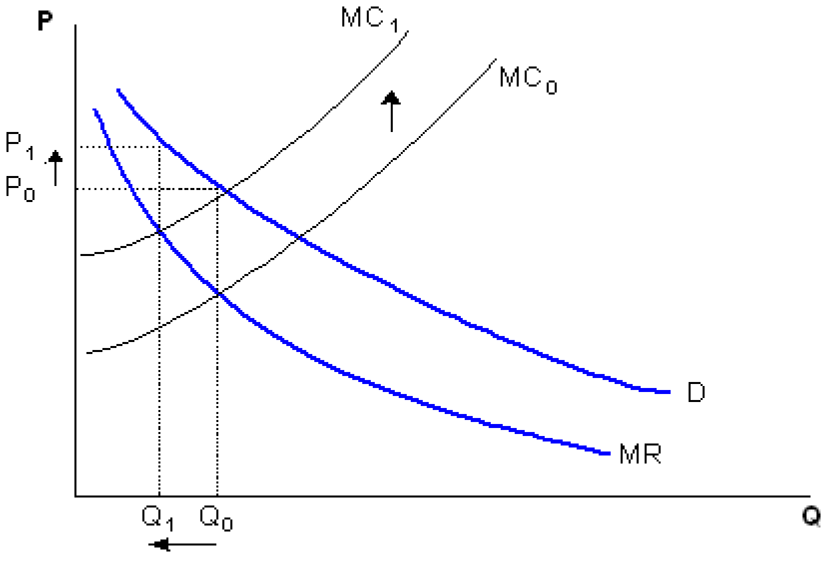

Figure A-3. With-Regulation Equilibrium

foreign vehicles has two impacts on foreign trade. Foreign imports become more attractive to U.S. consumers and U.S. exports become less attractive to foreign consumers. The Agency has used available data to estimate the magnitude of these impacts as described below.

A.5.1 U.S. Imports

The final regulation may lead to an increase in the price of domestic vehicles, which, in turn, could potentially trigger an increase in demand by U.S. consumers for substitutes such as unregulated, imported vehicles. To estimate this spillover effect, EPA assumed domestic and foreign vehicles are imperfect substitutes that are differentiated by their country of origin (commonly referred to as the Armington assumption). The conceptual approach for estimating spillover effects using Armington elasticities is described in Gallaway, McDaniel, and Rivera (2000). From an economy-wide perspective, a representative consumer maximizes his utility for "composite" vehicles (V) by allocating expenditures between domestic (D) and imported vehicles (M), taking relative prices as given.[5] The Armington specification assumes a constant elasticity of substitution (CES) utility function of the form:

$$V = \alpha\,[\delta\, M^{(\sigma-1)/\sigma} + (1-\delta)\, D^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)} \qquad \text{(A.10)}$$

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[5] Vehicle classes are aggregated in the foreign trade section because of data limitations.

where σ is the Armington elasticity of substitution between domestic and imported vehicles, and α and δ are calibrated parameters of the demand function. Utility maximization subject to the budget constraint leads to the following first order condition:

$$M/D = [(\delta/(1-\delta)) * (P_D/P_M)]^{\sigma} \tag{A.11}$$

Thus, the ratio between imported and domestic vehicles is a function of their relative prices and the elasticity of substitution. Gallaway, McDaniel, and Rivera (2000) use monthly data from 1989 through 1997 to estimate Armington elasticities for several manufacturing industries. For SIC 3714, motor vehicle parts and accessories, they estimate a value of 2.07. Additional substitution elasticity estimates for motor vehicles are reported in Ho and Jorgenson (1998) and range from 1.52 to 3.59. The Agency has used all three estimates to compute low and high end estimates of the change in import-to-domestic vehicles ratio for a given change in the price of domestic cars.

A.5.2 U.S. Exports

Exports of U.S.-made vehicles can also fall if their own-price increases due to the final regulation. While U.S. exports of passenger cars in this industry are only one-fourth the level of imports, they still represent about 18 percent of domestic production in 1997 and are growing (AAMA, 1998). Unfortunately, data were lacking connecting specific facilities to specific markets. Thus, foreign demand for U.S.-made vehicles is modeled by one representative foreign consumer using the following constant elasticity demand function:

$$q_x = B_x[p]^{\epsilon_x} \tag{A.12}$$

where p is the average price of exported U.S. vehicles, ϵ_x is the export demand elasticity, and B_x is a multiplicative demand parameter that calibrates the foreign demand equation, given data on price and foreign demand elasticity to replicate the observed baseline year 1999 level of exports. Ho and Jorgenson (1998) report export demand elasticities for motor vehicles. These estimates range from –0.9 to –1.55. These export demand elasticity estimates are used along with our estimates of change in the average price of U.S. vehicles to forecast the corresponding change in quantity demanded by foreign consumers.

Appendix B

Estimating Social Costs Under Imperfect Competition

B.1 Social Cost Effects Under Imperfect Competition[6]

The conceptual framework for evaluating social costs and distributive impacts in an imperfectly competitive market model is illustrated in Figure B-1. The baseline equilibrium is given by the price, P_0, and the quantity, Q_0. In a pure monopoly situation, the baseline equilibrium is determined by the intersection of the marginal revenue curve (MR) and the MC curve. In imperfect competition, such as in the Cournot model used in this analysis, the baseline equilibrium is determined by the intersection of MC with some fraction of MR. Without the regulation, the total benefits of consuming automobiles is given by the area under the demand curve up to Q_0. This equals the area filled by the letters ABCDEFGHIJ. The total variable cost to society of producing Q_0 equals the area under the original MC function, given by IJ. Thus, the total social surplus to society from the production and consumption of output level Q_0 equals the total benefits minus the total costs, or the area filled by the letters ABCDEFGH.

The total social surplus value can be divided into producer surplus and consumer surplus. Producer surplus accrues to the suppliers of the product and reflects the value they receive in the market for the Q_0 units of output less what it costs to produce this amount. The market value of the product is given by the area DEFGHIJ in Figure B-1. Since production costs IJ, producer surplus is given by area DEFGH. Consumer surplus accrues to the consumers of the product and reflects the value they place on consumption (the total benefits of consumption) less what they must pay on the market. Consumer surplus is thereby given by the area ABC.

The with-regulation equilibrium is P_1, Q_1. Total benefits of consumption are ABDFI and the total variable costs of production are FI, yielding a with-regulation social surplus of ABD.[7] Area BD represents the new producer surplus and A is the new consumer surplus. The social cost of the regulation equals the total change in social surplus caused by the regulation. Thus, the social cost is represented by the area FGHEC in Figure B-1.

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[6] The Agency has developed this conceptual approach in a previous economic analysis of regulations affecting the pharmaceutical industry (EPA, 1996). For simplicity, this appendix assumes constant marginal costs. The marginal cost curves developed for the economic model are upward sloping curves $\left(\frac{\partial MC}{\partial q} > 0\right)$.

[7] Fixed control costs are ignored in this example but are included in the analysis.

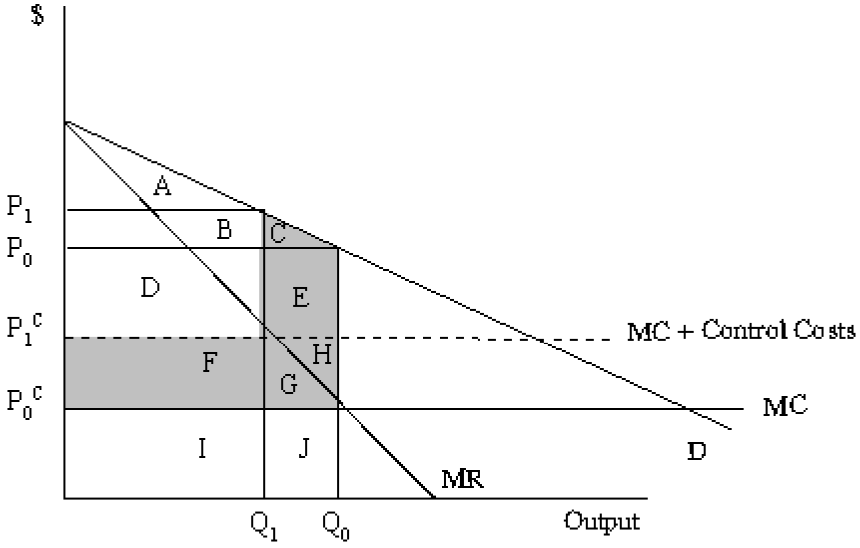

Figure B-1. Economic Welfare Changes with Regulation: Imperfect Competition

The distributive effects are estimated by separating the social cost into producer surplus and consumer surplus losses. First, the change in producer surplus is given by

$$\Delta PS = B - F - (G+H+E) \tag{B.1}$$

Producers gain B from the increase in price, but lose F from the increase in production costs due to regulatory control costs. Furthermore, the contraction of output leads to foregone baseline profits of G+H+E.

The change in consumer surplus is

$$\Delta CS = -(B + C) \tag{B.2}$$

This reflects the fact that consumer surplus shrinks from the without-regulation value of ABC to the with-regulation value of A.

The social cost or total change in social surplus shown earlier can then be derived simply by adding the changes in producer and consumer surplus together

$$\Delta SC = \Delta PS + \Delta CS = -(F + G + H + E + C) \qquad (B.3)$$

B.3 Comparison of Social Cost with Control Cost

It is important to compare this estimate of social costs to the initial estimate of baseline control costs and explain the difference between the two numbers. The baseline control cost estimate is given by the area FGH, which is simply the constant cost per unit times the baseline output level. In the case of imperfect competition, the social cost estimate exceeds the baseline control cost estimate by the area EC. In other words, the baseline control cost estimate understates the social costs of the regulation. A comparison with the outcome under perfect competition helps illustrate the relationship between control cost and total social cost.

Suppose that the MR curve in Figure B-1 were the demand function for a competitive market, rather than the marginal revenue function for a monopolistic producer. Similarly, let the MC function be the aggregate supply function for all producers in the market. The market equilibrium is still determined at the intersection of MC and MR, but given our revised interpretation of MR as the competitive demand function, the without-regulation (competitive) market price, P_0^C, equals MC and Q_0 is now interpreted as the competitive level of product demand. In this type of market structure, all social surplus goes to the consumer. This is because producers receive a price that just covers their costs of production.

In the with-regulation perfectly competitive equilibrium, price would rise by the per-unit control cost amount to P_1^c. Now the social cost of the regulation is given entirely by the loss in consumer surplus, area FG. As this is compared to the initial estimate of regulatory control costs, FGH, the control cost estimate overstates the social cost of the regulation. The overstatement is due to the fact that the baseline control cost estimates are calibrated to baseline output levels. With regulation, output is projected at Q_1, so that control costs are given by area F. Area G represents a monetary value from lost consumer utility due to the reduced consumption, also referred to as deadweight loss (analogous to area C under the monopolistic competition scenario).

Social cost effects are larger with monopolistic market structures because the regulation already exacerbates a social inefficiency (Baumol and Oates, 1988). The inefficiency relates to the fact that the market produces too little output from a social welfare perspective. In the monopolistic equilibrium, the marginal value society (consumers) places on the product, the market price, exceeds the marginal cost to society (producers) of producing the product. Thus, social welfare would be improved by increasing the quantity of the good provided. However, the producer has no incentive to do this because the marginal revenue effects of lowering the price and increasing quantity demanded is lower than the marginal cost of the extra units. OMB explicitly mentions the need to consider these market power-related welfare costs in evaluating regulations under Executive Order 12866 (OMB, 1996).

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16. ABSTRACT

Pursuant to Section 112 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA) has developed National Emissions Standards for Hazardous Air Pollutants (NESHAP) to control emissions released from the coating of automobiles and light-duty trucks (LDT). The purpose of this rule is to reduce the flow of HAPs from potential emission points within auto and LDT facilities. Eighty percent of the HAPs released are xylene, glycol ethers (EGBE), MIBK, and toluene. The other HAPs include methanol, glycol ethers, MEK, formaldehyde, and ethyl benzene. The facilities in the auto and LDT source category are controlling HAP emissions from their coatings operations, as required, to meet maximum achievable control technology (MACT) standards. As of 1999, there were 65 auto and LDT assembly facilities owned by 14 companies. The estimated total annual cost for these facilities to comply with the final MACT standard is approximately $154 million. Due to the total annual cost of compliance, an economic impact model estimates that production of autos and LDT declines by 0 to 0.02 percent across various vehicle classes. The estimated price increase due to the regulation is less than 0.01 percent. Pre-tax earnings for the companies owning the facilities in this source category decline by about 1.08 percent according to the economic model developed in the regulatory impact analysis. According to the Small Business Administration size standards, none of these businesses are considered small. Based on the economic impact analysis, impacts of the NESHAP on companies owning auto and LDT assembly facilities are anticipated to be negligible.

17. KEY WORDS AND DOCUMENT ANALYSIS

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