

CAFE and the U.S. Auto Industry Revisited

 Equity

A Growing Auto Investor Issue, 2011-2016

- **What's New?** — In partnership with Ceres and the Investor Network on Climate Risk, we, along with the Planning Edge, University of Michigan Transportation Research Institute, Meszler Engineering Services, and the Natural Resources Defense Council, evaluated the impact that changes to the U.S. Corporate Average Fuel Economy (CAFE) program may have on the industry in 2016. We have issued this report as a follow-up to Citi's October 22, 2007 report "CAFE and the U.S. Auto Industry – A Growing Auto Investor Issue, 2012-2020" in which we examined the impact of proposed fuel economy regulation on the U.S. auto industry.
- **New CAFE and GHG Standards** — On May 19, 2009, President Obama announced the adoption of one national program ("National Program") for model years 2012-2016 that will set higher fuel economy standards and new greenhouse gas (GHG) emissions standards. The GHG standards are intended to be equivalent to applying California's GHG vehicle emissions standard to the national sales fleet. In model year 2016, the car and light truck GHG standards will be set to an equivalency of 250 grams of CO₂ per mile average over the entire fleet, about equal to 35.5 mpg, representing approximately a 40% increase in fuel economy. With this approach, the Administration addressed both auto companies' concern regarding multiple regulatory schemes, and the desire of California and several other states to enforce stricter regulations. California has agreed to defer to the National Program through model year 2016, clearing the way for a uniform national standard through that time period.
- **Key Takeaways** — The analysis demonstrates that the proposed National Program is likely to benefit both domestic automakers (the Detroit 3) and the Japan 3 by boosting variable profits, based on the relative value consumers put on fuel costs compared to vehicle price, the future price of fuel, and the level of direct costs to improve fuel economy. Additionally, our research indicates the Detroit 3 would be able to mitigate market share erosion by producing more competitive fuel-efficient fleets in the coming years.
- **Suppliers of Key Technologies Will Benefit, Maintain Buy on BWA** — The U.S. auto industry is still in the early stages of adopting fuel saving technologies to meet rising regulatory standards. Key beneficiaries of relevant technology include Buy-rated BorgWarner (BWA) and Hold-rated Johnson Controls (JCI). BorgWarner appears best positioned to benefit as the company derives most of its sales from fuel savings technologies such as turbochargers and dual-clutch transmissions.

See Appendix A-1 for Analyst Certification and important disclosures.

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U.S. Auto Industry: New CAFE/GHG Standards

I. Overview of Findings

This past May, the Obama Administration announced a new approach to vehicle regulation; a single National Program that will coordinate both fuel economy and greenhouse gas (GHG) emissions standards. The GHG national standard is intended to be equivalent to California's formerly stricter GHG vehicle emissions standard for the U.S. sales fleet. In model year 2016, the car and light truck GHG standards will be set to an equivalency of 250 grams of CO₂ per mile average over the entire fleet, about equal to 35.5 mpg (depending on how the automakers choose to comply with the GHG standards), representing approximately a 40% increase in fuel economy.¹ This report looks at the impacts of more stringent regulation, including overall technology impacts and costs, financial impacts, and strategies of individual auto manufacturers to compete under this new regulatory environment.

In this analysis, we sought to understand how a CAFE standard of 35 miles per gallon by 2020 – the minimum industry-wide target established by Congress in the Energy Independence and Security Act of 2007 (EISA)– as well as a national version of the California Pavley standard would affect profitability within the industry. Our national Pavley scenario assumes an industry-wide fuel economy level of 35 miles per gallon in 2016, compared to the nominal 35.5 miles per gallon target set for the National Program (in 2016). The National Program is expected to allow automakers more flexibility than the existing CAFE program, so the 0.5 miles per gallon difference in our scenario and the National Program is not material. In particular, it is expected that the automakers will make use of GHG credits for reducing air conditioning refrigerant emissions which could easily allow account for this difference. Because we lack a sufficiently detailed sales forecast for model year 2016, we simply adopt the model year 2015 forecast sales mix.

Our analysis reveals that meeting the requirements of the National Program by 2016 will be not only be economically and technically feasible, but also will likely raise variable profits for both the Detroit 3 and the Japan 3 automakers. Under the National Program, Detroit's gross profits are likely to increase by roughly \$3 billion per year, compared to a \$0.8 billion increase for the Japanese 3, and sales are expected to increase by the equivalent of two large assembly plants for the Detroit 3. These factors include the relative value consumers put on fuel costs compared to vehicle price, the future price of fuel, and the level of direct costs to improve fuel economy. While these three factors could result in losses rather than gains in profits, the potential losses are relatively small, and all three factors are more likely to result in gains. In fact, in our central analysis, the only potential loss suffered by the Detroit 3 occurs when the Detroit 3 stay at their current mpg and meet neither the National Program nor the EISA requirement. Most importantly, complying with the National Program renders the vehicles in the majority of segments more cost effective for consumers; the present value of the fuel saved will be greater than the increase in purchase price associated with the new fuel saving technology.

Figure 1. Summary of Changes in Variable Profit

<i>Gain or (Loss) \$Billions</i>		
<u>Detroit 3 / Japan 3</u>	<u>National Pavley</u>	<u>Current CAFE</u>
Consumers Value 100%	\$3.4 / \$0.8	\$4.1 / \$0.8
Consumers Value 70%	\$0.9 / \$0.6	\$1.7 / \$0.6
Consumers Value 70%	(\$0.2) / \$0.6	(\$0.7) / \$1.0
<i>Detroit stays at current mpg</i>		

Source: UMTRI

II. Fuel Economy and Climate Change

An Update on Current Regulations

On May 19th, 2009, President Obama announced that his Administration plans to establish a National Program governing both fuel economy and GHG emissions from vehicles. The proposed rulemaking for the National Program was announced on September 15, 2009.² The National Program represents the culmination of years of litigation and debate regarding new standards for the auto industry. The new GHG emissions standard should be roughly equivalent to the GHG emissions standard that California, thirteen other states and the District of Columbia have adopted. The Administration's approach is intended to harmonize federal and state regulation so that automakers are in effect subject to the single National Program. Three agencies exist with independent authority to regulate vehicle emissions (or emissions influencing parameters): the California Air Resources Board (CARB), authorized to regulate California vehicles for GHGs now that it has recently received a waiver from EPA, the Environmental Protection Agency (EPA), authorized to regulate vehicle GHG emissions based on a Supreme Court ruling from 2008, and the National Highway Traffic Safety Administration (NHTSA), responsible for CAFE standards since 1975. For the first time, all three agencies will work together to produce a final uniform rule.

California's Greenhouse Gas Pollution Standards

In 2004, California adopted the Pavley regulation (Pavley 1) that will require about a 30% reduction in carbon emissions from new passenger vehicles sold in the state by model year 2016 (approximately 35.5 mpg). Under the Clean Air Act, California was given leeway to adopt its own, more stringent, vehicle emission standards, pending an EPA waiver approval. Other states would then be free to implement California's standards once California received its waiver. Amid initial pushback from the EPA to grant California's proposal, President Obama directed the agency to revisit the waiver request, which was ultimately granted in June 2009.³

Pavley 1's impact alone on national fuel economy would have been significant. Beyond California, thirteen additional states and the District of Columbia adopted the Pavley 1 regulation, representing about 37% of U.S. new passenger vehicle sales. Four more states (corresponding to an additional 10% of vehicle sales) were in the administrative process of adopting California's standards when President Obama made his May announcement. At

that time, California agreed to harmonize its regulations for model years (MYs) 2012-2016 with the federal standards, and announced that compliance with its standards for MYs 2009-2011 could be demonstrated based on the fleet of vehicles sold in California and in the states that adopted California's standards (thereby expanding the averaging pool). In return, auto manufacturers agreed to dismiss pending litigation associated with California's and other states GHG standards, and not to renew such litigation for MYs 2009-2016.

The California Air Resources Board (CARB) has announced its plan to adopt a second phase of its carbon emission regulation (Pavley 2) that would reduce CO₂ emissions from new cars by about 50% by model year 2020 (roughly equivalent to 39.2 mpg assuming the national mix of gasoline cars and light trucks). California has also agreed to work with federal agencies and other stakeholders to develop a national standard for the model years after 2016, but it retains authority to have its own vehicle emissions program.

EPA's Authority to Regulate GHG Emissions

In April 2007, the Supreme Court in the *Mass. vs. EPA* decision found that greenhouse gases are air pollutants under the Clean Air Act. The decision thus provided EPA with the authority to regulate greenhouse gases from motor vehicles once the agency made an "endangerment" finding (a finding that greenhouse gas emissions are adversely affecting human health and welfare). On April 17, 2009, the EPA issued a proposed rule finding that CO₂ endangers human health and welfare and that vehicle GHG emissions cause or contribute to that endangerment. It is widely expected that EPA will make a positive endangerment finding, and indeed, President Obama's May 2009 announcement anticipates such a finding.

NHTSA's Authority to Regulate Fuel Economy

Shortly after the release of our previous CAFE report, Congress passed the EISA 2007, which President Bush signed into law on December 18, 2007. The Act contained a provision to raise the Corporate Average Fuel Economy (CAFE) standard to a fleetwide average (combining cars and light trucks) of at least 35 mpg by 2020, an approximate 40% improvement over today's levels.

On May 2, 2008, as required by EISA 2007, the National Highway Traffic Safety Administration (NHTSA) of the DOT issued proposed standards for model years 2011 to 2015 (the Notice of Proposed Rulemaking (NPRM)).⁴ It then released a draft final rule in November of 2008, but held off finalizing the proposal. At the direction of President Obama, NHTSA published a final rule for MY2011 in March 2009 with a combined fleet average fuel economy estimated at 27.3 mpg.

The new national standard will change the old CAFE system of a single fleetwide average for all manufacturers to an attribute-based standard based on vehicle size (that is, the footprint, or wheelbase times track width, of the vehicle). A CAFE standard will be established for each automaker's car and truck fleets based on the size and number of vehicles produced, and the overall fuel economy the manufacturer achieves at the end of the model year must meet that standard. As a result, it is likely that all automakers will be required to improve the fuel economy of their vehicle fleets (as opposed to requiring improvements from only some automakers as under the old system). The new guidelines will also reduce incentives to "game" the system by shifting mix; shifting production from larger, less fuel-efficient vehicles to smaller, more fuel-efficient vehicles would increase the company's average fuel economy, but it would also raise the company's production-weighted fuel economy target. Thus, the size-based system for cars will greatly mitigate the law's impact on companies' sales mix, although volatile fuel prices will likely also exert pressure to increase the proportion of lighter, more fuel-efficient vehicles. Accordingly, some automakers will provide fuel economy standards that go beyond the regulatory requirements, and will change vehicle mix independently in response to consumer demand.

New Federal Climate Change Legislation

The Waxman-Markey bill, named the American Clean Energy and Security Act (ACES), passed the House in July 2009, with Senate resolution forthcoming. In its current form, ACES would impact the auto industry in several key ways. First, the bill would bring in immediate and long-term investments in electric vehicles and other advanced automobile technology and deployment. Starting in 2012, automakers would receive 3% of the federal government's revenue from carbon emissions permits through 2017 and 1% from 2018 through 2025, to be used exclusively for such investments.⁵ Second, the bill would authorize the federal government to provide financial assistance for regional deployment and integration of grid-connected vehicles. Through the bill's "Large-Scale Vehicle Electrification Program," automakers would be eligible to receive federal funds to help offset the cost of purchasing new plug-in electric drive vehicles, deploy electric charging stations or battery exchange locations, or facilitate the integration of smart grid equipment with plug-in electric drive vehicles. The bill would double a \$25 billion Energy Department loan program designed to help automakers produce more fuel-efficient cars and trucks. The bill would also require utilities to develop plans to support electric vehicle infrastructure and establish protocols for integration with smart grid systems. Finally, the bill directs EPA to establish national transportation GHG reduction goals in consultation with the Secretary of Transportation.

On September 30, 2009, Senators John Kerry and Barbara Boxer introduced the Clean Energy Jobs and American Power Act. The Senate bill amends the Clean Air Act to require EPA to establish GHG emission standards for new heavy-duty road and non-road vehicles and engines. In addition, the bill establishes a Clean Vehicle Technology Fund to boost plug-in electric vehicle usage. The Fund would be stocked by the proceeds of the GHG allowances auction. Eighty percent of the Fund would be available to the Secretary of Energy to support the development and demonstration of a national transportation low-emissions energy plan and the use of medium- and heavy-duty plug-in electric vehicles. From that 80%, not more than 5% would be used to develop the low-emissions plan, which must: project the near- and long-term need for electric vehicle refueling infrastructure at strategic locations across all major transportation corridors; identify infrastructure and

standardization needs for electricity providers, infrastructure providers, vehicle manufacturers, and electricity purchasers; establish a goal for achieving strategic deployment of electric vehicle infrastructure by 2020; involve relevant stakeholders; and develop smart card billing and port systems. The remaining 20% of the Fund would be available to EPA to provide grants for reducing diesel engine emissions through the State Clean Diesel Grant Program created by the Energy Policy Act of 2005. The Senate bill would further require the Secretary to establish pilot projects to demonstrate electric vehicles and infrastructure, at least one of which must be carried out in a rural region and another one of which must focus on freight issues.

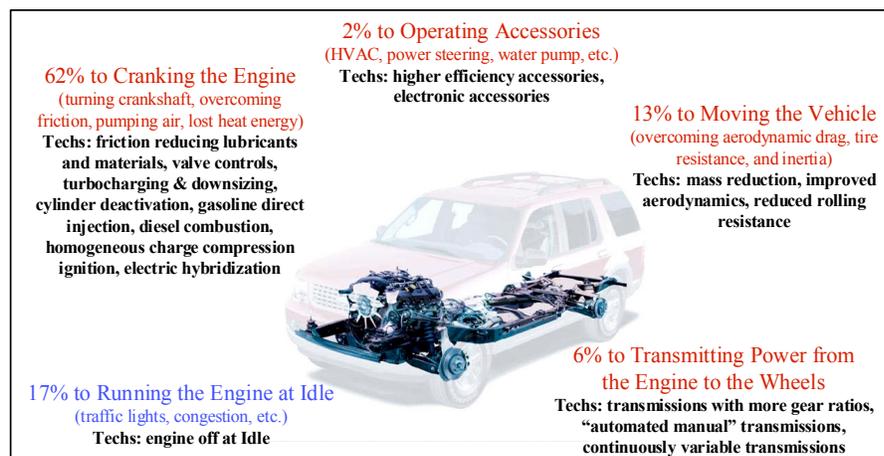
International Fuel Economy Standards and Incentives

Countries across the world are stepping up regulation of vehicle fuel economy and greenhouse gas emissions. In many cases, these international regulations are much more aggressive than those of the United States. In fact, in late May 2009, China announced that it would require automakers to improve fuel economy by an additional 18% by 2015; raising fuel economy to approximately 42 mpg. (This may disproportionately affect multinationals because increases in fuel economy requirements are greater for segments where multinationals are stronger, namely midsize and compact cars.) China has already increased taxes on large engine vehicles (over four liters) to 40%, increased taxes on vehicles with engines between three and four liters to 25%, and decreased the tax on small engine vehicles (1-1.5 liters) to 1%. In April 2009, European Union lawmakers adopted regulations requiring a reduction of CO₂ from new passenger cars from an average level of 159g/km (in 2006) to a maximum of 130g/km by 2015, corresponding to a fuel economy of roughly 48.9 mpg. The EU requirement includes much more significant penalties for noncompliance than the United States, and also sets a target for 2020 emissions at 95 g/km (subject to review prior to becoming a standard). Japan's fuel economy target is 48 mpg by 2010. Australia's fuel economy standards will increase to 34.4 mpg by 2010. In addition, most of the countries in the EU currently vary the tax on cars based on their carbon emissions, and those EU members that do not currently do so have committed to adopting carbon based emissions taxes.

III. Technology Impacts and Costs

Although energy efficiency has continued to advance through the evolution of the automobile, significant inefficiencies remain in the conversion of fuel energy to motive energy. Moreover, much of the potential reduction in fuel consumed per mile of travel resulting from more efficient drivetrain development has been offset by inefficiencies resulting from enhanced vehicle performance (i.e. increased horsepower per unit engine displacement). Figure 2 presents a generalized energy consumption distribution for a vehicle driven in an urban environment, illustrating both how total fuel energy is consumed and where room lies for efficiency improvement.

Figure 2. Urban Fuel Energy Breakdown



Source: Meszler Engineering Services

As one would expect, the largest energy losses are associated with converting fuel energy to mechanical energy in the engine. Such losses take place as heat escapes through the radiator, engine block, and exhaust system. Since engines must be designed to operate over a wide range of speed and load conditions – from crawling along in city traffic to zipping along on faster highways, both with and without significant cargo weight – engines are designed for “worst case” operating conditions and seldom operate under conditions of maximum efficiency. A typical gasoline engine is only about 25% efficient on average – meaning that 75% of fuel energy is simply “lost” as heat. Thermodynamics places a practical limit on the potential improvement of this energy conversion process, but substantial improvements – into the 40% average efficiency range – are possible.

The technologies automakers can employ to promote increased engine efficiency are generally designed to reduce mechanical friction, improve “breathing” (facilitating airflow through the engine), improve fuel control, or adjust the effective engine load to maximize high efficiency operations. Such technologies include the use of improved lubricants and low friction materials (to reduce mechanical resistance), improved valvetrain controls (to allow for finer air and combustion control), the increased use of turbocharging (to allow for greater performance from smaller engines), cylinder deactivation (to effectively change the “size” of an engine with operating conditions), gasoline direct injection (to allow for finer fuel control), dieselization (since the diesel cycle has inherent efficiency advantages relative to gasoline), homogeneous charge compression ignition (HCCI, which brings gasoline combustion efficiency closer to diesel, while retaining important gasoline emissions advantages), and hybridization (to supplement heat energy with higher efficiency electrical energy).

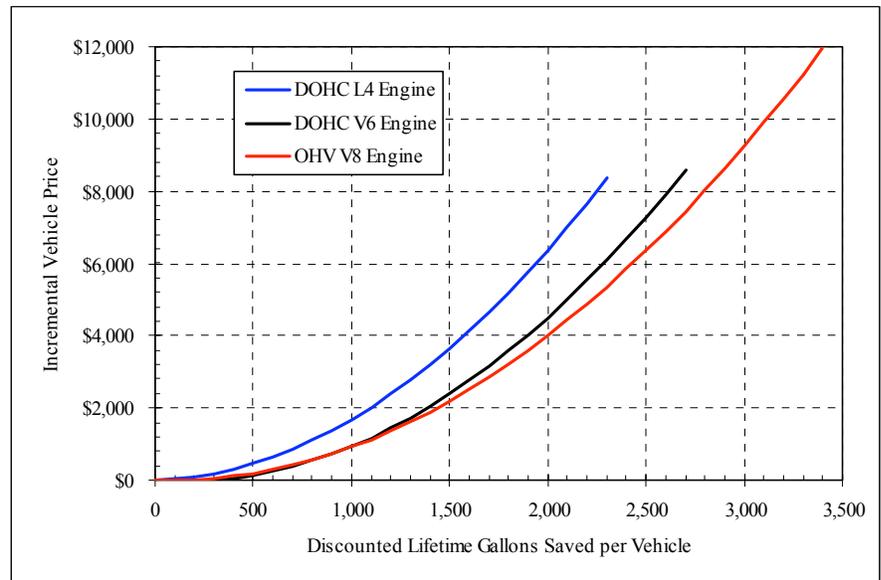
Energy losses also occur as energy moves from the engine to the wheels or due to non-motive engine loads. In urban driving, 17% or more of energy is consumed while the vehicle is not moving and the engine is simply idling – consuming fuel but producing no motive work. Recouping this energy through technology that allows the engine to be shut off at idle can provide for significant improvements in effective driving cycle efficiency. About 2% of fuel energy is expended on vehicle accessories such as power steering pumps and air conditioning systems. Accessories that demand less energy to operate or accessories that are operated electrically can reduce this energy consumption.

About 6% of energy is lost in moving energy from the engine to the vehicle wheels through transmission and axle systems. More efficient transmission technology can both reduce these losses and contribute to improved engine efficiency by allowing the engine to operate under high efficiency conditions more often. Since the load placed on an engine varies with road speed, transmissions with more gear ratios allow engine speed to adjust more frequently to road conditions and thereby maximize efficiency. The idealization of this is the continuously variable transmission that could potentially allow for infinite engine speed adjustment.

About 13% of fuel energy is actually used to move the vehicle. This energy is used to overcome a vehicle's inertial resistance, which is a function of vehicle mass, air resistance, and the rolling resistance of vehicle tires. Thus, technologies such as high strength, low mass materials, more streamlined vehicle designs, and lower rolling resistance tires can increase vehicle fuel efficiency.

Meszler Engineering Services (MES) undertook a limited meta analysis to estimate the fuel economy and cost impacts of various vehicle efficiency technologies. Details regarding the analysis can be found in Appendix C on page 24. Figure 3 shows the fuel economy technology cost curves for the three base engine types evaluated. As expected, costs increase more rapidly with each successive gallon of fuel saved.⁶ However, it might be less intuitively obvious to recognize that the cost to obtain a specific reduction in fuel volume is higher for 4 cylinder engines due to the fact that such engines are already more fuel efficient. In effect, 6 and 8 cylinder engines use more fuel and therefore have more potential to eliminate existing inefficiencies.

Figure 3. Fuel Economy Technology Cost Curves

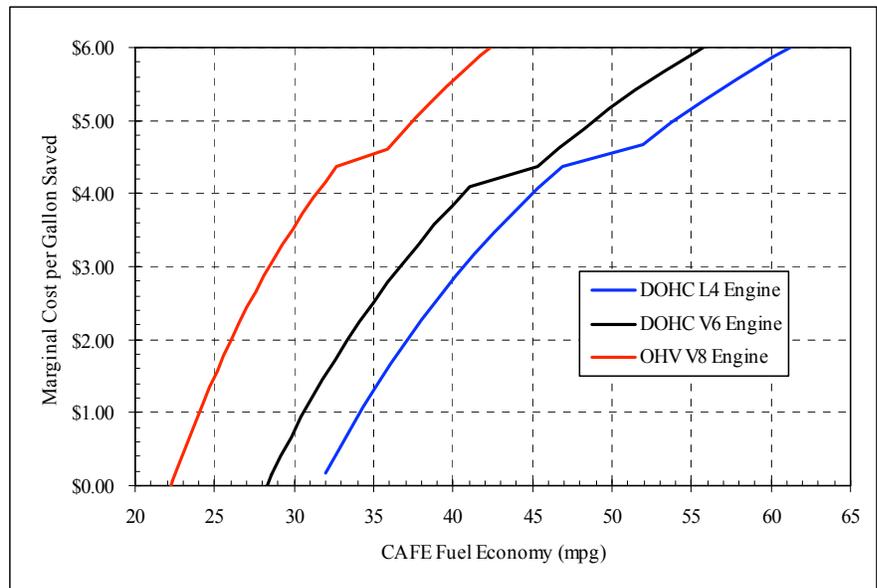


Source: Meszler Engineering Services

Figure 4 represents these same data in terms of marginal cost (expressed on a retail price increase basis) per discounted gallon of fuel saved versus specific levels of CAFE fuel economy. By expressing the data in terms of the marginal cost per gallon of fuel saved, one can roughly estimate the cost effective level

of CAFE by simply equating the marginal cost with an expected fuel price. Thus, for example, for a fuel price of \$3.50 per gallon, CAFE standards of about 43 mpg, 39 mpg, and 30 mpg would be cost effective for DOHC L4, DOHC V6, and OHV V8 base engine technology respectively.⁷ It is perhaps worth noting that the V6 curve can be taken as an approximate indicator of the cost effective CAFE level for the overall U.S. fleet since roughly 30% of engines are 4 cylinder, 47% 6 cylinder, and 23% 8 cylinder.

Figure 4. Marginal Fuel Economy Cost by CAFE Increase



Source: Meszler Engineering Services

It is also notable that Figure 4 illustrates that a 35 mpg CAFE standard, as required by under EISA 2007, is cost effective at a fuel price of about \$2.50 a gallon. A CAFE standard of 32.5 mpg is cost effective at a fuel price of \$2.00 per gallon, and CAFE standards above 40 mpg become cost effective at \$4.00 per gallon.

In considering this data, it is also important to recognize that the estimated cost of fuel savings does not assume any ancillary benefits for reduced fuel consumption such as the economic savings of reduced foreign energy dependence or the direct savings of reduced military expenditures necessary to protect that dependence. Inclusion of such benefits would further reduce the effective cost of CAFE. Additionally, no assumptions regarding future reductions in technology cost are made. To the extent that more efficient means of achieving fuel savings are developed, these advances will also reduce the cost of CAFE. Perhaps most importantly, the data clearly demonstrate that cost effective fuel economy improvements can be made to engines of all sizes. Increased CAFE does not need to signal the demise of the 8-cylinder engine or the advent of the small car era. Both U.S. and foreign manufacturers can significantly improve fuel economy while simultaneously maintaining consumer choice by implementing available and cost effective vehicle efficiency technology.

IV. Specific Impacts on Individual Automakers

Below is a detailed analysis of individual companies' respective strategies to meet the National Program requirements.⁸

Our analysis has focused on the impact of the National Program scenario on the various automakers in terms of sales volume, miles per gallon, revenue and profit in 2015. Overall, the market size would be expected to remain constant.

General Motors

Even as General Motors faced a turbulent 2009, fuel efficiency improvements remained a key priority at the company, and will likely become a critical component of the turnaround at "New GM".

GM is expected to continue to utilize its own international sources for vehicles and powertrains (even if it has less of an ownership stake in Opel), enabling it to increase its volume of small cars and diesel engines, among other products. For example, the Chevrolet Spark (provided by Daewoo in Korea) will be sold in the U.S. In addition, the Chevy Cruze, another vehicle based on a global platform, will reportedly be built in the U.S. and serve as a more fuel efficient replacement to the Cobalt.

Changing the distribution of its products is another key strategy, with production of cars and car-like trucks (generally front wheel drive trucks based on car platforms) increasing at the expense of larger rear wheel drive trucks. These larger vehicles, due to their weight and larger displacement engines, generate lower gas mileage.

GM also has the highest car share of its Detroit 3 competitors. This gives it some advantages as it seeks to increase its fuel economy although it is currently behind the curve on car-based crossovers, a shortcoming it is trying to remedy with products of varying sizes and styles.

While GM has gained generally positive exposure for its forthcoming EV Chevy Volt (which uses hybrid technology in the form of plug in lithium ion batteries), its projected share of hybrid vehicles represents only 3.6% of the industry's total volume in the baseline and 8.8% in the CAFE scenario under our assumptions. The Two Mode Hybrid, another fuel economy-themed offering by GM, will focus on drivers who primarily drive on highways. Diesel penetration increases from 4.6% in the baseline to 7.0% in the CAFE scenario. In order to meet the CAFE requirements by 2015, just over 50% of vehicles not powered by diesels or hybrids will need to be improved. This means that about one-third of GM's fleet will not undergo major improvements in fuel economy. The share of vehicles in this category varies by segment, with lower cost vehicles generally less likely than higher priced vehicles to receive fuel economy improvements (which more cost conscious customers may reject).

As is true with most of its rivals, the most significant gain in mileage will be in internal combustion engines, where a variety of technologies will be utilized. The cost, and return in terms of fuel economy improvement, of these technologies is less than that of the diesel and hybrid vehicles, but given the share of sales with these engines, they are a critical part of the fuel economy improvement equation. GM's share of four cylinder engines in its fleet has increased from 18% in 2007 to 26% in 2008 to over 30% by 2011, with further gains expected in the future.

Ford

Since CEO Alan Mulally's arrival at Ford, the company has championed a "One Ford" approach designed to commonize the product line globally. One impact of that approach has been to significantly expand the small car market in the U.S. and to make diesel technology more available in the U.S. Changes in the auto market have only quickened that plan. The cost of this change in product offerings is immense, but Ford has leveraged its international manufacturing footprint in order to reduce costs. We expect to see average mileage increases of 14% for cars and 17% for trucks.

While Ford is working on a number of fronts and has received attention for its hybrid Escape (one of the first sport utility vehicles with hybrid technology), the Escape is only projected to comprise 5.1% of all hybrid vehicles sold in 2015 and 9.5% in the CAFÉ scenario. Additional vehicles will be incorporating hybrid powertrains soon, including the Fusion and the Edge. Diesel penetration increases from 8.9% in the baseline to 11.3% in the CAFE scenario, although there have been short term delays in adding diesel engines to the F-150 and Expedition. In order to meet the CAFE requirements by 2015, almost 55% of vehicles not powered by diesels or hybrids will be improved. This leaves about one-fourth of Ford's fleet without major improvements in fuel economy. In 2007, 17% of Ford's fleet was powered by four cylinder engines, but we expect Ford to double that share by 2014. Meanwhile, the company's share of V8 offerings should shrink by half in that timeframe.

Ford has recently introduced or upgraded a number of new products in underserved segments. Such products include the Ford Fusion, Edge, Flex, and Lincoln MKS. Ford's new and heightened focus on small cars such as the Ford Fiesta, the updated Ford Focus, and smaller crossovers such as the Ford Transit Connect and EcoSport should continue to improve the position of the company, and reduce its dependence on larger sport utility vehicles and pickup trucks. The EcoBoost engine is another key component of Ford's fuel improvement program, as a smaller engine delivers better fuel economy without sacrificing performance.

The cost and availability of investment funds is a significant issue in the necessary transition process, and the general economic environment in which Ford and the auto industry operate over the next several years will determine how the company does in the medium term.

Chrysler

The last year has been particularly unkind to Chrysler, with its truck-heavy lineup stifling retail sales. Although vehicles like the new crossover Dodge Journey may help tilt the balance away from an industry high truck mix, Chrysler continues to significantly trail the competition in small cars and crossovers. Chrysler will benefit from the soon-to-be-launched V6 Phoenix engine program and its existing I4 engine family. While these new products will help, they are not sufficient to meet the increased CAFE requirements.

The company's recent Chapter 11 filing necessitated a strategic alliance with Fiat, which should provide needed access to fresh vehicle and powertrain products. In fact, without Fiat, Chrysler would stand little chance of complying with tighter fuel economy standards given its truck-centric, fuel-inefficient suite of vehicle offerings. The Fiat link provides potential flexibility in Chrysler's product line, as small cars derived from Fiat's vehicle platforms could be developed. Examples of current Fiat vehicles that could be modified to form the basis of new products include the Fiat 500 (a minicar), Grande Punto (a small hatchback), and Panda Cross (a small crossover).

While Chrysler has used Cummins technology in its pickups for many years, it is behind the curve in the use of alternative powertrain technologies. Before the link with Fiat, its share of volume in hybrid vehicles in 2015 was expected to be only 0.8% of total volume in the baseline and 5.8% in the CAFE scenario. Diesel penetration was to increase from 12.7% in the baseline to 25.1% in the CAFE scenario. And again, in the absence of Fiat, over 40% of vehicles not powered by diesels or hybrids were to be improved. This would have left about one-quarter of Chrysler's fleet where major improvements in fuel economy were not planned. The introduction of Fiat's products and powertrains would dramatically change the nature of Chrysler's product line.

Chrysler recently announced its intention to sell an electric vehicle (either a plug in hybrid or a fully electric vehicle) by 2010. It is important to note that the vehicles shown as prototypes use lithium ion batteries, although that technology is still not ready for regular production. Chrysler's goal is twofold: to have the technology available for consumers and to improve its standing with the public and the financial community. The lack of such technology has hurt its reputation, especially in comparison to its competitors, many of whom are moving forward on a variety of alternative powertrain technologies.

Honda

Honda has been one of the best performers in this current difficult environment. It has benefited from development decisions that have produced vehicles that consumers want to drive backed by a reputation consumers want to own. Additionally, Honda is a market leader in fuel economy in part on its corporate focus on engine technology, which goes beyond vehicles to a variety of products including lawn mowers, power tools, and airplanes. While it has looked into expanding its product line and powertrain options to cover a greater portion of the market, Honda has benefited from not offering products in segments that have recently been poor performers. Average mileage increases by 18% for cars and 17% for trucks.

Honda benefits from a cost perspective because most of its products are based on two platforms, the Civic and the Accord. Each of these provides the base technology for a wide variety of vehicles including sedans, hatchbacks, crossovers, and utility vehicles, as well as vehicles marketed under the Acura brand.

Honda's projected share of volume in hybrid vehicles in 2015 is a relatively high 6.4% of total volume in the baseline (based on a significant increase in these products between now and 2015) and almost 17% in the CAFE scenario. The company recently relaunched the Insight and will likely add a smaller hybrid. Embracing a strategy that values affordability, Honda's hybrids are less expensive than Toyota's, although they deliver somewhat less improvement in fuel economy.

Although a diesel engine for the U.S. has been delayed, our vehicle forecast expects diesel penetration by 2015 to increase from 6.8% (again based on a significant increase in these products between now and 2015) in the baseline to almost 14% in the CAFE scenario. In order to meet the CAFE requirements by 2015, just over 35% of vehicles not powered by diesels or hybrids will be improved. This leaves about one-third of Honda's fleet where major improvements in fuel economy will not be made. We expect that Honda's four cylinder share of its total product line will grow from an already high 56% in 2007 to 68% in 2010 and even more thereafter.

Nissan

Although many of Nissan's products have been updated in the last few years, the company has experienced significant volume declines amid an overall weak U.S. market. Nissan has been known as a design leader, and the Nissan Altima and 370Z are examples of particularly stylish recent launches. Their engines are also highly regarded, particularly in terms of performance, and have average to above average performance with regards to fuel economy.

However, trucks are a different story. Nissan's truck offerings have performed very poorly as of late, and the company expects to eschew these products in favor of more fuel efficient, car-like trucks with front wheel drive transmissions.

Nissan is the leading provider of continuously variable transmissions (CVT), based on product provided by JATCO, a supplier in which it holds a large ownership stake. CVTs generally provide a 5% improvement in fuel economy, compared to standard automatic transmissions. Average mileage increases by 19% for cars and 20% for trucks.

Nissan's share of volume in hybrid vehicles in 2015 is only 0.5% of total volume in the baseline and 9% in the CAFE scenario. Diesel penetration increases from 2.9% in the baseline to 11.0% in the CAFE scenario. In order to meet the CAFE requirements by 2015, just over 50% of vehicles not powered by diesels or hybrids will be improved. This leaves about 30% of Nissan's fleet without planned fuel economy improvements.

While company CEO Carlos Ghosn seemed somewhat skeptical about the value of hybrid and diesel technologies in the past, the company is now working to improve its position with the use of these technologies. The company is also making significant changes in the distribution of its internal combustion engines, from 65% in 2007 to 80% of total sales in 2011, with V8 engines almost non-existent.

Toyota

Toyota has not escaped the current difficulties of the automotive marketplace. While the company's recent struggles have taken many observers by surprise (Toyota should report a loss for FY2009), its growth into a full-line manufacturer, as well as its expanded geographical and manufacturing footprint, has resulted in significant volume and profit declines. Toyota's truck products have performed poorly of late and, as a result, we expect more emphasis on cars and crossovers. The decline in truck production explains, in part, an increased share of I4 engines (52% in 2007 to 63% in 2011) and declines in V8 share from 15% in 2007 to 7% in 2011.

Over the years, Toyota's retail and marketing prowess, especially with regard to fuel economy, has set a high standard for the industry and pushed competitors to improve. The company benefits from a strong capital position and has used this advantage to research and develop a variety of fuel efficient products across its product line. Hybrids are a key pillar of Toyota's fuel economy strategy, and the company expects to offer hybrid versions of all its high-volume products. It currently offers the Prius, Camry Hybrid, Highlander Hybrid, and RX400h and is expected to offer a hybrid Yaris, in part to compete with the Honda Insight.

Due to continuing improvements across automakers, Toyota should lose some of its currently held market advantage. Average mileage increases by 21% for both cars and light trucks. More importantly, the company is looking to reduce the cost of hybrid technology, which should mitigate lost variable profit. To the extent that Toyota is successful, it will not only improve its profit position, but also its market share.

V. Financial Implications of Tougher Regulation

In our analysis, we take into account the altered nature of the marketplace in the last few years, the financial position of the automotive industry, the existing CAFE target, and the alternative national Pavley target (functionally equivalent to the National Program for analytical purposes). We have analyzed the changes compared to the baseline in sales and profits in the U.S. market under two regulatory scenarios: 1) CAFE 2020 – imposing the existing CAFE target of 35 miles per gallon in 2020; and 2) national Pavley – imposing a national Pavley target of 35 miles per gallon in 2016 (again, essentially equivalent to the National Program).

It can be argued that in the past, the Detroit 3 tended to underestimate U.S. consumers' willingness to pay for higher fuel economy or environmental benefits, so a mandated increase in fuel economy is likely to increase retail prices by more than it would increase variable costs. While this point is frequently debated, its tendency is evidenced in the following:

- Consumer references to poor selection (“I can't find the vehicle I want with the fuel economy I need”) increased during the 1970s, peaked in 1980, and did not return to pre-oil shock levels until 2002. These complaints started rising again in 2003 and exceeded the 1980 peak in 2008.⁹
- In recent years, as the real price of gasoline increased, the unit sales of fuel-inefficient SUVs and large cars, which ought to have fallen at the same rate, did not seem to be affected until prices soared to over \$4 per gallon. This was because automakers substantially offset the increase in the resulting present value of fuel costs by reducing prices of fuel-inefficient vehicles. Estimates of the responsiveness of vehicle sales to fuel prices that ignore these vehicle price reductions understate consumer preferences for fuel economy.¹⁰
- Continuing loss of market share by Detroit 3 to competitors with more fuel efficient vehicles.

While the above points indicate that automakers have historically underestimated the value of fuel economy to consumers, we also examined how sensitive our findings are to alternative beliefs about the value consumers put on fuel economy. We estimate the lifetime fuel cost of operating a vehicle as the present discounted value of the expected annual fuel expenses. Our estimates assume a 15-year vehicle life, annual miles of driving that start at 15,000 and decline at 5.2% per year, a 7% real consumer discount rate, and a constant real price of \$3 per gallon of gasoline. In the market demand model, the quantity demanded for each market entry is a function of the effective full prices of all vehicles in the market. The effective price is defined as:

$$\text{Purchase Price} + \phi(\text{Expected Lifetime Fuel Costs})$$

The parameter ϕ measures the relative consumer responsiveness to operating costs compared to capital costs in the purchase decision. A “rational” consumer would have $\phi = 1.0$. Some analysts assume $\phi < 1.0$ based on consumers’ inadequate understanding of risks.¹¹ Recent empirical estimates have found that significant heterogeneity in the parameter exists between consumers: the median $\phi = 1.4$, $\phi > 1$ for 63% of consumers, and $\phi > 5.0$ for 30% of consumers. In the sensitivity analysis we compare our findings under two alternative values of ϕ : 0.70 and 1.0.¹²

The Baseline case reflects automakers’ expected product plan for 2015 without specific efforts to comply with fuel economy requirements. It does include existing plans for alternative powertrains and a change in product mix due to the recent shift in market demand away from trucks and toward cars. However, these plans would neither meet the CAFE 2020 target of 35 miles per gallon as set forth in the EISA, nor the national Pavley standard we assumed (35 mpg in 2016). Thus, the utilization of a variety of additional fuel saving technologies and changes in product mix would be necessary to meet future fuel economy standards.

The increase in fuel economy we simulated was the same in both the CAFE 2020 and the national Pavley scenarios. The difference is in the timing, with the national Pavley scenario achieving the CAFE 2020 target in 2016.

Figure 5 below shows the change in average fuel economy by automaker and vehicle type:

Figure 5. Estimated Average Fuel Economy Savings By Automaker and Vehicle Type

	Cars			Light Trucks			Industry		
	BASE	SCENARIO	CHANGE	BASE	SCENARIO	CHANGE	BASE	SCENARIO	CHANGE
Chrysler	32.0	40.8	27%	23.1	30.4	32%	26.9	35.0	30%
Ford	28.7	38.7	35%	24.1	31.1	29%	25.2	32.8	30%
GM	30.3	40.3	33%	21.9	29.9	37%	24.3	32.9	36%
Honda	30.0	40.0	33%	21.4	29.5	38%	24.4	33.2	36%
Nissan	35.2	40.2	14%	25.5	31.5	24%	31.4	37.0	18%
Toyota	32.1	42.1	31%	24.7	31.7	28%	28.7	37.3	30%
Others	37.0	42.0	14%	25.6	30.6	20%	31.7	36.8	16%
	29.8	40.8	37%	23.2	31.2	34%	27.2	37.0	36%

Source: UMTRI

We simulated the scenarios using a market demand model developed by UMTRI, with a baseline established by The Planning Edge, and cost curves from Meszler Engineering Services.

In addition to the two regulatory scenarios, we analyzed two alternative assumptions about how consumer value of fuel costs compared to vehicle prices and whether the Detroit 3 comply with the standard. An efficient consumer would value expected fuel costs exactly the same as vehicle price: a \$100 increase in expected fuel costs would have the same impact on vehicle demand as a \$100 increase in vehicle price, making the value of $\phi = 1.00$. The alternative assumption is that consumers are less responsive to fuel cost changes ($\phi = 0.70$): a \$100 increase in expected fuel costs would have the impact on vehicle demand as only a \$70 increase in vehicle price. Under a scenario with a National Pavley standard in which consumers fully value fuel savings, variable profit for the Detroit 3 increases by \$3.4 billion, or 9% (as compared to a 3% increase for the Japan 3); and unit sales for the Detroit 3 increase by 8% (as compared to a 2% increase for the Japan 3).

Figure 6. National Pavley (Short Term Multiplier)

Scenario Assumptions:									
100% The share of computed fuel savings that consumers perceive.									
145% Indirect Cost Multiplier (ICM) multiplier to cover indirect costs.									
6% Pure price margin to cover profit.									
30% The overall improvement in MPG.									
	unit sales (000)				variable profit (billions)				
	base	scenario	Change		base	scenario	Change		
			(000)	%			bn	%	
Chrysler LLC	1,592	1,740	148	9%	Chrysler LLC	\$8.1	\$8.9	\$0.8	10%
Ford Motor Co.	2,339	2,528	189	8%	Ford Motor Co.	\$12.1	\$13.2	\$1.1	9%
General Motors	3,345	3,574	229	7%	General Motors	\$19.3	\$20.7	\$1.5	8%
Honda	1,559	1,602	43	3%	Honda	\$8.1	\$8.4	\$0.3	4%
Nissan	1,089	1,131	42	4%	Nissan	\$5.3	\$5.7	\$0.3	6%
Toyota	2,634	2,656	21	1%	Toyota	\$13.6	\$13.8	\$0.1	1%
Others	2,646	2,790	144	5%	Others	\$18.8	\$19.8	\$1.0	5%
Market Total	15,204	16,020	816	5%	Market Total	\$85.3	\$90.5	\$5.2	6%
Detroit 3	7,276	7,842	566	8%	Detroit 3	\$39.5	\$42.8	\$3.4	9%
Japan 3	5,282	5,388	106	2%	Japan 3	\$27.1	\$27.9	\$0.8	3%
Others	2,646	2,790	144	5%	Others	\$18.8	\$19.8	\$1.0	5%

Source: UMTRI

Under a scenario with a National Pavley standard in which consumers only value 70% of fuel savings, the Detroit 3 still realize a gain in variable profit of \$0.9 billion, while vehicle sales decrease by only 2,000, equal to a 0.02% change in unit sales.

Figure 7. National Pavley (Short Run Multiplier) and Lower Consumer Value of Fuel Economy

Scenario Assumptions:
 70% The share of computed fuel savings that consumers perceive.
 145% Indirect Cost Multiplier (ICM) multiplier to cover indirect costs.
 6% Pure price margin to cover profit.
 30% The overall improvement in MPG.

	unit sales (000)					variable profit (billions)			
	base	scenario	Change			base	scenario	Change	
			(000)	%			bn	%	
Chrysler LLC	1,592	1,620	28	2%	Chrysler LLC	\$8.1	\$8.4	\$0.3	3%
Ford Motor Co.	2,339	2,323	(16)	-1%	Ford Motor Co.	\$12.1	\$12.3	\$0.2	2%
General Motors	3,345	3,330	(14)	0%	General Motors	\$19.3	\$19.7	\$0.4	2%
Honda	1,559	1,595	37	2%	Honda	\$8.1	\$8.4	\$0.3	4%
Nissan	1,089	1,056	(33)	-3%	Nissan	\$5.3	\$5.4	\$0.1	1%
Toyota	2,634	2,667	32	1%	Toyota	\$13.6	\$13.9	\$0.3	2%
Others	2,646	2,609	(37)	-1%	Others	\$18.8	\$19.1	\$0.3	2%
Market Total	15,204	15,201	(3)	0%	Market Total	\$85.3	\$87.1	\$1.8	2%
Detroit 3	7,276	7,274	(2)	0%	Detroit 3	\$39.5	\$40.3	\$0.9	2%
Japan 3	5,282	5,318	36	1%	Japan 3	\$27.1	\$27.7	\$0.6	2%
Others	2,646	2,609	(37)	-1%	Others	\$18.8	\$19.1	\$0.3	2%

Source: UMTRI

VI. Appendices

Appendix A. Forecasting CAFE/National Pavley Impacts

A Brief Overview of Corporate Average Fuel Economy (CAFE)

U.S. CAFE standards are defined in terms of the harmonic average fuel economy of vehicles sold by a manufacturer in a given model year, and manufacturers are required to meet the standards for cars and light trucks (with domestic and imported fleets measured separately). Penalties are assessed for fleets that do not meet the standards. Since CAFE's inception in the 1970s, the Detroit 3 have always met CAFE standards, the Japanese 3 have always exceeded CAFE standards, and the European automakers have either met standards or failed to do so (due to their production of high-performance, luxury vehicles). Fines are assessed at a rate of \$5.50 per tenth of a mpg that the manufacturer attained below the CAFE standard, multiplied by the number of vehicles in the affected fleet in a given year. While the CAFE program has some recognized weaknesses – among them the lack of automatic review and adjustment, and the CAFE credit given to producers of “dual-fuel” vehicles whether or not those vehicles actually use the alternative fuel in question (which will be phased out between 2016 and 2020) – it has nonetheless proven to be a viable option for reducing oil consumption in the United States, a topic of increasing priority for a country reliant on oil imports from several politically volatile countries. According to a 2002 National Academy of Science report, CAFE contributed to saving 2.8 million barrels of fuel a day, the equivalent of 14% of consumption in that year, and noted that increases to CAFE standards would contribute to future oil savings – and that the necessary improvements to fuel efficiency could be achieved without large increases in vehicle costs.¹³ Preliminary analysis indicates that the National Program will result in cumulative greenhouse gas reductions of approximately 900 million metric tons (CO2 equivalent) and fuel savings of approximately 1.8 billion barrels of oil.¹⁴

As reformed by NHTSA, both car and light truck CAFE fleets are assigned a target fuel economy level for each vehicle based on a measure of size (footprint, or wheelbase multiplied by track width) and sets a CAFE standard for each automaker based on the weighted (harmonic) average fuel economy targets of its vehicles. A size-based CAFE standard has a number of advantages over the un-reformed system it is replacing. In contrast to the former CAFE system that required improvements only from some automakers, under the proposed standards, all automakers would be required to improve the fuel economy of their vehicle fleets. The size-based system is less biased than legacy CAFE, which penalized full-line manufacturers and rewarded niche (i.e., small vehicle) manufacturers. Under the size-based system, “gaming” CAFE by shifting mix or making vehicles smaller (just to game CAFE) is reduced because changing mix and vehicle size will result in a change in the CAFE standard in the same model year. (It is the function that the automaker faces, not a single number.) An automaker can choose to meet the CAFE standard in a given fleet (cars or trucks) through two avenues: 1) shift its mix to more fuel-efficient vehicles for the same size, and/or 2) apply technologies to improve the fuel economy of specific vehicles.

Methodology and Assumptions

In our quantitative analysis of sales and variable profits we compared two regulatory scenarios: the existing CAFE target in 2020 of 35 miles per gallon and a national Pavley program target in 2016 of 35 miles per gallon. Each alternative standard was applied in a market simulation model developed by UMTRI. The Planning Edge developed the baseline for sales and vehicle attributes by automaker and segment. All the changes we consider in this report were with respect to this baseline. The scenario represents The Planning Edge’s mid-range outlook for the U.S. market in the near future. Cost curves for increasing fuel economy were developed by Meszler Engineering Services. Variable profits increase relative to the base in both scenarios, but the increase is larger for the existing CAFE target in 2020 scenario. The difference is due to our assumption that it costs more to increase fuel economy at a faster pace.

Regulatory standards exert substantial influence on product portfolios and the attributes of products. Our analysis tests this conclusion by addressing the question, “Would *tightening* the standards and/or *speeding* their implementation result in higher or lower profits for the Detroit 3?”

We used a future market simulation to estimate the impacts of higher industry wide fuel economy requirements. Both supply and demand were modeled. We used a baseline “middle” market scenario and examined two fuel economy improvement scenarios: (CAFE 2020 or national Pavley 2016) and its impact on consumer demand and supplier costs and profits. We then conducted an extensive sensitivity analysis to the key parameters in our model.

We began our analysis with a scenario that represents a mid-range outlook for the U.S. market in the near future.

We defined cost and demand at the automaker by segment level. In the analysis, a market entry (the lowest level we modeled) is defined as an aggregate of an automaker’s products in a segment. For example, GM has several Luxury Car products that we aggregated into a composite “GM Luxury Car” market entry. The attributes of the GM Luxury Car market entry are the sales-weighted averages of the products that comprise the market entry (fuel economy is the sales-weighted harmonic average).

The aggregation to automaker by segment market entries is consistent with our market demand and automaker cost information. We are using a price-elasticity demand model that is defined at the automaker by segment level. The own- and cross-price elasticities were originally derived from a segment level elasticity model from General Motors. We estimated the automaker by segment elasticities using a method developed by the Congressional Budget Office. The costs of improving fuel economy, which were provided by Meszler Engineering Services, are defined at the segment level. We applied these segment-level costs to each automaker within the appropriate segment.

Consumer demand is modeled as a set of 75 demand equations – one for each market entry. There are 7 automakers: the Detroit 3, the Japan 3, and an aggregate of all others. With the 15 segments in our model, there are 105 (=15x7) possible market entries, but since an automaker may not offer products in all segments there are 75 actual market entries.

The quantity of entry, m , demanded by consumers is a function of the “effective consumer prices” of all 75 market entries. (The elasticity matrix is 75 x 75.) The effective consumer price for an entry, n , is the retail price of that entry plus the adjusted expected future fuel costs for that entry. The adjustment in expected fuel costs consists is multiplied by ϕ , a measure of the relative consumer response to fuel cost (an operating cost) vs. retail price (a capital cost).

We estimate the expected fuel costs as the discounted present value over the life of the vehicle of the annual future expected fuel costs of operating the vehicle. Along with the fuel economy of entry n , several consumer preference factors determine expected fuel costs. Vehicle Lifetime is the consumer time horizon for the present value calculation. First Year Fuel Price and First Year Miles Driven establish the level of annual fuel costs.

The future fuel costs are brought into present value by applying the Overall Discount Rate, which is defined by consumer behavior and expectations about the Expected Fuel Price Growth, the Rate of Change in Miles per Year, and the (real) Consumer Discount Rate. Expected annual vehicle miles generally fall as a vehicle ages based on two considerations. Not all vehicles survive from one year to the next, and a declining fraction of vehicles of a given vintage remain in use as they age. There is also evidence from the National Household Travel Survey that older vehicles are driven fewer miles.

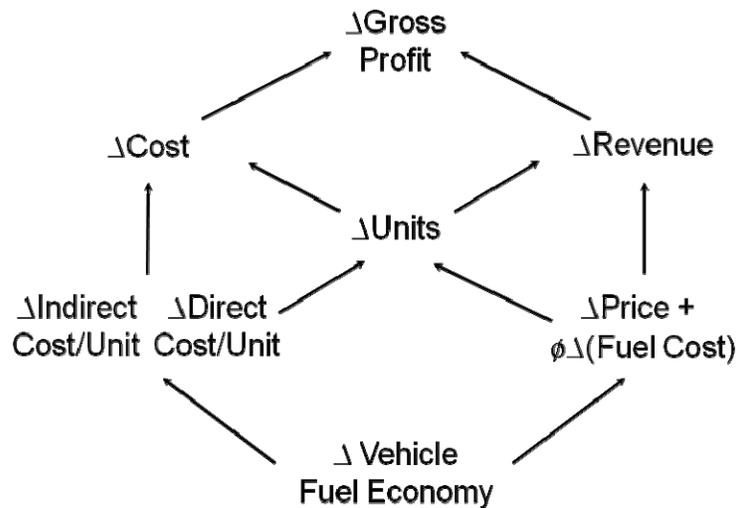
We developed a model of product cost to estimate the impact of improving vehicle fuel economy on OEM and Dealership cost and retail price. Our estimates of the impact of a given industry-wide percentage increase in fuel economy on product cost and profit assume that each market entry is improved by the same percentage. This significantly eases the model’s computational burden, and does not materially influence our directional findings. Our analysis focuses on the impact of alternative scenarios on the gross profits of the Detroit 3. If they can meet an industry-wide increase in fuel economy by applying different rates of improvement by segment, then they would be able to increase profits (reduce losses) above what results from the assumed uniform improvement rate. Thus our (gross) profit impacts are understated.

The OEM Product Cost model distinguishes between Direct and Indirect Costs. We received estimates of the direct cost of improving fuel economy from Meszler Engineering Services. Direct cost = Direct Labor + Direct Materials. We assumed that an improvement in fuel economy also increases some Indirect Cost items including, Warranty & Freight, Factory Overhead (mainly Engineering in Indirect Labor and Depreciation, Maintenance, and Other). We measured the Indirect Cost increase by multiplying Direct cost by an Indirect Cost Ratio (assumed to be identical for all automakers).

The Dealership New Vehicle Cost model also distinguishes between Direct and Indirect Costs. From the vertical perspective of the enterprise (the OEM and its dealerships), dealership costs are all indirect. We incorporate dealership costs that change when technologies are used to improve fuel economy into our measure of Enterprise Indirect Cost. These may include Direct Cost Dealership-Installed Options, Dealership Overhead, and Other Indirect Costs.

Figure 8. Matrix of Operating Impacts on OEM and Dealership Business Models from Fuel Economy

An industry-wide increase in vehicle fuel economy has impacts on OEMs' and dealerships' product costs, on product prices, and on consumers' willingness to pay for vehicles—leading to changes in profits.



Source: UMTRI

We combined each automaker and its dealerships for an enterprise view of costs, sales, revenue, and profits. An industry-wide increase in fuel economy increases the cost per vehicle. Direct Costs changes include OEM direct labor and materials costs of new components that raise the cost of manufacturing. Indirect Cost changes include other changes in OEM costs that vary with output (warranty and freight, if affected by new technologies); and some OEM costs that do not vary with production, but cover the costs of changing the vehicle or the manufacturing process: OEM engineering expense and OEM factory overhead. Indirect costs also include dealership costs that are changed to deal with selling and servicing new technologies.

Vertical View of Enterprise (Automaker and Its Dealerships)

Change in Cost = (1 + Indirect Cost Multiplier) x (change in Direct Cost)

Change in Price = (1 + ICM + Gross Profit Rate) x (change in Direct Cost)

Consumers

Change in Full Price = Change in Price + ϕ (Change in Fuel Cost)

The prices and full prices of all market entries are changed by the industry-wide improvement in fuel economy. The impact on sales on vehicles by automaker and segment is predicted by applying the elasticity matrix to the changes in full prices.

Change in Gross Profit = Change in Revenue - Change in Variable Cost

Our estimates of the impact on Direct Cost of a percentage increase in fuel economy were computed using information provided by Meszler Engineering Services. We defined cost curves for each segment that predict the change in Direct Cost as a quadratic function of the percentage change in fuel economy.

$$\Delta DC = A(\Delta E/E) + B(\Delta E/E)^2$$

In the sensitivity analysis, we treat uncertainty in the change in cost through an uncertain multiplicative factor that scales the change in direct costs to be higher or lower than the prediction from the curves.

Using the True WTP (assuming consumers respond the same to fuel cost as to retail price) the net gain to consumers is the area A. Automakers can raise prices and increase Gross Profits.

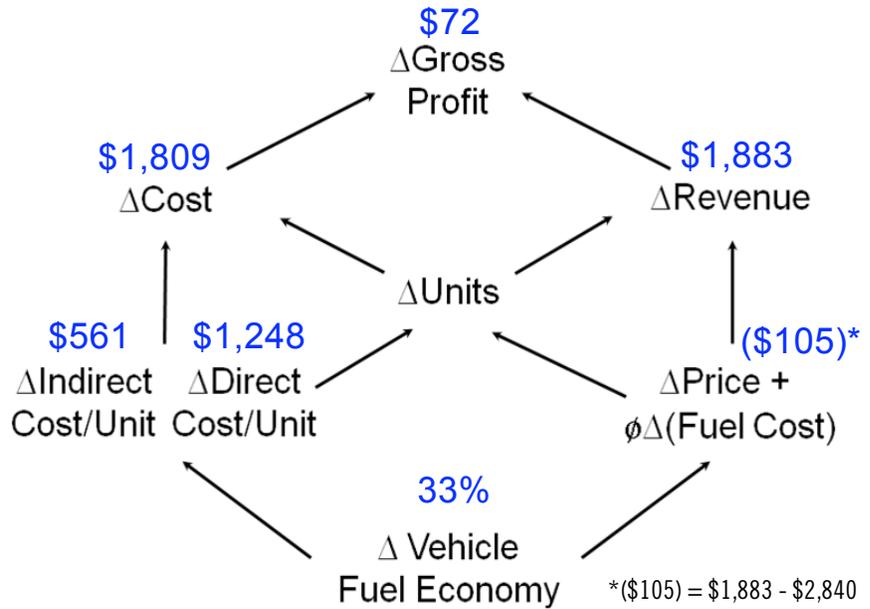
Industry average fuel economy is 26.9 mpg in the baseline mid-level future-market scenario. Gross profits are estimated for the automakers and their dealerships combined at \$85.3 billion for the industry. Vehicle unit sales are 15.204 million, reflecting The Planning Edge's expectation of a recovery from current sales that are running below 10 million on an annual basis.

Appendix B. Calculating the Economic Impact to OEMs (A Representative Example of Appendix A)

An increase in vehicle fuel economy has impacts on product costs, on product prices, and on consumers' willingness to pay for vehicles—leading to changes in profits. The diagram in Figure 9 is a schematic of the model we used to estimate profit impacts. We use two symbols that need to be defined. Delta, Δ , is used to indicate the change in the variable to which it is applied (for example, Δ Cost is the change in a vehicle's cost associated with an increase in its fuel economy). Phi, ϕ , measures the relative responsiveness of consumers to operating costs compared to capita costs. For a given change in fuel economy, the consumer response would be larger with a higher ϕ than it would be with a lower ϕ .

The following example is for the aggregate GM luxury car, and traces the impacts of a 33% increase in fuel economy through the paths shown in Figure 9. The dollar terms shown are per vehicle, so we do not show the change in units.

Figure 9. CAFE Economic Impacts -- GM Luxury Car Unit (An Example of the Calculation)



Source: UMTRI

- A 33% increase in the fuel economy of GM luxury cars would add \$1,248 in direct costs per vehicle.
- Indirect costs would add \$561 (45 percent of direct costs).
- The change in total cost would be \$1,809 (= \$561 + \$1,248).
- A 33% increase in fuel economy would save consumers \$4,057 (present value over the life of the vehicle), but in this example $\phi = 0.7$, so the perceived savings are \$2,840.
- We assume a 6% margin on the incremental costs, which would increase the price to consumers by \$1,883.
- The change in full price (capital plus fuel operating cost to the consumer) would fall \$105.
- Average revenue per vehicle is the same as the price to the consumer, \$1,883.
- Profit of \$74 per vehicle is the difference between \$1,883 and \$1,809.

Appendix C. Costs and Fuel Economy Impacts of Various Fuel Efficiency Technologies

As stated above, Meszler Engineering Services (MES) undertook a limited meta analysis to estimate the fuel economy and cost impacts of various vehicle efficiency technologies. While MES undertook this analysis for both individual technologies and selected packages of technologies, only the technology package estimates were used to evaluate industry impacts. This technology package approach was employed in recognition of the fact that many technologies target the same inefficiencies, so their combined application results in a lesser efficiency improvement than would be expected were their individual impacts simply summed. The evaluated technology packages were selected to cover a broad range of fuel economy impacts, basically ranging from modest (~10%) improvements due to conventional engine technology advances to large (>100%) improvements due to advanced technologies such as diesel hybrid electric vehicle technology, with associated reductions in vehicle mass and drag.

Specific studies or information sources included in the meta analysis include the National Highway Traffic Safety Administration's 2008 CAFE (Corporate Average Fuel Economy) proposal and related support documents,¹⁵ a 2004 report on greenhouse gas reduction technology from the Northeast States Center for a Clean Air Future,¹⁶ the 2008 version of the Energy Information Administration's NEMS (National Energy Modeling System) Transportation Demand Module (which is used to support their Annual Energy Outlook forecast series)¹⁷, the National Academy of Science's 2002 CAFE review¹⁸, and numerous articles in automotive trade publications such as Automotive News and Automotive Engineering International. By definition, the impact estimates reflect a compendium of work performed by others, but it is important to recognize that the references utilized are generally considered to be "middle of the road" sources, reflecting neither inordinate optimism nor inordinate pessimism.

Generally, the technology packages included in the analysis were intended to reflect the lowest cost technologies available to support a broad range of fuel economy improvements. Moreover, these packages generally reflect technologies that are or will be market ready within the next few vehicle model years. Technologies such as fuel cells and hydrogen internal combustion engines that either require further development or supporting (e.g., refueling) infrastructure establishment before being viable on a high volume basis are not considered, as the driver of this study is technology that can support CAFE compliance through the 2016 timeframe. Due to differences in costs (and, in some cases, cost savings) for engines of different sizes, the data were analyzed in terms of 4, 6, and 8 cylinder engines individually.

The specific technologies considered include:

Variable valve timing (or cam phasing)

Valves are used to allow air and exhaust gases to respectively enter (intake valves) and exit (exhaust valves) the combustion chambers (cylinders) of the internal combustion engines that currently power the vehicle fleet. Traditional valve opening and closing is controlled by fixed cams located on one or more camshafts that are driven by the rotation of the engine crankshaft, limiting the ability to tailor either intake or exhaust performance to specific engine operating conditions. Variable valve timing technology allows the timing of intake and/or exhaust valve openings to vary in accordance with engine speed and load. This allows for improved breathing (intake air and exhaust gas movement) and more efficient combustion.

Variable valve lift

Variable valve lift is an adjunct to variable valve timing technology, which allows valve opening height (and duration) to also vary with engine speed and load. This further improves breathing and combustion efficiency.

Camless valve actuation

Camless valve actuation allows for valve functionality that is fully independent of crankshaft and/or cam operation. Electromechanical actuators allow valve operation to be continuously varied in accordance with engine speed and load, so that breathing and combustion efficiency can be optimized. In addition, the elimination of mechanical camshafts and actuators reduces engine load and friction. Camless valve actuation is not included in the technology packages evaluated for this analysis due to current costs that outweigh the additional efficiency potential relative to less expensive variable valve timing and lift systems.

Cylinder deactivation

Cylinder deactivation technology effectively “shuts off” engine cylinders under operating conditions where their output is not necessary for performance purposes. This essentially creates a smaller displacement engine that operates closer to its optimum efficiency speed and load conditions. When the smaller displacement configuration is not adequate for demanded performance, the deactivated cylinders are “turned back on” and the performance capacity of the larger displacement engine is restored. For this analysis, it is assumed that cylinder deactivation technology can be effectively applied to engines of 6 or more cylinders, but that 4 cylinder engines are not viable technology candidates.

Turbocharging

Turbocharger technology utilizes some of the energy that leaves engine cylinders in the form of exhaust heat to drive a compressor in the engine air intake manifold. This compressor increases the quantity of air delivered to the combustion chambers, and this increased charge density allows for greater engine power (than would be delivered by the same size non turbocharged, or naturally aspirated, engine). This higher specific power allows for a smaller (and more efficient) engine to be used for a given level of performance. For certain engines (DOHC V6 and V8 engines), the cost savings associated with engine downsizing can offset the incremental cost of the turbocharger. However, the savings are reduced if 2 valves per cylinder OHV engines are simultaneously converted to 4 valves per cylinder DOHC configurations. For this analysis, it is assumed that there is no significant cost savings associated with downsizing a 4 cylinder engine (as the downsized engine will retain all cylinders, valves, camshafts, etc.).

Gasoline direct injection

“Conventional” gasoline engine fueling is accomplished through relatively low pressure fuel injection outside (at the air intake ports) of the engine cylinders. This currently conventional multiport fuel injection technology allows for significantly enhanced fueling (and efficiency gains) relative to the predecessor carburetion technology, but even greater advantages can be attained through higher pressure fuel injection directly into the engine cylinders. This so called gasoline direct injection (GDI) technology allows for much more precise fuel

control, higher compression, increased EGR, and stratified lean burn (more air/less fuel per unit of power than conventional non stratified combustion) under certain operating conditions. For this analysis, it is assumed that stratified operations would occur at relatively light load operation and that additional exhaust gas aftertreatment costs would be incurred to adequately control altered emissions characteristics (relative to non stratified systems).

Direct injection diesel engines

Direct injection diesel engine technology is well established and offers considerable efficiency benefits relative to current gasoline engines, primarily through high compression throttle less lean burn combustion characteristics. About one half of all vehicles currently sold in the EU are diesel powered, but more stringent emissions requirements as well as continuing stigmas of noise, soot, etc. and a higher fuel price must be overcome in the U.S. market. The cost impacts assumed in this analysis include both downsizing credits for 6 and 8 cylinder engines and additional exhaust aftertreatment costs for all diesel applications.

Transmission technology

Increasing the number of steps between the lowest and highest transmission gear ratios allows the engine to operate in the region of greatest efficiency more often. For this reason, significant movement from four speed toward five and six speed automatic transmissions is already underway, and seven and eight speed automatic transmissions have entered the market. Continuously variable transmission (CVT) technology, which provides an essentially "infinite" range of gear ratios, allows the engine to operate in the region of greatest efficiency most often. Historically, torque limitations have hindered the widespread application of CVT technology, but improved technology has extended potential application to most light duty vehicles.

12 volt idle off technology

Considerable fuel energy is used during engine idle operations in typical urban driving environments. Turning the engine off during these operations would improve the overall driving cycle average fuel efficiency of the vehicle. A 12 volt belt driven alternator/starter (BAS) system can offer a relatively simple solution, allowing automatic engine shutdown and automatic, fast, and reliable restart (upon brake release). For this analysis, it is assumed that BAS systems are not sufficiently able to control larger 6 and 8 cylinder engines, but are reliably able to control engine off at idle operations for 4 cylinder engines.

42 volt integrated starter/generator (ISG)

A step up from the 12 volt BAS, the 42 volt ISG is a small, high performance electric motor that is either integrated into the driveline of a vehicle (generally referred to as a flywheel alternator/starter or FAS) or belt driven like the 12 volt BAS. Like the 12 volt BAS, the technology allows the vehicle engine to be turned off at idle and instantaneously restarted (both automatically) and accessories to be powered electrically during the engine off period. However, the higher system voltage also allows for regenerative braking (where braking energy is captured and stored for later use) and a modest level of launch assist (where electrical energy is used to supplement internal combustion engine performance). Sometimes termed a "mild hybrid" as a result of these features, the 42 volt ISG system is capable of controlling all light duty engines. The

costs estimated for this analysis include an associated electrical system upgrade.

Improved aerodynamics

In urban driving, 20-30% of motive energy is expended in overcoming air resistance, 50-65% at highway speeds. More streamlined designs that allow for less turbulent airflow reduces fuel use.

Reduced rolling resistance

30-40% of motive force is expended overcoming the resistive torque of tires. Improved tire designs (and reduced vehicle weight) can reduce this force, but tradeoffs in traction, etc. are limiting.

Reduced vehicle weight

Vehicle weight affects both the force required to overcome rolling resistance and the force required to induce a given motion. Generally, each 10% weight reduction reduces fuel use by about 8%. The efficiency advantages of weight reduction must, however, be considered in conjunction with possible safety concerns.

Advanced power steering

Electric and electrohydraulic power steering systems offer improved efficiency over conventional hydraulic systems. Conventional hydraulic power steering systems rely on a pump that is connected to the engine via a belt, and this pump places a continuous load on the engine. Conversely, the electric and electrohydraulic power steering systems are operated electronically on an as needed basis, resulting in improved engine efficiency through the elimination of the continuous load otherwise placed on the engine by a conventional power steering pump.

Electric hybrid powertrains

Three hybrid electric designs were evaluated as part of the technology packages included in this analysis. Since hybridization facilitates several complementary technologies, simple hybridization of the engine was not evaluated in isolation. Instead, three hybrid package designs were included: a Honda like parallel hybrid package, a Toyota like dual mode (series/parallel) hybrid package, and a diesel version of the Toyota like package. Each package includes the basic engine hybridization, which allows for the recapture of braking energy (regenerative braking), engine off at idle capability, and electric launch assist (thereby allowing the combustion engine to be downsized). The Toyota like design also offers limited electric only drive capability. In addition to this basic hybridization, the packages also include other features typically associated with the Honda and Toyota designs. The Honda like package assumes a 2.5% mass reduction, a 22% drag improvement, VVT, a CVT transmission, electric accessories, and electric power steering. The Toyota like packages assume Atkinson cycle combustion (in the gasoline version), a 15% mass reduction, a 7% drag improvement, VVT, an electronic CVT transmission, electric accessories, and electric power steering. More advanced hybrid designs (e.g., plug in hybrids), electric only designs, or fuel cell vehicles were not evaluated in this analysis due to the focus on 2016 CAFE compliance.

Figure 10 presents a list of the individual technologies evaluated, along with their respective fuel economy and cost impacts, while Figure 11 presents similar impacts for the selected technology packages.

Figure 10. Vehicle Technologies with Associated Fuel Savings and Cost Impacts

Fuel Economy Technology	Change in mpg	Cost Basis	Cost to Vehicle Manufacturer for:		
			DOHC L4	DOHC V6	OHV V8
VVT (variable valve timing, cam phasing)	3%	Dual coupled, with EGR credit	\$25	\$90	\$90
VVL (variable valve lift)	2%	Discrete lift technology	\$75	\$115	\$150
VVT+VVL	5%		\$100	\$205	\$240
CVA (camless valve actuation)	8%		\$340	\$565	\$720
Cylinder Deactivation (1/2 of cylinders deactivate)	5%	Independent system	n/a	\$115	\$150
		If combined with VVL	n/a	\$200	\$260
Turbocharging (with downsizing)	10%	Turbocharger system cost	\$400	\$400	\$400
		Downsizing credit, V8 to DOHC	\$0	(\$700)	\$100
		Net cost	\$400	(\$300)	\$500
Gasoline Direct Injection (stratified at light loads)	10%	Engine cost	\$135	\$185	\$210
		Aftertreatment cost	\$215	\$275	\$330
		Net cost	\$350	\$460	\$540
Diesel Direct Injection (relative to MPFI gasoline)	35%	Engine cost (V6 to L4, V8 to L6)	\$1,000	\$300	\$950
		Aftertreatment cost	\$500	\$600	\$1,000
		Net cost	\$1,500	\$900	\$1,950
12V Idle Off	8%		\$200	n/a	n/a
42V ISG - Idle Off/Regen Braking/Launch Assist	10%	Technology cost	\$300	\$300	\$350
		Electrical system upgrade	\$100	\$100	\$100
		Net cost	\$400	\$400	\$450
Mass Reduction (per % reduction in mass)	0.80%	Per pound reduced	\$1	\$1	\$1
Drag Reduction (per % change in drag)	0.20%	Per percent change in drag	\$5	\$5	\$5
Lower Rolling Resistance (per % change in RR)	0.20%	Per percent change in RR	\$4	\$4	\$4
Electric Power Steering	1%		\$20	\$40	\$40
Transmission Transition from:					
4 Speed Automatic to 6 Speed Automatic	5%		\$50	\$75	\$80
4 Speed Automatic to 7 Speed Automatic	6.50%		\$75	\$110	\$120
4 Speed Automatic to 8 Speed Automatic	8%		\$110	\$160	\$170
5 Speed Automatic to 6 Speed Automatic	3%		\$20	\$25	\$20
5 Speed Automatic to 7 Speed Automatic	4.50%		\$45	\$60	\$60
5 Speed Automatic to 8 Speed Automatic	6%		\$80	\$110	\$110
6 Speed Automatic to 7 Speed Automatic	1.50%		\$25	\$35	\$40
6 Speed Automatic to 8 Speed Automatic	3%		\$60	\$85	\$90
4 Speed Automatic to CVT	10%		\$150	\$175	\$200
5 Speed Automatic to CVT	8%		\$120	\$125	\$140
6 Speed Automatic to CVT	5%		\$100	\$100	\$120

mpg = miles per gallon, DOHC = dual overhead cam engine, OHV = overhead valve engine, EGR = exhaust gas recirculation

MPFI = multiport fuel injection, ISG = integrated starter/generator, Regen = regenerative, RR = rolling resistance

CVT = continuously variable transmission

Source: Meszler Engineering Services

Figure 11. Fuel Economy Impact and Cost of Technology Packages

Technology Package	Change in mpg	Cost to Vehicle Manufacturer for:		
		DOHC L4	DOHC V6	OHV V8
		With a Base Weight of:		
		2800 lbs	3500 lbs	4800 lbs
VVTL + A4-to-A6 + EPS	9%	\$170	\$320	\$360
with 5% Mass Reduction	13%	\$310	\$495	\$600
VVTL + Cylinder Deactivation + A4-to-A6 + EPS	14%	n/a	\$405	\$470
with 5% Mass Reduction	19%	n/a	\$580	\$710
VVT + Turbocharging + A4-to-A6 + EPS	15%	\$495	\$60	\$60
with 5% Mass Reduction	20%	\$635	\$235	\$300
VVT + Turbocharging + GDI + A4-to-A6 + EPS	27%	\$845	\$365	\$1,250
with 5% Mass Reduction	32%	\$985	\$540	\$1,490
VVT + Turbocharging + GDI + ISG + A4-to-A6 + EPS	39%	\$1,045	\$765	\$1,700
with 5% Mass Reduction	45%	\$1,185	\$940	\$1,940
VVTL + Cylinder Deactivation + ISG + A4-to-A6 + EPS	25%	n/a	\$805	\$920
with 5% Mass Reduction	30%	n/a	\$980	\$1,160
VVTL + Cylinder Deactivation + GDI + ISG + A4-to-A6 + EPS	34%	n/a	\$1,265	\$1,460
with 5% Mass Reduction	39%	n/a	\$1,440	\$1,700
Diesel Direct Injection	35%	\$1,500	\$900	\$1,950
with 5% Mass Reduction	40%	\$1,640	\$1,075	\$2,190
Moderate (Honda-Style) Gasoline Hybrid Package				
Package includes engine hybridization plus 2.5% mass reduction, 22% drag improvement, VVTL, CVT, electric accessories, and EPS.	50%	\$2,000	\$2,000	\$2,500
Advanced (Toyota-Style) Gasoline Hybrid Package				
Package includes hybridization, Atkinson cycle combustion, 15% mass reduction, 7% drag improvement, VVT, e-CVT, electric accessories, & EPS.	80%	\$4,000	\$4,000	\$5,300
Advanced Diesel Hybrid Package				
Package includes engine hybridization, 15% mass reduction, 7% drag improvement, VVT, e?CVT, electric accessories, and EPS.	125%	\$5,400	\$5,400	\$7,500

All impacts are relative to a gasoline multiport fuel injected, 4 speed automatic transmission base technology
 mpg = miles per gallon, DOHC = dual overhead cam engine, OHV = overhead valve engine, VVTL = variable valve timing and lift
 VVT = variable valve timing, A4 = 4 speed automatic transmission, A6 = 6 speed automatic transmission, EPS = electric power steering
 GDI = gasoline direct injection, ISG = integrated starter/generator, MPFI = multiport fuel injection
 CVT = continuously variable transmission, e CVT = electronic CVT

Source: Meszler Engineering Services

As indicated in Figure 11, the evaluated technology packages are estimated to be capable of increasing CAFE fuel economy by as much as 125%.

Notes

1. Since regulations implementing the National Program have not yet been developed, it is not possible to state with certainty exactly what the program will entail. While public statements reflect the standards cited herein, actual standards are expected to be established independently for passenger cars and light trucks so that effective fleet average standards are dependent on the proper design of these component standards for a given fleet mix.
2. See 74 Fed. Reg. 186, 49454.
3. Published on Mar. 6, 2008, in the Federal Register.
4. See 73 Fed. Reg. 24,352.
5. These allowances are estimated to be worth \$12-\$17 billion. "UAW Endorses House Democrats climate Change bill," May 18, 2009, Detroit News.
6. Note that the discontinuity in each of the CAFE cost curves results from the differential relationship between CAFE and in use fuel economy for non hybrid and hybrid vehicles. The curves would be continuous if graphed in terms of in use fuel economy. In effect, the discontinuities reflect the point at which significant hybrid penetration becomes necessary for CAFE compliance.
7. It is important to note that the figures and estimates presented in this section are independent of the larger industry analysis discussed in this report. The cost estimates provided for the larger industry analysis are expressed in terms of incremental costs to the vehicle manufacturer (as stated in Tables Q1 and Q2), and all associated manufacturer markups are introduced as a component of the larger industry analysis. For the limited estimates presented in this section, a simple markup factor of 1.5 has been employed to estimate retail pricing impacts. This value is consistent with the value employed by NHTSA in recent CAFE rulemakings. Additional economic assumptions employed in the limited analysis presented in this section are as follows: vehicle lifetime = 12 years/150,000 miles, annual mileage decline = 4.5 percent, annual discount factor = 8 percent (for 12 years of fuel savings, this equates to a lifetime economic discount multiplier of 0.707), composite in use fuel economy (relative to CAFE) = 0.75 for non hybrids and 0.70 for hybrids (based on average data from a 2007 fuel economy database prepared by the U.S. Department of Energy and a U.S. Environmental Protection Agency in support of fuel economy labeling revisions), and fuel economy improvements of 50 percent or more require hybrid technology. Furthermore, the economic analysis assumes a societal viewpoint, in that fuel savings are valued over the full lifetime of the vehicle (albeit on a discounted basis).
8. Please note that this section regarding specific impacts on automakers only examines the impact of the CAFE scenario on the domestic performance of the various manufacturers. Their overall performance is, of course, based on their global results, which, depending on the automaker, will have a varying impact on their overall results. It should also be understood that our analysis focuses on the impact of

CAFE on company revenue and earnings and does not include the change in product mix that is already underway due to non-CAFE influences. Changes in response to CAFE will include a further change in product mix (which is included in our model used to generate the results in this report) as well as changes in powertrain technology and mix that are necessary to meet the requirements.

Our baseline forecast already includes significant changes in product mix and powertrain technology, but the CAFE requirements require further steps (particularly with respect to powertrain changes). This report only focuses on the direct impact of the CAFE regulations and does not include other factors such as quality, marketing, corporate reputation, and other characteristics of the companies' product lines which also affect market share. Finally, these results only consider the effects of fuel economy requirements through MY2016. Additional improvements will be necessary through 2020 to meet the more stringent fuel economy requirements through the period 2017-2020.

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13. http://books.nap.edu/openbook.php?record_id=10172&page=R1
14. Statement of Secretary of Transportation Ray LaHood before the Committee on Environment and Public Works at the hearing on Transportation's Role in Climate Change and Greenhouse Gases
15. U.S. Department of Transportation, National Highway Traffic Safety Administration, "Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011–2015," Notice of Proposed Rulemaking, *Federal Register*, Volume 73, Number 86, Page 24352, May 2, 2008.

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17. U.S. Department of Energy, Energy Information Administration, DOE/EIA 0554(2008), "Assumptions to the Annual Energy Outlook 2008, Transportation Demand Module," June 2008.
18. National Academy of Sciences, National Research Council, "Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards," National Academy Press, Washington, D.C., 2002.

BorgWarner Inc.

(BWA.N; US\$32.29; 1H)

Valuation

Our \$36 target price for BorgWarner shares is based on the average of our sum of the parts EV-to-EBITDA valuation, P/E analysis, and discounted cash flow model, consistent with our central point of tendency methodology (i.e. averaging) for the supplier group.

Our sum of parts analysis individually values BorgWarner's higher margin Engine Group and the smaller Drivetrain segment. Our blended EV-to-EBITDA multiple came out at 7x, in line with the company's median multiple over the past five years. (The company's EV-to-EBITDA multiple ranged from 4x to 10x and averaged 7x over the last five years.) In our debt calculation, we utilized 2010E net debt and included the underfunded pension. Our sum of parts analysis drives a total company (i.e. including Beru) EV-to-EBITDA multiple of 7x. Our sum of parts analysis yielded a value of \$35.

We apply a P/E multiple of 16x to our 2010 EPS estimate to arrive at a price of \$32. We view our P/E multiple as appropriate, as it is in line with that of investment grade peers including JCI. (The company's P/E multiple ranged from 8x to 24x and averaged 14x over the past five years.)

Our adjusted discounted cash flow (DCF) model yields a value of \$40. Within the framework of our DCF model, we assume revenue growth of 5% slightly below BorgWarner's implied three-year backlog growth rate of 10%+. Our operating margin expectation of 8.5% falls in line with the company's historic margins. We discount unleveraged free cash flow at an industry cost of capital of 8% and the company's weighted average cost of capital of 8.2%. We value BorgWarner's unleveraged free cash flow at an industry cost of capital to determine the value of the unlevered asset, as well as the weighted average cost of capital to estimate the value of the firm. Consistent with our treatment for auto suppliers with exposure to long-term penetration of non-conventional propulsion systems (i.e. hydrogen fuel cells, electric, and other technologies), we assume a negative 2% growth rate in our terminal value calculation.

Risks

We rate BorgWarner shares High Risk based on the company's market capitalization, earnings history, price volatility, and customer concentration. The primary driver of our risk rating is the potential for a bankruptcy at one or more of the company's Detroit 3 customers and the impact this may have on the company, potentially including precipitous production declines from lost volume at bankrupt customers and disruptions within the distressed supply chain resulting in cash outflows, impairment of customer receivables, and the need to financially support sub suppliers. We note that the company only has 12% revenue exposure to the Detroit 3 in North America and near 20% globally, and thus we place a High Risk rating instead of Speculative one. Other risks to the stock achieving our target price include execution risk of launching new business, production cyclicality, raw materials prices, and labor relations.

Johnson Controls Inc

(JCI.N; US\$27.13; 2H)

Valuation

Our \$24 target price for JCI is based on the average of our sum-of-the-parts EV-to-EBITDA valuation, P/E analysis, and discounted cash flow model.

We apply an EV-to-EBITDA multiple of 6x to our F2011 EBITDA estimate to arrive at a target price of \$24. We derive our multiple through sum-of-the-parts EV-to-EBITDA analysis. We use a multiple in line with covered suppliers for the Automotive Experience segment, who are competitors to Johnson Controls' Automotive Experience business with comparable size and operating performance. We assess a 30% premium to the automotive aftermarket group (including ATAC, AZO, GPC, and SMP) to value the Power Solutions segment due to the segment's superior margins. We use EMR, HON, and UTX as comparables for the Building Efficiency business, as they compete in similar business lines with comparable financial profiles. (The company's EV-to-EBITDA multiple ranged from 5x to 12x and averaged 8x over the last five years.)

We apply a P/E multiple of 11x to our F2011E EPS to derive a target of \$24. We view our P/E multiple of 11x as appropriate, as we use sum of parts analysis similar to our EV-to-EBITDA analysis (including comparables) for deriving our P/E target. (JCI's five-year P/E multiple ranged from 9x to 21x and averaged 15x.)

Our adjusted DCF model yields a value of \$23. Within the framework of our DCF model, we assume revenue growth of 5%. Our operating margin expectation of 5.5% falls in line with our F2011 expectations for the company. We discount free cash flow at a weighted average cost of capital of 10%. We value JCI's unleveraged free cash flow at an industry cost of capital to determine the value of the unlevered asset, as well as the weighted average cost of capital to estimate the value of the firm. We use no-growth in calculating terminal value for the shares, consistent with our methodology for automotive suppliers.

Risks

We rate Johnson Controls High Risk based on the company's market capitalization, earnings history, price volatility, and customer concentration. The primary driver of our risk rating is the potential for a bankruptcy at one or more of the company's Detroit 3 customers and the impact this may have on the company, potentially including precipitous production declines from lost volume at bankrupt customers and disruptions within the distressed supply chain resulting in cash outflows, impairment of customer receivables, and the need to financially support sub suppliers. Other risks to the shares exceeding or falling below our target price include a volatile production environment, execution risk of launching new programs, restructuring execution, raw material prices, and labor relations.

Appendix A-1

Analyst Certification

Each research analyst(s) principally responsible for the preparation and content of all or any identified portion of this research report hereby certifies that, with respect to each issuer or security or any identified portion of the report with respect to an issuer or security that the research analyst covers in this research report, all of the views expressed in this research report accurately reflect their personal views about those issuer(s) or securities. Each research analyst(s) also certify that no part of their compensation was, is, or will be, directly or indirectly, related to the specific recommendation(s) or view(s) expressed by that research analyst in this research report.

IMPORTANT DISCLOSURES

Borg Warner Inc (BWA) Ratings and Target Price History Fundamental Research

Analyst: Itay Michaeli
Covered since September 14 2007



Chart current as of 10 October 2009

Date	Rating	Target Price	Closing Price
1 29-Oct-06	1M	*\$34.50	29.13
2 12-Dec-06	1M	*\$35.50	28.82
3 8-Feb-07	1M	*\$43.50	37.20
4 1-Jul-07	1M	*\$49.50	43.02
5 26-Jul-07	1M	*\$50.00	43.10

Date	Rating	Target Price	Closing Price
6 12-Sep-07	1M	*\$48.50	41.60
7 25-Oct-07	1M	*\$54.50	47.33
8 2-May-08	1M	*\$58.00	51.48
9 1-Jul-08	1M	*\$57.00	45.09
10 18-Sep-08	1M	*\$49.00	36.79

Date	Rating	Target Price	Closing Price
11 7-Oct-08	1M	*\$46.00	26.50
12 29-Oct-08	1M	*\$32.00	22.26
13 11-Dec-08	1M	*\$27.50	22.38
14 15-Dec-08	*1H	*\$27.00	20.56
15 19-May-09	1H	*\$36.00	29.82

* Indicates change

Rating/target price changes above reflect Eastern Standard Time

Johnson Controls Inc (JCI) Ratings and Target Price History Fundamental Research

Analyst: Itay Michaeli
Covered since September 14 2007



Chart current as of 10 October 2009

Date	Rating	Target Price	Closing Price
1 11-Dec-06	1M	*\$32.33	28.04
2 1-Mar-07	1M	*\$36.33	31.56
3 2-Apr-07	1M	*\$36.67	31.77
4 22-Apr-07	1M	*\$38.67	34.12
5 27-Jun-07	1M	*\$43.67	38.63
6 12-Sep-07	*2M	*\$38.67	35.78
7 3-Oct-07	2M	*\$39.00	39.24

Date	Rating	Target Price	Closing Price
8 23-Oct-07	2M	*\$40.00	40.24
9 26-May-08	2M	*\$36.00	33.20
10 1-Jul-08	2M	*\$32.00	29.18
11 7-Oct-08	2M	*\$28.00	24.99
12 15-Oct-08	2M	*\$24.00	20.60
13 24-Oct-08	2M	*\$18.00	16.31
14 15-Dec-08	*2H	18.00	18.32

Date	Rating	Target Price	Closing Price
15 26-Jan-09	2H	*\$16.00	12.92
16 13-Mar-09	2H	*\$10.00	9.81
17 21-Apr-09	2H	*\$16.00	17.52
18 17-Jul-09	2H	*\$21.00	21.52
19 20-Jul-09	2H	*\$24.00	23.08

* Indicates change

Rating/target price changes above reflect Eastern Standard Time

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CAFE and the U.S. Auto Industry

Revisited

13 October 2009

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Investment ratings are determined by the ranges described above at the time of initiation of coverage, a change in investment and/or risk rating, or a change in target price (subject to limited management discretion). At other times, the expected total returns may fall outside of these ranges because of market price movements and/or other short-term volatility or trading patterns. Such interim deviations from specified ranges will be permitted but will become subject to review by Research Management. Your decision to buy or sell a security should be based upon your personal investment objectives and should be made only after evaluating the stock's expected performance and risk.

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