Tune Up

Fixing Market Failures to Cut Fuel Costs and Pollution from Cars and Trucks

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Executive Summary

The Biden administration is currently seeking to bolster the federal government's role in addressing climate change by reducing greenhouse gas emissions from the transportation sector, which is currently the largest source of these pollutants in the country. Federal fuel economy and vehicle emissions standards will thus be crucial tools in addressing climate change as well as improving the health of millions of Americans who are exposed to toxic tailpipe pollutants.

In addition to reducing pollution, these efforts can also save consumers money at the pump. Economists have long observed that consumers do not always select vehicles that will save them the most money over time, instead purchasing a slightly cheaper car or truck that will cost them more in the long run through greater fuel usage. This phenomenon is known as the "energy efficiency gap" or "energy efficiency paradox." Certain industry groups, car manufacturers, and economists have argued that the energy efficiency gap can be explained by rational behavior. Under their theories, stronger federal vehicle standards could not produce real, net cost savings for individual Americans.

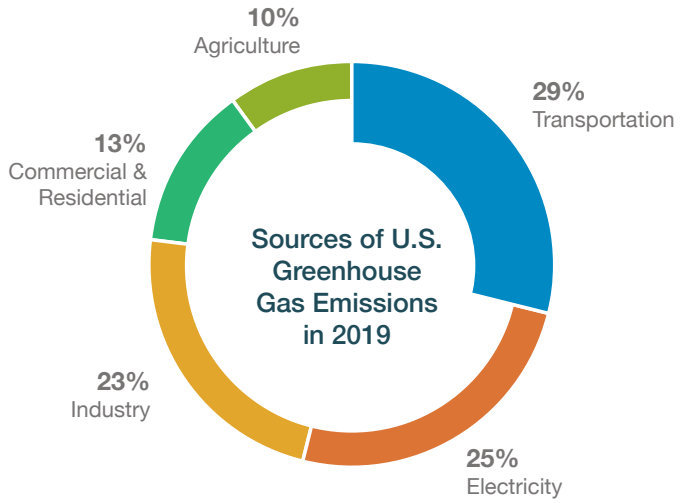
But as this report demonstrates, there is considerable economic research demonstrating that multiple market failures contribute to or exacerbate the energy efficiency gap in the markets for new passenger cars, SUVs, and pickup trucks, as well as for heavy-duty vehicles like tractor-trailers, motor homes, and buses. Key market failures include loss aversion, information costs and asymmetries, myopia and inattention, positional externalities, manufacturer market power, first-mover disadvantages, split incentives, and network externalities.

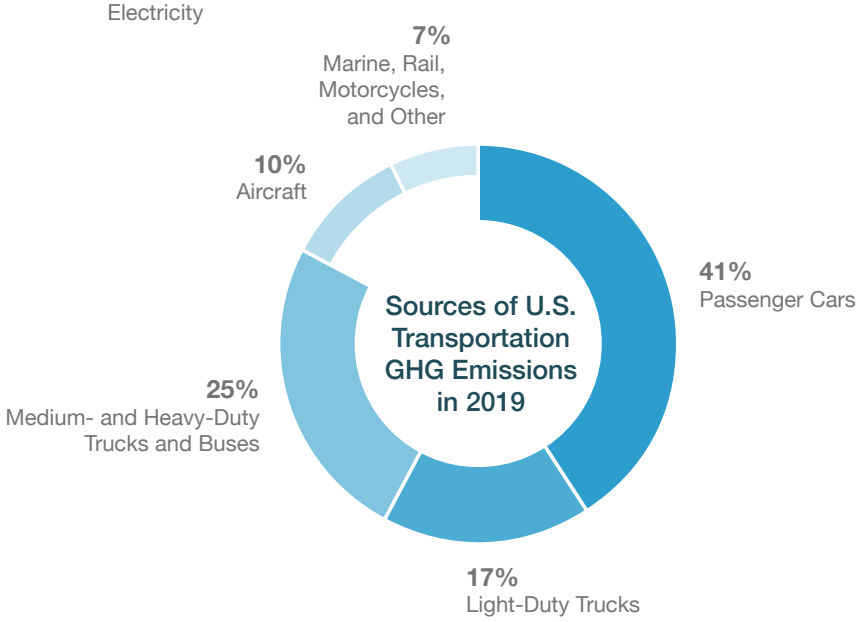
Given the plethora of evidence for these market failures, the Biden administration should continue the longstanding practice of incorporating private fuel savings in any evaluation of the costs and benefits of stronger standards for cars and trucks. In doing so, the federal government will not only be improving the health of Americans but keeping money in their pocket.

Introduction

The U.S. transportation sector is currently the largest source of greenhouse gas pollution in the country, accounting for 29 percent of total emissions in recent years.[1] It has also seen the biggest relative increases in greenhouse gas pollution.[2] For the Biden administration to meet its goal of meaningful action on climate change, cars, trucks, and other vehicles will need to improve their fuel economy dramatically and quickly.[3]

In addition to addressing climate change, better fuel economy will lead to reductions in other pollutants as well, which will have major health and environmental benefits. The transportation sector is one of the biggest sources of toxic pollutants like nitrogen oxides and fine particulate matter.[4] Nearly half of Americans live in areas with harmful levels of these pollutants, and as many as 50,000 premature deaths occur every year in the United States from motor vehicle emissions of these substances.[5] Improvements in vehicle fuel economy can have national security benefits as well, decreasing U.S. reliance on foreign oil and improving our energy independence. Properly valued, these compelling climate, health, and security benefits alone justify much stronger emissions and fuel economy standards for both cars and trucks.[6]





Beyond those public benefits, fuel economy and vehicle emission regulations also provide enormous private benefits to consumers by saving them money, since greater vehicle efficiency reduces the fuel costs per mile of driving.[7] Without sufficiently strong fuel economy regulations, consumers have not been able to demand the kinds of efficient cars and trucks that will collectively save them the most money over time. Economists have long observed that consumers do not always spend an extra dollar now to purchase a more efficient car or truck model that would save them much more than a dollar in fuel costs over the vehicle's life, even when discounted to present values.[8] This phenomenon is known as the "energy efficiency gap" or "energy efficiency paradox."

Despite the name, the energy efficiency gap is not such a mystery. Multiple well-known market failures explain why consumers are not able to demand the optimal amount of fuel economy in the unregulated marketplaces for new cars and trucks. Vehicle manufacturers can also contribute to the energy efficiency gap because of market failures that lead them to underinvest in energy efficient technologies, further exacerbating the problem.[9] Regulations that address these market failures, therefore, achieve not just social benefits but private benefits for consumers as well. Key market failures include loss aversion, information costs and asymmetries, myopia and inattention, positional externalities, manufacturer market power, first-mover disadvantage, split incentives, and network externalities. This report provides an overview of these key market failures and the relevant economic literature that supports them.

The Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) are responsible for issuing vehicle emission standards and fuel economy standards, respectively, for passenger cars as well as light-duty, medium-duty, and heavy-duty vehicles.[10] The agencies classify vehicles into these categories by weight. Passenger cars and light-duty trucks, such as pickup trucks, minivans, and SUVs, weigh less than 8,500 pounds.[11] Medium and heavy-duty vehicles weigh more than 8,500 pounds, such as large pickups, utility vans, school buses, city delivery vehicles, garbage trucks, construction vehicles, transit buses, motor homes, and tractor-trailers.[12]

Examples of Which Consumers Buy Which Cars and Trucks

This graphic shows some representative examples of the types of consumers that buy various cars and trucks. The examples are not comprehensive or universal.

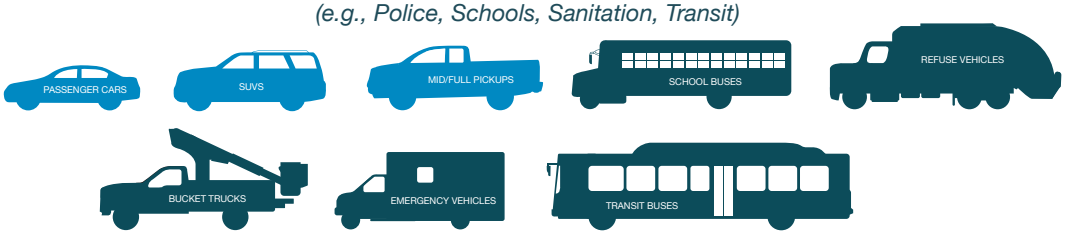
INDIVIDUALS

Retail Consumers of Personal Vehicles

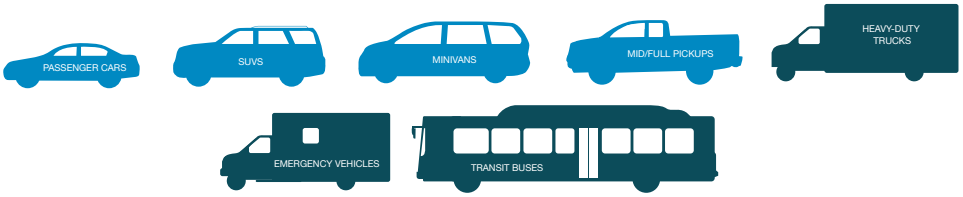
Owner-Operators of Trucks

INSTITUTIONS

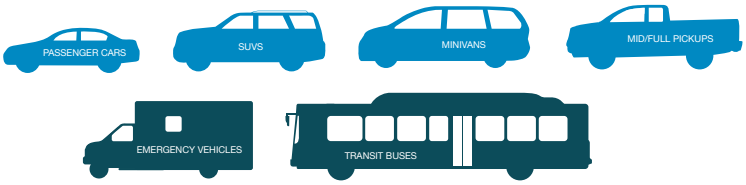
Local Governments
(e.g., Police, Schools, Sanitation, Transit)



Federal Government Agencies
(e.g., Postal Service, Military, Homeland Security)



Universities, Hospitals, and Non-Profit Institutions



Light-Duty Vehicles Medium- and Heavy-Duty Vehicles

Examples of Which Consumers Buy Which Cars and Trucks (Continued)

This graphic shows some representative examples of the types of consumers that buy various cars and trucks. The examples are not comprehensive or universal.

SMALL AND FAMILY BUSINESSES

Independent Trucking Companies

Construction, Landscape, Home Service Companies

Smaller Commercial Fleets
(e.g., Company Cars and Trucks)

LARGER BUSINESSES

Rental Car Companies

Freight, Delivery, and Transit Companies

Commercial Fleets
(e.g., Food & Beverage, Construction, Sanitation)

Utilities
(e.g., Electricity, Natural Gas, Telecommunications)

Light-Duty Vehicles Medium- and Heavy-Duty Vehicles

Purchasers of these vehicle types include individual consumers, independent truck drivers, small businesses, local governments, and large corporations, which all buy some share of each vehicle type.[13] For instance, both newer "transportation network companies" like Uber and Lyft and more traditional rental car companies primarily use passenger car and light-duty vehicles,[14] while in the trucking industry, small, family-owned fleets make up approximately 75 percent of the market and individual owners operate about 15 percent of trucks on the road.[15] Because of this overlap in purchasers among vehicle classes, the various market failures that result from the behaviors of individuals, institutions, and large and small corporations will apply to some degree across all categories of vehicles.

For decades, EPA and NHTSA have recognized that regulations that increase vehicle efficiency can deliver massive cost savings to consumers by correcting for failures in both the car and truck markets.[16] Recently, however, industry and a few economists have pushed back on the characterization of these cost savings, arguing that since consumers theoretically should be able to achieve them on their own in the market, the fact that consumers do not demand more efficient vehicles must mean they do not value the cost savings.[17]

As this report demonstrates, these arguments have several flaws and limits, and should not lead EPA and NHTSA to ignore private fuel savings in their cost-benefit analyses of vehicle emission and fuel economy standards.[18] There is abundant empirical evidence that market failures lead to inefficiencies that can be corrected through government regulation, saving Americans money while addressing health and environmental harms from motor vehicle pollution.

The Prior Debates over Raising Fuel Economy Standards

In 2012, EPA and NHTSA jointly issued a set of regulations known as the "Clean Car Standards." The rulemaking harmonized greenhouse gas emission and fuel economy standards for passenger cars and light-duty trucks in model years 2017 through 2021 as well as model years 2022 through 2025,[19] with the latter model years subject to a second review to determine whether they remained appropriate.[20] The Clean Car Standards were expected to result in an increase in fuel economy and decrease in greenhouse gas emissions of approximately 5 percent per year on average.[21] At the time the regulations were first issued, EPA and NHTSA conducted a rigorous cost-benefit analysis that showed the Clean Car Standards would result in over $450 billion in net benefits, with any upfront increase in vehicle purchase price significantly outweighed by fuel savings totaling approximately $475 billion.[22] The agencies also detailed many of the key market failures that explained the energy efficiency gap and the need for government intervention.[23] These include consumer loss aversion, myopia, and lack of information, all of which are explained further below.[24]

EPA and NHTSA subsequently tightened greenhouse gas emission and fuel economy standards for medium- and heavy-duty vehicles in 2016 for model years 2018 to 2025.[25] These standards were a key aspect of President Obama's Climate Action Plan and were expected to save vehicle owners over $170 billion in fuel costs.[26] In finalizing the 2016 rule, the agencies affirmed that market failures in purchases of medium- and heavy-duty vehicles contributed to an energy efficiency gap that could be rectified through regulatory intervention.[27] Some of these issues were comparable to those in the car and light-duty truck market, such as lack of information, while others were more prominent in the medium- and heavy-duty truck market, such as network externalities and split incentives, which are discussed in more detail later in this report.[28]

When the 2022 to 2025 passenger car and light-duty truck standards were reevaluated for a second time in 2016, EPA and NHTSA confirmed that the Clean Car Standards would result in substantial net benefits, based in part on the fact that "the reduced operating costs from fuel savings over time are expected to far exceed the increase in up-front vehicle costs."[29] Thereafter, in January 2017, EPA issued a Final Determination that the Clean Car Standards remained appropriate and would result in substantial improvements in economic welfare.[30] Consumer fuel savings alone exceeded the costs of the regulation even without considering any environmental benefits.[31]

Despite these repeated assessments demonstrating the clear benefits from stronger fuel economy standards, in 2018 the Trump administration decided to repeal the Clean Car Standards, though they left the medium- and heavy-duty vehicle regulations in place.[32] EPA and NHTSA subsequently issued a new rule for passenger cars and light-duty trucks that required only 1.5 percent increases in fuel economy through 2026—considerably lower than the 2012 Clean Car Standards' target of 5 percent increases per year.[33] The administration relied on a deeply flawed economic analysis to justify its actions and claimed the prior Clean Car Standards would impose high consumer costs and safety costs while achieving only limited environmental benefits.[34] In the rollback, the agencies also sought to cast doubt on the market failures that explain the energy efficiency gap, even going so far as to suggest that fully valuing the lifetime fuel savings to consumers "distorts" the analysis, and musing about whether they could somehow ignore the billions of dollars in increased fuel costs that consumers would face under the rollback.[35]

As this report shows, well-established economics research demonstrates not only the existence of the energy efficiency gap, but how market failures contribute to the problem. These failures include loss aversion, lack of information, infrastructure network externalities, and a lack of incentives for manufacturers to develop more efficient vehicles. By promulgating government standards for fuel economy and greenhouse gas emissions, EPA and NHTSA can address these issues and generate considerable savings for vehicle purchasers.

The Biden Administration is now in the process of rewriting the Trump-era fuel economy rule for light-duty vehicles.[36] The current administration is also expected to announce ambitious new climate plans around Earth Day on April 22.[37] Greenhouse gas pollution reductions from the entire transportation sector, including medium- and heavy-duty trucks, will be crucial in meeting such goals. New fuel economy regulations will also provide additional incentives for a greener transportation sector beyond the current infrastructure stimulus bill, which is intended to galvanize the adoption of electric vehicles and expand charging stations throughout the United States. But beyond the urgent need to address climate change, stronger fuel economy standards for cars and trucks will save consumers significant amounts of money. Based on the extensive economics research demonstrating how market failures cause the energy efficiency gap, the Administration should fully incorporate private fuel savings in assessing the costs and benefits of new regulations and so spur efficiency increases that will deliver environmental gains along with significant cost savings for consumers.

Problematic Attacks on the Cost Savings from Vehicle Standards

As EPA and NHTSA have sought to reduce vehicle emissions and improve fuel economy in the past, a few industry groups, vehicle manufacturers, and economists have suggested that the energy efficiency gap reflects actual consumer preferences for less efficient vehicles and is not evidence of a market failure.[38] In making this argument, they have offered various alternative explanations for the gap, such as inherent tradeoffs between other vehicle features and fuel economy, consumer application of high discount rates to fuel savings, financial constraints, and preferences for time-tested technologies. The first three phenomena have been identified in the markets for both individual consumer purchases as well as commercial vehicles, while the fourth issue has been suggested as a problem primarily in the heavy-duty truck market.

Similar arguments were a theme in the Trump administration's justification to roll back the Clean Car Standards, and they have been levied against past efforts to increase fuel economy standards for both light-duty and heavy-duty vehicles. Yet each of the arguments is incomplete or based on limited support. They should not lead EPA or NHTSA to hesitate in developing stronger standards for car or trucks, and the agencies should continue to fully value the private cost savings from better fuel economy.

The passenger car, light-duty truck, and medium- to heavy-duty vehicle markets offer purchasers a range of vehicle options at a variety of price points. Consumers and commercial businesses must evaluate a vehicle's fuel economy in addition to other features before making a selection. According to some economists and industry groups, purchasers are frequently forced to choose between better fuel economy and other attractive attributes when deciding what vehicle to buy. This line of thinking suggests that observations of the energy efficiency gap are not evidence of market failures but instead simply reveal consumers' preferences for these other features over improved fuel economy.

Yet many fuel-efficient technologies can increase vehicle performance and are entirely compatible with other features,[39] as a plethora of evidence has shown.[40] In fact, research has demonstrated that the probability of a light-duty vehicle obtaining a negative evaluation of its operational characteristics is lower when that vehicle has fuel-saving technologies—in other words, more fuel-efficient light-duty vehicles are less associated with negative performance reviews.[41] Any possible performance tradeoffs are also likely to decline over time, with technological advancements and manufacturer learning.[42] While in the short run manufacturers may face some constraints in overhauling a vehicle's design, in the long run they have greater flexibility to improve their designs and reduce compliance costs in ways that obviate any need for tradeoffs.[43] The only situation that would force vehicle manufacturers to trade off energy efficiency against other features would be if there is a technical or engineering constraint that made it impossible to add both those features and the technologies that improve fuel economy, or if the technology for improving fuel economy necessarily increases the marginal cost of adding additional features.[44] Researchers have found only isolated examples of inherent tradeoffs in practice, and there is no evidence that such problems alone could explain the energy efficiency gap.[45]

In fact, many technologies, such as high-strength aluminum alloy bodies,[46] turbocharging,[47] and certain hybridization technologies, can improve both fuel economy and other vehicle performance metrics.[48] Additional examples include increasing the number of gear ratios in new transmissions, which help the engine both run more efficiently and in the optimal "power band" for performance.[49]

Furthermore, EPA and NHTSA have accounted for such concerns about tradeoffs by assuming in their compliance cost estimates that manufacturers will install whatever additional technologies are needed to maintain key performance levels even as fuel economy is increased.[50] If manufacturers in fact were to trade off reduced performance for increased fuel economy, then the actual costs of achieving that fuel economy would drop substantially, and consumers would see lower purchase prices.[51] The literature consistently shows that if manufacturers are allowed to use attribute-tradeoffs to comply with regulatory standards, compliance costs could be "significantly lower" than what the agencies estimate.[52] The fact that estimated fuel savings from recent regulations vastly outweigh estimated compliance costs for both cars and trucks even after factoring in additional costs to maintain vehicle performance attributes strongly suggests that attribute tradeoffs alone cannot explain the energy efficiency gap.[53]

Another hypothesized reason for the energy efficiency gap is that consumers might be applying exceedingly high discounts to future fuel savings.[54] But such an explanation for the energy efficiency gap would have to posit that consumers routinely discount future fuel savings at rates as high as 24 percent.[55] This is eight times higher than the 3 percent discount rate historically applied to assess how private consumers trade off their consumption over time[56] and almost four times higher than the rate commonly applied to assess how private industry values returns on investments.[57]

It is not rational, however, for consumers to apply such high discount rates to future fuel savings. Typically, the interest rate on a loan reveals the rate at which consumers are willing to trade off future spending versus current consumption—and surely most vehicle purchasers would balk at a loan with a 24 percent interest rate. As detailed below, current car loan interest rates are far lower, averaging around 5 percent in recent years.[58] There is no reason why—absent some market failure—individual, institutional, or corporate consumers of cars or trucks would adopt vastly different attitudes towards their future finances depending on whether the money is spent buying fuel or paying a loan.[59]

Some opponents of stronger vehicle standards have posited that the energy efficiency gap can be explained by financial constraints on the part of consumers and trucking companies.[60] According to this view, fixed budgets and high upfront costs prevent purchasers from paying for a car or truck that has both fuel economy improvements and all the additional features they want. Yet 85 percent of new passenger vehicles are financed by loans,[61] and both commercial and institutional purchasers of heavy-duty vehicles should have ready access to credit as well.[62] The wide availability of vehicle financing for individual and corporate consumers means that budget constraints should not force consumers to sacrifice future fuel savings or require them to choose between fuel savings and other features, such as greater horsepower.[63] A rational consumer would be willing to pay for the additional cost of greater fuel economy through a slightly higher monthly loan payment, which will be more than offset over time by the fuel savings—and, similarly, a rational bank or lender would be willing to offer such a loan affordably, knowing that the long-term fuel savings will help the consumer make the monthly loan payments.[64] In fact, some banks even offer consumers rate reductions in loans for fuel-efficient vehicles.[65]

Reliability issues and maintenance of newer, more efficient vehicles are other frequently cited explanations for the energy efficiency gap, particularly with regard to heavy-duty vehicles.[66] But although some focus group research has suggested that truck drivers, fleet managers, and chief operating officers of transportation companies do harbor such fears about energy efficient vehicles and may therefore make purchasing decisions that ultimately forgo net cost savings,[67] this tendency is symptomatic of a market failure known as the first-mover disadvantage, which is explained in more detail in the next section. Mandatory efficiency standards can decrease these issues by requiring widespread adoption, which will improve adaptation over time, incentivize more robust networks for servicing newer technologies, and lead to decreased costs from better management of logistics and maintenance.

Nor are isolated examples of rational decision-making in vehicle purchases sufficient to show that market failures are not responsible for the energy efficiency gap. For instance, in a recent article on adoption of fuel-efficient technologies in the medium- and heavy-duty truck market, the authors observed that truck drivers on high-speed interstate highways had more fuel-efficient technologies on their vehicles than those driving on the local highways used for shorter routes.[68] These observations, they suggest, indicate that the market is functioning competitively and that "regulatory agencies' claims of large private benefits from requirements to adopt such energy-efficient technology should be subjected to special scrutiny."[69] But this is one limited case in which one regional segment of the trucking industry has adopted particular energy efficiency technologies once they have been proven reliable—and after fuel economy standards for heavy-duty trucks had already been adopted.[70] As discussed in the next section, there are a whole host of market failures that make it difficult for trucking companies, without any assistance from regulatory standards, to make perfectly informed, rational decisions when deciding whether to purchase vehicles with better fuel economy.

Arguments that the energy efficiency gap reflects purely rational consumers preferences are thus, on the whole, supported by incomplete evidence that does not explain the wide gulf between observed and optimal vehicle purchasing decisions. EPA and NHTSA should not eliminate private fuel savings in regulatory cost-benefit assessments on the basis of such limited research.

How Market Failures Explain the Energy Efficiency Gap

If vehicle purchasers were all adequately informed and free to make rational, welfare-maximizing choices in a fully competitive market without concern for negative externalities, consumers might on their own perfectly balance their future fuel cost savings against the increased purchase price for a more efficient vehicle. But in the real world, consumers face a host of market failures that bias their information, disrupt their rational decision-making, constrain their choices, and subject them to uncompensated costs.

Extensive empirical evidence identifies multiple market failures that contribute to the energy efficiency gap among consumers.[71] In light of this research, "there is general agreement that the actual fuel savings realized over time should be fully valued in cost-benefit analyses."[72] Some of the most glaring market failures include loss aversion, information costs and asymmetries, myopia and inattention, positional externalities, manufacturer market power, first-mover disadvantages, split incentives, and network externalities. This section provides an overview of these key market failures.

Some of these market failures may be more or less likely to apply to particular categories of vehicle consumers. For example, given their incentives to maximize profit and their greater resources, large businesses may seem to have an advantage over individuals in collecting adequate information and processing that information fully and rationally. However, not only may small and large businesses face their own unique informational failures (see below on the first-mover disadvantage), but the decisionmakers at businesses are, ultimately, people—people who may at times suffer from the same behavioral failures as any other consumer (see below on inattention) and unique failures (see below on split incentives). Similarly, governmental and institutional consumers of vehicles may sometimes act more like individuals or sometimes more like businesses, and experience various market failures accordingly when buying cars or trucks.

Furthermore, within each broad category of consumers, not every consumer will necessarily face every market failure. But on the whole, the economic research suggests that many purchasers are likely to make information processing errors and experience a range of other obstacles.[73] While some individuals may be able to purchase the most optimally efficient vehicle on their own, overall consumers appear unable to maximize their fuel cost savings without the assistance of government regulations.[74]

Loss Aversion. Economists have described loss aversion as "a behavioral pattern in which individuals facing risky choices place greater weight on losses compared to gains of an equivalent monetary value."[75] In the case of fuel economy, consumers may irrationally emphasize the upfront "losses" of purchasing a more expensive, more fuel-efficient vehicle over the somewhat more uncertain gains of future fuel savings.[76] As a result, they may not purchase more efficient vehicles, even if they (and society) would have saved more over time than the additional amount they pay upfront. Recent economics research has demonstrated that loss aversion may also contribute to the energy efficiency gap in the trucking industry, with fleet managers underinvesting in more efficient vehicles because they placed "greater weight on losses compared to gains of an equivalent monetary value."[77] Loss aversion can thus affect individuals as well as businesses and institutions buying new cars and trucks, and can be compounded by a lack of information and the costs of obtaining information.[78]

Information Costs and Asymmetries. Empirical evidence suggests that consumers struggle to rationally utilize available fuel economy information when making their vehicle purchases and may find it too difficult to obtain other important data to guide their decisions. In one study of highly educated purchasers, half of respondents were unable to determine how much they would be willing to pay for a 50 percent increase in fuel economy, and only a couple individuals were able to offer explanations of their decisions that the interviewers found to be economically rational.[79] More recent surveys have found fewer than 1 in 4 individual purchasers made *any* calculations to compare fuel savings in purchasing their vehicles, and the calculations that were done by this group varied widely in their comprehensiveness.[80] When combined with a predisposition to avoid a risk of loss, "the decision to buy or not buy a fuel economy technology appears to be a risky bet that loss averse consumers are likely to decline."[81]

Behavioral economics research has found that the cost of obtaining detailed and actionable information regarding vehicle fuel economy may lead consumers to purchase vehicles without fully weighing fuel economy, potentially leading to lower fuel economy than they would optimally prefer.[82] Consumers may also lack information to fully value some benefits of more efficient vehicles—like the benefit of not having to stop as often (or at all) to refuel—until after the consumer has already purchased and experienced the good.[83] Reliable information about fuel savings can also be costly to obtain for heavy-duty vehicle buyers, particularly as small-business owners and individuals make up a vast majority of vehicle operators.[84] Because insufficient information can mute consumer demand for fuel economy, this can also lead manufacturers to underinvest in fuel economy.

Myopia and Inattention. Consumers may also use heuristics and rules of thumb that underemphasize or miscalculate the value of the fuel they will save by purchasing more efficient vehicles, even if consumers would value those savings given a more focused, systematic, or accurate evaluation of the costs and benefits of a purchase decision.[85] Recent research on consumer myopia and inattention provides powerful evidence for this market failure.[86] Economists were able to analyze a "natural experiment" in how purchasers value fuel economy after two car companies misstated the miles per gallon achievable by numerous vehicle models.[87] The mistake prompted the largest correction in fuel economy ratings in U.S. history, impacting 1.6 million car purchases.[88] In examining how consumers subsequently responded to price adjustments in the affected models, the researchers found that "consumers systematically undervalue fuel economy in vehicle purchases to a larger degree than reported by much of the recent literature."[89] The study underscores that "that it is possible for a policy that shifts consumers into more efficient vehicles to be welfare-improving, even if environmental externalities are fully internalized."[90] Another example of myopia can be seen with hybrid vehicles. Across all hybrid electric versions offered from 2004 to 2015, even when the hybrid version "is visually identical to a gasoline version of the same model and requires no significant compromises in performance, trunk space or other vehicle attributes," and when fuel savings would "more than pay for [the] price premiums," "fewer than 20% of consumers opt for the [hybrid electric vehicle] option."[91]

Though myopia and inattention may more commonly plague individual consumers, economists have also found that managers at certain companies can exhibit similar kinds of inattention and so fail to implement many energy efficiency initiatives despite positive paybacks.[92] Businesses may also face a kind of myopia called short-termism, in which certain corporate employees have an incentive to favor short-term profits over long-term investments if, for example, their personal compensation or career prospects are tied to near-term earnings.[93] Employees given such incentives may have reason to purchase cheaper, less efficient vehicles.[94] To the extent short-termism is exacerbated by an informational asymmetry either between employees (who know that lower vehicle purchase prices will favorably boost short-term earnings reports) and investors (who may not know that more efficient vehicle purchases could have increased their

long-run returns), or is caused by myopia, the phenomenon is a market failure.[95] Economic studies suggest that short-termism can affect managers' choices about energy efficiency specifically,[96] and about environmental sustainability more broadly.[97]

Positional Externalities. Recent economic studies have also identified cars as "positional" goods whose value is partially determined according to how much status a good imparts in relation to the amount of the good others have, rather than according to innate characteristics of the good itself.[98] In practice, this means that consumers do not necessarily want the biggest and fastest vehicle, so long as their vehicle is bigger and faster than their friends' and neighbors' vehicles.[99] Positional goods can lead to an arms race among purchasers, with consumers spending more resources on status attributes like horsepower without improving their relative status.[100] In fact, every time some consumers increases their own status by buying a bigger, faster car, the purchase inflicts a negative externality on other consumers by decreasing their relative status.[101] Along the way, consumers deprioritize investments in efficiency that may not improve their relative status, and so they impose costs on society through increased pollution and other negative externalities. Regulation can ameliorate this market failure by allowing consumers to maintain their relative position with respect to positional vehicle features while mandating better fuel economy.[102] Consumers will not suffer any positional loss, while society will see decreased external harms from the behavior. This market failure is more likely to affect individual consumers, though institutions and businesses could fall into the positional arms race as well, as when luxury corporate cars are offered to employees as status-boosting perks.

Manufacturer Market Power. Because of the limited competition in at least some segments of the vehicles market, manufacturers may be able to act strategically when pricing vehicles and when producing vehicles with combinations of different fuel economy and other vehicle features in order to push consumers towards purchases that lead to higher manufacturer profits at the expense of optimal fuel economy.[103] There are a relatively small number of firms producing several types of vehicles and engines across the light-duty and heavy-duty markets.[104] This market failure therefore could influence purchases by all consumer groups and across several vehicle classifications.

First-Mover Disadvantage. Supply-side problems in the market may lead vehicle manufacturers to underinvest in fuel-efficient technologies, compounding the issues with consumer valuation of fuel economy.[105] These problems can occur for two reasons: "uncertainty of future consumer demand for improved fuel economy and irreversibility of the large capital investments required."[106] Because of uncertain consumer demand and high, irreversible capital investments, "being a first mover may appear to have a greater downside risk than upside risk; that is, there is a 'first mover disadvantage.'"[107] Economists have also noted that the first-mover disadvantage can be especially pronounced when returns to society are greater than those to the investor, as is the case with fuel-efficient technologies that reduce oil use and greenhouse gas emissions.[108] Because of these issues, manufacturers may not see a private return that fully reflects the benefits of their investment.[109] Federal vehicle standards can help in several ways. They reduce manufacturers' risks, perceived or real, in investing in fuel economy, and lower "the costs of the fuel efficiency technologies through economies of scale, learning curves, and more rapid innovation."[110] Short-termism can also compound the first-mover disadvantage, as manufacturers have to balance the immediate costs and risks of research against the longer-term profits from future sales.[111] Since each manufacturer faces muted incentives to be the first to research and deploy new technologies, without regulations, no manufacturer is likely to produce vehicles with the socially optimal level of fuel economy.[112] Because manufacturers are responding to consumer demand for fuel economy that multiple other market failures have already depressed, this first-mover dynamic can exacerbate the energy efficiency gap.[113] By affecting manufacturers, this aspect of first-mover disadvantage decreases fuel economy for all consumer groups.

First-mover effects can also affect vehicle purchasers, including corporate and institutional purchasers. For example, some focus group studies of medium- and heavy-duty truck purchasers have found that they may hesitate to purchase more fuel-efficient vehicles because they are unsure about their reliability.[114] Because a firm's knowledge about reliability and fuel savings is also useful to other fleets, and because a firm's choice of vehicles may reveal information to competitors, this can create first-mover issues and knowledge spillover effects.[115] Without regulatory incentives, firms may underinvest in purchasing such efficiency-enhancing technology as they all wait for their competitors to go first and bear the costs of testing the implementation of new technology.

Split Incentives. When the purchaser of a vehicle does not have to pay the costs of fuel usage, this can create a market failure known as split incentives or the principal-agent problem.[116] Economists have found that split incentives can lead to undervaluation of fuel economy in the trucking industry, as parties that own or operate tractor-trailers are frequently not responsible for fuel costs.[117] A similar dynamic can occur in other contexts, such as in the large rental vehicle fleets, since rental companies do not pay for fuel costs. Government intervention can ensure that purchasers make societally optimal investments in energy efficiency technologies when they receive inadequate market incentives because of principal-agent problems.[118]

Network Externalities. The benefits of a new technology sometimes depend on widespread adoption by others, creating a situation where "proven" technologies are chosen even though others would save more money in the long run.[119] This problem has been observed among heavy-duty trucking firms, which have hesitated to invest in alternative types of vehicles due to a lack of refueling infrastructure, while fuel companies are reluctant to build the infrastructure until more vehicles are in operation.[120] Network externalities can affect investments in natural-gas refueling, electric vehicle charging, maintenance facilities, and replacement parts.[121] In turn, these externalities can affect a range of consumers and vehicles, from individuals to businesses, and from passenger cars to heavy-duty trucks. Because consumers buying alternative fuel or more efficient vehicles must make predictions about the future development of these critical networks in order to estimate their long-term savings, various market failures from information asymmetries and costs, myopia, and loss aversion all come into play here. Fuel economy standards help resolve the coordination, first-mover, and informational problems facing the developers of this network infrastructure, thereby providing greater certainty that consumers can achieve long-term cost savings.[122]

Taken together, the considerable evidence of these market failures underscores the importance of including private fuel savings in cost-benefit assessments of fuel economy and vehicle emissions standards. Their potential influence across all types of vehicles and purchasers should prompt EPA and NHTSA to consider fuel savings regardless of whether the agencies seek to regulate passenger cars or light-, medium-, and heavy-duty trucks.

EPA and NHTSA's Authority to Include Fuel Savings in Cost-Benefit Assessments

Incorporating private consumer benefits from stronger fuel economy and greenhouse gas emission standards is in accordance with longstanding agency practices.[123] For over forty years, under administrations of both political parties, NHTSA has consistently included fuel savings in its cost-benefit analyses for fuel economy regulations.[124] Similarly, over the past six presidential administrations, EPA has regularly used the value of the fuel saved to calculate the benefits that are produced from its vehicle emission standards.[125]

Numerous government guidance documents on cost-benefit analyses also make clear that including fuel savings can ensure that regulations are based on sound economics. For example, the Office of Management and Budget's *Circular A-4*—a guide for agencies on regulatory cost-benefit analysis issued under President George W. Bush and endorsed by both the Obama and Trump Administrations—includes a specific discussion regarding how to evaluate fuel economy that suggests agencies should use the value of fuel saved when determining the benefits of a regulation.[126]

Similarly, EPA's *Guidelines for Economic Analysis* ("Guidelines") supports using fuel savings to calculate the benefits of regulations.[127] The Guidelines instruct EPA to consider the social value of goods saved when market distortions may lead to an incomplete measure of their benefits. In this case, the agency should use the price of fuel rather than consumers' valuation of fuel economy since the latter is subject to multiple market failures.

The Guidelines' discussion of the appropriate discount rate to use when evaluating regulation also supports incorporating fuel savings in cost-benefit assessments. As explained above, the energy efficiency gap could perhaps be characterized as reflecting consumers' use of very high discount rates when evaluating vehicles with increased fuel economy—rates multiple times higher than normally assumed for rational consumer behavior.[128] However, because the purpose of regulation is to maximize societal benefits, the Guidelines direct EPA to calculate the value of future savings using the rate that society discounts future costs and benefits.[129] The appropriate rate would consequently mirror present interest rates, rather than consumers' use of irrationally high discount rates. The Department of Transportation's guidance documents on cost-benefit analysis also indicate that agencies should fully value fuel savings in assessing their regulations. In its *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, the Department of Transportation explains that the benefits for programs that avoid vehicle use should be calculated based on vehicle operating costs, including avoided fuel costs.[130]

In developing new fuel economy regulations, the Biden administration should follow these longstanding agency practices and include private fuel savings in their cost-benefit analyses. These agency guidance documents and recommendations are clear that best economic practices require incorporating such benefits when market failures prevent consumers from obtaining the full value of fuel savings on their own.

The Biden Administration Can Help Spur Technological Innovation

After the 2020 election, car manufacturers made numerous commitments to produce more fuel-efficient and environmentally friendly vehicles. Shortly after Biden was declared the winner by most major media outlets, General Motors withdrew from a lawsuit over California's right to set more stringent tailpipe emission limits.[131] In January 2021, the company announced that it intends to end all gasoline passenger car and truck sales by 2035.[132] Volvo subsequently pledged to make its entire car line-up fully electric by 2030.[133] Even the Alliance for Automotive Innovation, a trade group representing major automakers that had been opposed to mandatory increases in fuel economy, last month backed nationwide rules to achieve vehicle emissions reductions roughly midway between the Trump and Obama standards.[134] These developments suggest that the market is already anticipating the need to meet stronger federal standards under the Biden Administration. But as this report has explored, due to a variety of market failures, on its own the market will consistently tend to undershoot the level of fuel efficiency that will best serve the American consumer—let alone the level of efficiency necessary to protect public health and the environment. Through even stronger regulations, NHTSA and EPA can address these market failures and spur even greater innovation in the transportation sector.

Economic studies and historical evidence demonstrate that government can play a major role in technological innovation. In the absence of a forcing mechanism like regulation, risk-averse manufacturers—which face first-mover disadvantages, switchover disruptions, and other barriers—are likely to apply only small, incremental innovations to fuel economy, instead of pursuing more major advances that may have greater potential to improve both fuel economy and performance simultaneously.[135] There is also robust evidence that countries and sectors with stronger environmental controls experience greater innovation than would occur absent these government mandates.[136] Consequently, the Biden Administration should consider the importance of spurring technological innovation in promulgating new fuel economy and vehicle emissions regulations.

The state of California and several car companies had previously struck a deal that set fuel economy goals at a level in between the Obama and Trump administration's proposed standards.[137] But given the significant market failures at the root of the energy efficiency gap and the multitude of other environmental and health harms from vehicle emissions, those existing targets likely do not represent the standards that are most beneficial to society. Just as all cars and trucks need regular tune ups to operate at their peak efficiency, the car and truck fleets and markets nationwide need regular tune ups to maximize net benefits—not just for climate change, public health, and energy security, but for consumer savings as well. The Biden administration should analyze how more ambitious vehicle regulations can remedy the numerous market failures that contribute to the energy efficiency gap and significantly reduce consumer costs along with pollution.

Endnotes

[1] *See Inventory of U.S. Greenhouse Gas Emissions and Sinks*, Env't Prot. Agency, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks (last visited Apr. 19, 2021).

[2] *See Carbon Pollution from Transportation*, Env't Prot. Agency, https://www.epa.gov/transportation-air-pollution-and-climate-change/carbon-pollution-transportation (last visited Apr. 10, 2021).

[3] *See* Brady Dennis & Juliet Eilperin, *Biden Faces 'Moment of Truth' as He Weighs Key U.S. Climate Promise*, Wash. Post (Mar. 23, 2021), https://www.washingtonpost.com/climate-environment/2021/03/23/biden-paris-climate-pledge/.

[4] *See* Environmental Defense Fund, Clean Cars, Clean Air, Consumer Savings: 100% New Zero Emission Vehicle Sales by 2035 Will Deliver Extensive Economic, Health and Environmental Benefits to all Americans 4 (Jan. 2021), http://blogs.edf.org/climate411/files/2021/01/FINAL-National-White-Paper-Protective-Clean-Car-Standards-1.26.21.pdf.

[5] *See* David Farnsworth, Camille Kadoch & Nancy Seidman, *Cleaner by the Mile: Electric Trucks Can Have Outsized Environmental and Health Benefits*, Utility Drive (Apr. 14, 2021), https://www.utilitydive.com/news/cleaner-by-the-mile-electric-trucks-can-have-outsized-environmental-and-he/598369/ (citing Fabio Caiazzo et al., *Air Pollution and Early Deaths in the United States. Part I: Quantifying the Impact of Major Sectors in 2005*, 79 Atmospheric Env't 198 (2013)); *see also* Environmental Defense Fund, *supra* note 4 (attributing 20,000 premature deaths to the transportation sector every year).

[6] *See* Kristin Igusky, *4 Reasons Why the Trump Administration Should Keep Fuel Standards in Place*, World Res. Inst. (Mar. 14, 2017), https://www.wri.org/blog/2017/03/4-reasons-why-trump-administration-should-keep-fuel-standards-place.

[7] Fuel economy and vehicle emissions regulations generate additional private benefits by reducing consumers' time spent refueling, and by allowing drivers to go farther on the same amount of fuel. This report focuses largely on the fuel cost savings for consumers. The term "consumers" refers to both individual drivers of passenger vehicles or trucks and to the companies or institutions that purchase vehicles for their employees to drive. In the case of commercial and institutional purchasers, not only will those entities save money, but some of those savings may be passed on to other consumers or taxpayers.

[8] In this scenario, future cost savings have been discounted at a reasonable discount rate. The energy efficiency gap is characterized by consumers not spending an additional dollar today to save more than a dollar in discounted, present value fuel savings.

[9] These market failures, discussed later in the report, include issues like spillover effects and first mover disadvantages.

[10] *See* NHTSA, Phase 2 Fuel E¬fficiency Standards for Medium- and Heavy-Duty Engines and Vehicles: Final EIS Summary S-1 (Aug. 2016), https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/mdhd2-final-eis-summary.pdf.

[11] *See* 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624, 62,624 n. 1 (Oct. 15, 2012) [hereinafter Clean Car Standards].

[12] *See* NHTSA, Phase 2 Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, *supra* note 10, at S-4.

[13] *See, e.g.*, U.S. Gen. Serv. Admin., FY 2019 Federal Fleet Report, https://www.gsa.gov/cdnstatic/FY2019Federal-FleetReportFinal.xlsx (dated July 2020) (showing the vehicle classes purchased by federal agencies); U.S. Dept. of Energy, State & Alternative Fuel Provider Covered Fleets, https://epact.energy.gov/covered-fleets (last accessed April 16, 2021) (showing over 300 local government and institutional fleets with over 50 light-duty vehicles); U.S. Dept. of Energy, FOTW #1003, https://www.energy.gov/eere/vehicles/articles/fotw-1003-november-13-2017-cars-constituted-larger-fraction-light-duty (Nov. 13, 2017) (showing new light-duty sales to rental, corporate, utility, and government fleets).

[14] California Air Resources Board, 2018 Base-year Emissions Inventory Report 9 (Dec. 2019), https://ww2.arb.ca.gov/sites/default/files/2019-12/SB%20 1014%20-%20Base%20year%20Emissions%20Inventory_December_2019.pdf?utm_medium=email&utm_source=govdelivery (anticipating the growth of transportation network companies to overall greenhouse gas emissions from car and light-duty truck vehicles); *Strong Fleet Sales Help Prop Up Slow September,* Cox Automotive (Oct. 3, 2019), https://www.coxautoinc.com/market-insights/september-2019-fleet/ (last visited Apr. 15, 2021) (explaining that rental, government, and commercial fleets make up over 17 percent of all new vehicle sales); EPA, Regulatory Impact Analysis: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average

Fuel Economy Standards 4-116 (2012) (noting that rental, corporate, and government fleets make up "about 20% of new vehicle sales").

15 The top 200 largest companies only control about 11 percent of trucks on the road. *See* National Academy of Sciences, Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles 17 (2010), https://www.nap.edu/read/12845/chapter/4 (finding that "small fleets make up 75 percent of Class 4 through 8 trucks").

16 *See* Bethany Davis Noll, Peter Howard, Jason Schwartz & Avi Zevin, *Shortchanged: How the Trump Administration's Rollback of the Clean Car Standards Deprives Consumers of Fuel Savings*, Inst. Pol'y Integrity 22–24 (June 4, 2020), https://policyintegrity.org/files/publications/Clean_Car_Standards_Rollback_and_Fuel_Savings_Report.pdf.

17 *See, e.g.*, Arthur G. Fraas, Randall W. Lutter & Derek C. Wietelman, *The Energy Paradox in Seemingly Competitive Industries: The Use of Energy-Efficient Equipment on Heavy-Duty Tractor Trailers*, 129 Energy Pol'y 467 (2019); Alliance of Automobile Manufacturers, Supplemental Comments on the SAFE Vehicles Rule 9 (May 30, 2019); Toyota Motor North America, Inc., Supplemental Comments on Safer Affordable Fuel-Efficient Vehicles Rule 4 (Mar. 25, 2019); Julian Morris & Baruch Feigenbaum, *The Economic Consequences of Fuel Economy Standards*, Reason 10–11 (Mar. 2020) https://reason.org/wp-content/uploads/economic-consequences-fuel-economy-standards.pdf.

18 National Academy of Sciences, Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy—2025-2035 11-351 (2021) (summarizing the economics literature in this area and concluding that "there is general agreement that the actual fuel savings realized over time should be fully valued in cost-benefit analyses.").

19 *See* Clean Car Standards, *supra* note 11, at 62,624.

20 *See* Richard K. Lattanzio, Linda Tsang & Bill Canis, *Vehicle Fuel Economy and Greenhouse Gas Standards: Frequently Asked Questions*, Cong. Res. Service (Aug. 26, 2019), https://www.everycrsreport.com/files/20190826_R45204_3f145570e778207a10e64af12ad4c13ff785f545.pdf.

21 *See EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks*, 4 Env't Prot. Agency (Aug. 2012), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EZ7C.PDF?Dockey=P100EZ7C.PDF.

22 *See* Clean Car Standards, *supra* note 11, at 62,629 (reporting that EPA's CO2 standards would achieve $451 billion in lifetime net benefits at a 3% discount rate, or $326 billion at a 7% discount rate); *see id.* at 62,663 (reporting that the standards would achieve $475 billion in fuel savings at a 3% discount rate, or $364 billion in fuel savings at a 7% discount rate).

23 *See id.* at 62,914–16, 63,114–20 (explaining some of the reasons for the energy efficiency gap and how the regulation can correct for these market failures).

24 *See id.* at 62,914.

25 *See* Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles— Phase 2, 81 Fed. Reg. 73,478 (Oct. 25, 2016).

26 *See* Paul Haven & Ori Gutin, *Fact Sheet: Vehicle Efficiency and Emissions Standards*, Env't & Energy Study Inst. 3 (Aug. 2015), https://www.eesi.org/files/FactSheet_Vehicle_Emissions_081815.pdf.

27 *See* Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2, 81 Fed. Reg. at 73,859.

28 *See id.* at 73,859-62.

29 EPA, NHTSA & CARB, Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 at ES-4, 12-74, 13-102 (2016), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF [hereinafter Draft TAR].

30 *See* EPA, Final Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation 29 (2017), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100QQ91.pdf.

31 *See id.* at 6-7.

32 *See* Mid-Term Evaluation of Greenhouse Gas Emissions Standards for Model Year 2022-2025 Light-Duty Vehicles, 83 Fed. Reg. 16,077, 16,078 (Apr. 13, 2018). The conclusion that the Clean Car Standards were "not appropriate" was not supported by the evidence. *See* Bethany Davis Noll, Peter Howard & Jeffrey Shrader, *Analyzing EPA's Vehicle-Emissions Decisions: Why Withdrawing the 2022-2025 Standards Is Economically Flawed*, Inst. Pol'y Integrity (2018), https://policyintegrity.org/files/publications/Analyzing_EPAs_Fuel-Efficiency_Decisions_Policy_Brief.pdf.

33 *See* The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 85 Fed. Reg. 24,174, 24,258 (Apr. 30, 2020) [hereinafter SAFE Rule].

34 *See Shortchanged*, *supra* note 16, at 9.

35 *See* SAFE Rule, *supra* note 33, at 25,110–11 ("[C]onsider[ing] fuel savings, spread over the lifetime of the vehicle . . . compared to the upfront vehicle costs . . . distorts the comparison."); *id.* at 24,612 ("If either case is true—that the analysis is incomplete regarding consumer valuation of other vehicle attributes or discount rates used in regulatory analysis inaccurately represent consumers' time preferences—no market failure would exist to sup-

port the hypothesis of a fuel efficiency gap. In either case, the agencies' central analysis would overstate both the net private and social benefits from adopting more stringent fuel economy and CO2 emissions standards. . . . Because government action cannot improve net social benefits in the absence of a market failure, if no market failure exists to motivate the $26.1 billion in private losses to consumers, the net benefits of these final standards would be $42.2 billion.").

[36] Jennifer A Dlouhy & Keith Laing, *Automakers Withdraw Support for Trump-Era Emissions Rule*, Bloomberg Green (Feb. 2, 2021), https://www.bloomberg.com/news/articles/2021-02-02/automakers-push-fuel-economy-targets-modeled-on-california-pact.

[37] *See* Jeff Mason, *Biden's Climate Duo of Kerry and McCarthy Puts U.S. Back in Global Warming Fight*, Reuters, (Apr. 16, 2021), https://www.reuters.com/business/environment/bidens-climate-duo-kerry-mccarthy-puts-us-back-global-warming-fight-2021-04-16/.

[38] Some opponents of stronger standards have also claimed that EPA may underestimate costs such as the opportunity cost of other features or higher implementation costs. *See Shortchanged*, *supra* note 16, at 17 (noting the lack of evidence for this claim versus the considerable evidence that compliance costs and vehicle price effects have been overestimated).

[39] *See* NHTSA & EPA, SAFE Rule Final Regulatory Impact Analysis 326 (Mar. 2020) https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200330.pdf [hereinafter SAFE FRIA] (explaining that multiple options exist for "technology [to] provide both improved fuel economy and performance").

[40] *See* EPA, Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Standards under the Midterm Evaluation: Technical Support Document at 4-20 (2016), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3L4.pdf discussing, e.g., Hsing-Hsiang Huang, Gloria Helfand, Kevin Bolon, Robert Beach, Mandy Sha & Amanda Smith, *Re-Searching for Hidden Costs: Evidence from the Adoption of Fuel-Saving Technologies in Light-Duty Vehicles*, 65 Transp. Res. 194, 194 (2018) (finding that "automakers have typically been able to implement fuel-saving technologies without harm to vehicle operational characteristics" like "acceleration, handling, ride comfort, noise, braking feel, and vibration"). *See also* Draft TAR, *supra* note 29.

[41] *See* Gloria Helfand et al., *Searching for Hidden Costs: A Technology-Based Approach to the Energy Efficiency Gap in Light-Duty Vehicles*, 98 Energy Pol'y 590, 605 (2016) ("Though we are unable to demonstrate causality or robustness, we find that technologies are more likely to be associated with reducing negative reviews of operational characteristics than with increasing them.").

[42] *See* Gloria Helfand et al., *Power and Fuel Economy Tradeoffs, and Implications for Benefits and Costs of Vehicle Greenhouse Gas Regulations*, Env't Prot. Agency 17 (powerpoint presentation, 2018), https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OAR-2018-0283-6963&attachmentNumber=17&contentType=pdf, *also available at* https://www.epa.gov/sites/production/files/2018-10/documents/sbca-benefit-cost-ghg-regs-helfand-2018-03.pdf ("The tradeoff between power & fuel economy has dropped over time."). *See also Shortchanged*, *supra* note 16, at 15 (explaining that "recent technological advancements have likely disrupted any historical tradeoffs between fuel economy and vehicle features"). Furthermore, there may be technical limits on increasing performance traits like acceleration, as well as diminishing marginal willingness to pay among consumers for additional performance traits. *See id.*

[43] *See* Antonio M. Bento et al., *Flawed Analysis of U.S. Auto Fuel Economy Standards*, 362 Sci. 1119, 1119 (2018), https://doi.org/10.1126/science.aav1458.

[44] *See* Gloria Helfand & Ann Wolverton, *Evaluating the Consumer Response to Fuel Economy: A Review of Literature*, 5 Int'l Rev. Env't & Rsch. Econ. 103, 130 (2011), https://www.nowpublishers.com/article/Details/IRERE-0040 ("Only if there are limits on the total amount of efficiency that can go in a vehicle does economic theory predict that the marginal benefit of fuel economy should not equal its marginal cost.").

[45] *See* Christopher Knittel, *Automobiles on Steroids: Product Attribute Trade-Offs and Technological Progress in the Automobile Sector*, 101 Am. Econ. Rev. 3368, 3379 (2012); Thomas Klier & Joshua Linn, *The Effect of Vehicle Fuel Economy Standards on Technology Adoption*, 133 J. Pub. Econ. 41, 49 (2016). These two publications are often cited to support the notion of inherent tradeoffs. However, the authors never make any connection between opportunity costs and the energy efficiency paradox. The publications use historical data to observe possible tradeoffs that manufacturers may have made in the past between installing fuel economy technologies versus increasing the horsepower or weight of vehicles. *See also* EPA & NHTSA, Final Rulemaking to Establish Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Regulatory Impact Analysis 9-3 (2011) [hereinafter 2011 Heavy-Duty FRIA] ("[A]n additional explanation—adverse effects on other vehicle attributes—did not elicit supporting information in the public comments.")

[46] *See* Draft TAR, *supra* note 29, at 4-35 to 4-36.

[47] *See* SAFE FRIA, *supra* note 39, at 239 (relaying comments from industry that "manufacturers may apply turbocharging to improve not just fuel economy, but also to improve vehicle performance"); *see also id.* at 317.

[48] *See id.* at 320 ("[A] PHEV50 may have an electric motor and battery appropriately sized to operate in all electric mode through the repeated accelerations and high speeds in the US06 driving cycle, but the resulting motor and battery size enables the PHEV50 slightly to over-perform in 0-60 acceleration."); *see also id.* at 324 (concluding it is "an appropriate outcome" that certain electrification or hybridization options lead to a "small increase in passing performance").

[49] *See id.* ("[I]f a new transmission is applied to a vehicle, the greater number of gear ratios helps the engine run in its most efficient range which improves fuel economy, but also helps the engine to run in the optimal 'power band' which improves performance.").

[50] *See, e.g.*, SAFE FRIA, *supra* note 39, at 318–20 (explaining that the agencies' model for estimating compliance costs for light-duty vehicle regulations already accounts for such tradeoffs by holding key attributes "constant" to "maintain performance neutrality"); EPA & NHTSA, Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2, Regulatory Impact Analysis 8-7 (Aug. 2016), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100P7NS.PDF?Dockey=P100P7NS.PDF [hereinafter "2016 Heavy-Duty FRIA"] (explaining that "the technology cost estimates developed here take into account the costs to hold other vehicle attributes, such as size and performance, constant").

[51] *See* David Cooke, Union of Concerned Scientists, The Trade-Off Between Fuel Economy and Performance: Implications for the Mid-Term Evaluation of the National Program 7 (2016).

[52] Research suggests that manufacturers will instead produce different vehicles with mixes of fuel economy and other attributes, allowing those consumers who are willing to pay for extra attributes on top of fuel economy to do so, while those consumers who do not value extra attributes like acceleration as much can purchase cheaper but more efficient vehicles. *See* Kate S. Whitefoot, Meredith L. Fowlie & Steven J. Skerlos, *Compliance by Design: Influence of Acceleration Trade-Offs on CO_2 Emissions and Costs of Fuel Economy and Greenhouse Gas Regulations*, 51 Env't Sci. & Tech. 10,307, 10,308, 10,312, 10,313 (2018), https://www.regulations.gov/contentStreamer?documentId=NHTSA-2018-0067-11903&attachmentNumber=1&contentType=pdf (finding significant heterogeneity across vehicles and manufacturers, and noting that competition for those consumers who value acceleration will be reduced; also finding less of a change in sales composition between trucks and cars); *see also* Bento et al., *supra* note 43, at 1121 ("[B]oth the 2016 TAR and 2018 NPRM have likely overestimated compliance costs. Neither analysis considers the full extent of options that manufacturers have available to respond to these policies, including changes in vehicle prices, performance, and other attributes") (emphasis added).

[53] *See also Shortchanged*, *supra* note 16, at 32–33 (explaining that the agencies' constant-performance assumption in their compliance cost model in fact unavoidably increases performance attributes, such as when adding technology to maintain initial acceleration also improves passing acceleration).

[54] *See* SAFE Rule, *supra* note 33, at 24,612. (explaining that the "central analysis" in the Final Rule "does not account for the possibility that imposing stricter standards may require manufacturers to make sacrifices in other vehicle features that compete with fuel economy, and that some buyers may value more highly").

[55] *See id.* at 24,605 (reporting that, in one of the agencies' three preferred studies (Allcott & Wozney), consumers are only fully valuing future fuel savings if consumers were applying "discount rates of 24 percent or higher.").

[56] *See* Office of Mgmt. & Budget, Circular A-4: Regulatory Analysis 33 (2003).

[57] *See* Council of Economic Advisors, Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate 10–11 (Jan. 2017), https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf (explaining that the pre-tax rate of return to private capital, previously estimated at 7%, should be lowered below 7%).

[58] *See* Yowana Wamala, *Average Auto Loan Interest Rates: Facts & Figures*, ValuePenguin (Mar. 1, 2021), https://www.valuepenguin.com/auto-loans/average-auto-loan-interest-rates (examining national average car loan interest rates for a typical 5-year loan).

[59] *See Finance Rate on Consumer Installment Loans at Commercial Banks, New Autos 60 Month Loan,* FRED Economic Data, https://fred.stlouisfed.org/series/RIFLPBCIANM60NM (last visited Apr. 14, 2021) (providing historical interest rates on five-year car loans, with current rates set at approximately five percent).

[60] *See* SAFE Rule, *supra* note 33, at 24,612.

[61] *See id.* at 24,706–07.

[62] *See* 2011 Heavy-Duty FRIA, *supra* note 45, at 9-8 ("The agencies received no evidence indicating that constrained access to capital might explain the efficiency gap in this [heavy-duty] market."); 2016 Heavy-Duty FRIA, *supra* note 50, at 8-7 (reporting one study that did not find capital constraints to be a problem for medium- and large-sized businesses, though noting another study where access to capital was a challenge for smaller businesses).

[63] *See* Heather Klemick, Elizabeth Kopits, Keith Sargent & Ann Wolverton, *Heavy-Duty Trucking and the Energy Efficiency Paradox*, Nat'l Ctr. for Env't Econ. 12, 20 (Jan. 2014), https://19january2017snapshot.epa.gov/sites/production/files/2014-12/documents/heavy-duty_trucking_and_the_energy_efficiency_paradox.pdf.

[64] If a consumer anticipates selling the car before the end of its life, the value of the remaining fuel savings would be reflected in the car's resale value, and so should still accrue to the vehicle's initial purchaser.

[65] *See* Comments from University of California, Berkeley's Environmental Law Clinic, 16–17 (Sep. 5, 2018), https://www.regulations.gov/document?D=EPA-HQ-OAR-2018-0283-0879 (citing a November 2016 memorandum commissioned by EPA, identifying over 60 financial institutions that offer loan rate reductions to consumers that purchase fuel-efficient vehicles); Memorandum from Hsing-Hsiang Huang & Gloria Helfand to EPA, Lending Institutions That Provide Discounts for More Fuel-Efficient Vehicles (Nov. 2016), https://www.regulations.gov/document?D=EPA-HQ-OAR-2015-0827-5832 ("EPA believes this information is valuable in illustrating the current practice of lenders providing green auto loans that factor in the consumer fuel savings from more efficient vehicles into the lending terms.").

[66] *See, e.g.*, Volvo Group, Comments on Proposed Advanced Clean Truck Regulation (Dec. 9, 2019), https://www.arb.ca.gov/lists/com-attach/74-act2019-WjtXMgZzWFQCZ1I9.docx (arguing that the heavy-duty vehicle market faces different energy efficiency issues than the light-duty market because "different buyer motivations, lower vehicle volumes and diverse market segmentation mean that the economy of scale wheels will turn much more slowly").

[67] *See* Klemick, *supra* note 63, at 12.

[68] *See* Fraas, *supra* note 17, at 467–68.

[69] *Id.* at 474. This study should be interpreted carefully, as it suffers from: small sample size according to the authors and limited spatial variation; a narrow definition of the principal-agent problem; and measurement error in their key principal-agent variable due to difficulty measuring truck-trailer ownership. In comparison, the authors present stronger evidence of incomplete information.

[70] *Compare id.* (reporting observations along particular east-coast highways from 2015-2017) *with* Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, 76 Fed. Reg. 57,106 (Sept. 15, 2011) (establishing greenhouse gas emissions and fuel efficiency standards for medium- and heavy-duty engines and vehicles starting with model year 2014).

[71] *See* David Greene, Anushah Hossain, Julia Hofmann, Gloria Helfand & Robert Beach, *Consumer Willingness to Pay for Vehicle Attributes: What Do We Know?*, 118 Transp. Rsch. Part A: Pol'y & Prac. 258 (2018), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6260949/ (meta-analysis of the academic literature regarding consumers' willingness to pay for fuel economy and other attributes); *see also* Marcel Stadelmann, *Mind the gap? Critically reviewing the energy efficiency gap with empirical evidence*, 27 Energy Res. & Soc. Sci. 117, 120, 126 (2017).

[72] *See* National Academy of Sciences, *supra* note 18, at 11-351.

[73] *See* David L. Greene, *Implications of Behavioral Economics for the Costs and Benefits of Fuel Economy Standards*, 6 Current Sustainable/Renewable Energy Rep. 177, 182 (2019) (describing research on how people make fuel economy decisions that found few study participants made any fuel calculations at all when purchasing a vehicle).

[74] *See* National Academy of Sciences, *supra* note 18, at 11-346 (2021) (discussing evidence for the existence of the energy efficiency gap and concluding that "there is general agreement that the actual fuel savings realized over time should be fully valued in cost-benefit analyses" of fuel economy standards).

[75] Note that this is distinct from risk aversion, which can be rational. *See* Heather Klemick et al., *Heavy-Duty Trucking and the Energy Efficiency Paradox: Evidence from Focus Groups and Interviews*, 77 Transp. Rsch. Part A: Pol'y & Prac. 154, 163–64 (2015).

[76] David L. Greene, *Consumers' Willingness to Pay for Fuel Economy and Implications for Sales of New Vehicles and Scrappage of Used Vehicles*, Env't Defense Fund 5 (Oct. 21, 2018), https://www.edf.org/sites/default/files/CARB_Report_Greene_UTenn_Consumer_Behavior_Modeling.pdf (describing behavioral economic explanations for the fuel efficiency paradox, including loss aversion).

[77] Klemick et al., *supra* note 75, at 163–64 (finding that "[f]leet managers' concern about uncertainty is consistent with loss aversion, a behavioral pattern in which individuals facing risky choices place greater weight on losses compared to gains of an equivalent monetary value and that "firms in our sample do not behave as risk neutral profit-maximizers with full information when investing in tractor fuel economy").

[78] *See* Kellen Mrkva et al., *Moderating Loss Aversion: Loss Aversion Has Moderators, But Reports of its Death Are Greatly Exaggerated*, 30 J. Consumer Psych. 407–28 (2020).

[79] David L. Greene, *Implications of Behavioral Economics for the Costs and Benefits of Fuel Economy Standards*, 6 Current Sustainable/Renewable Energy Rep. 177, 182 (2019) (noting that the result "is especially surprising because three of the ten groups were comprised of (1) college or graduate students nearing graduation, (2) computer hardware or software engineers, and (3) professionals in the financial services sector").

[80] *See id.* at 183.

[81] *Id.* at 190.

[82] *See* James Sallee, *Rational Inattention and Energy Efficiency*, 57 J. Law & Econ. 781, 782–85 (2014). With incomplete information, it is possible that some consumers may overestimate their savings from purchasing more efficient

vehicles, while other consumers underestimate those savings. Several studies, however, show a bias pointing toward underestimation, especially in combination with loss aversion. *See supra* notes 78-79; *see also* Policy Integrity Comments on the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule, 35–40 (Oct. 26, 2018), https://policyintegrity.org/documents/Emissions_Standards_EPA_NHTSA_Comments_Oct2018.pdf (noting the limitations of studies by Allcott & Wozny, Sallee et al., and Busse et al.).

83 These kinds of "experience goods" can create market failures. *See* Cass R. Sunstein, *Rear Visibility and Some Unresolved Problems for Economic Analysis (with Notes on Experience Goods)*, 10 J. Benefit-Cost Analysis 317 (2019). Experience goods have been associated with plug-in hybrids. *See* Margaret Taylor & K. Sydny Fugita, *Consumer Behavior and the Plug-In Electric Vehicle Purchase Decision Process: A Research Synthesis* 9, 49 Lawrence Berkeley Nat'l Lab'y (Jan. 31, 2018).

84 2016 Heavy-Duty FRIA, *supra* note 50, at 8-4 to 8-5 (noting that information acquisition may be especially difficult for smaller businesses with less capacity to do in-house testing of new technologies).

85 Gloria Helfand & Reid Dorsey-Palmateer, *The Energy Efficiency Gap in EPA's Benefit-Cost Analysis of Vehicle Greenhouse Gas Regulations: A Case Study*, 6 J. Benefit Cost Analysis 432, 439 (2015).

86 *See* Kenneth Gillingham, Sébastien Houde & Arthur van Benthem, *Consumer Myopia in Vehicle Purchases: Evidence from a Natural Experiment*, Nat'l Bureau of Econ. Res. (May 2019), https://www.nber.org/system/files/working_papers/w25845/w25845.pdf.

87 *See id.* at 2.

88 *See id.*

89 *Id.*

90 *Id.* at 4.

91 EPA Science Advisory Board, Consideration of the Scientific and Technical Basis for the EPA's Proposed Rule Titled The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks 21 (Feb. 27, 2020), https://yosemite.epa.gov/sab/sabproduct.nsf/LookupWebReportsLastMonthBOARD/1FACEE5C03725F268525851F006319BB/$File/EPA-SAB-20-003+.pdf (citing D. Duncan et al., *Most Consumers Don't Buy Hybrids: Is Rational Choice a Sufficient Explanation?* 10 J. Benefit-Cost Analysis 1 (2019)).

92 *See* Suresh Muthulingam et al., E*nergy Efficiency in Small and Medium-Sized Manufacturing Firms*, 15 Mfg. & Serv. Operations Mgmt. 596, 612 (2013) (finding that manager inattention contributed to the non-adoption of energy efficiency initiatives, since initiatives that appear lower on a list of efficiency recommendations, and initiatives that require more managerial attention, are less likely to be adopted); Fraas et al., *supra* note 17 (finding that poor management has a statistically significant negative effect on the adoption of fuel improving technologies using non-compliance with federal standards as a proxy variable for poor management).

93 A similar dynamic could exist in government if officials are rewarded for short-term cost savings rather than long-term fiscal health.

94 This incentive could be muted by a firm's accounting practices if costs and expenses are amortized over time.

95 *See* Sheila Bair, *Short-Termism and the Risk of Another Financial Crisis*, Wash. Post (July 8, 2011) (op-ed by the former Chair of the FDIC, in which she calls short-termism a "market failure"); Marc Jarsulic et al., *Long-Termism of Lemons*, Ctr. for Am. Progress Rep. 11–12 (Oct. 2015), https://cdn.americanprogress.org/wp-content/uploads/2015/10/21060054/LongTermism-reportB.pdf (including a section called "short-termism as a market failure" attributed to "asymmetric information between managers and investors" and "behav[ing] myopically"); Lynne L. Dallas, *Short-Termism, the Financial Crisis, and Corporate Governance*, 37 J. Corp. L. 265, 310–16 (2012) (reviewing various explanations for short-termisms, including asymmetric information and myopia).

96 *See* Stephen J. DeCanio, *Barriers Within Firms to Energy-Efficient Investments*, 21 Energy Pol'y 906, 907–08 (1993) (explaining how tying management compensation to short-term performance can lead to underinvestment in energy efficiency, and also how stock markets and investors may not be able to detect inefficient management decisions); Suresh Muthulingam et al., *Adoption of Profitable Energy Efficiency Related Process Improvements in Small and Medium Sized Enterprises* 1, 7 (Working Paper, 2008) (finding that managers fail to implement energy efficiency improvements with short payback periods for several reasons, including myopia and a stronger focus on upfront costs than on net benefits, attributed partially to short-termism).

97 *See* Yujing Gong & Kung-Cheng Ho, *Corporate Social Responsibility and Managerial Short-Termism*, Asia-Pacific J. Accounting & Econ. (2018).

98 Robert H. Frank, *The Demand for Unobservable and Other Nonpositional Goods*, 75 Am. Econ. Rev. 101, 107 (1985) ("When an individual's ability level cannot be observed directly, such observable components of his consumption bundle constitute a signal to others about his total income level, and on average, therefore, about his level of ability. . . [I]mperfect information about ability might create incentives for people to rearrange consumption patterns to favor observable goods.").

[99] Specifically, a majority of people surveyed would trade a decrease in their car's absolute value for an increase in its relative value compared to other people's cars: in other words, they are happy to have their car lose value so long as everyone else loses more value on average. *See, e.g.*, Fredrik Carlsson et al., *Do You Enjoy Having More than Others? Survey Evidence of Positional Goods*, 74 Economica 586, 588, 593 (2007) (reporting results of a Swedish survey and finding support for the hypothesis that "visible goods and their characteristics, such as the value of cars, are more positional than less visible goods and their characteristics, such as car safety"); Francisco Alpizar, Fredrik Carlsson & Olof Johansson-Stenman, *How Much Do We Care About Absolute Versus Relative Income and Consumption?*, 56 J. Econ. Behav. & Org. 405, 412 (2005) (reporting results of Costa Rican survey). Though some such surveys were conducted in other countries, positionality for cars likely would be stronger in the United States, given the American affinity for cars and the income distribution. *See* Reid R. Heffner, Kenneth S. Kurani & Thomas S. Turrentine, *Effects of Vehicle Image in Gasoline-Hybrid Electric Vehicles* 2 U.C. Davis Inst. Transp. Stud. (2005) ("In the words of automobile psychologist G. Clotaire Rapaille, Americans are in 'a permanent search of an identity' and 'cars are very key . . . [they are] maybe the best way for Americans to express themselves.'") (citations omitted); Ed Hopkins & Tatiana Kornienko, *Running to Keep in the Same Place: Consumer Choice as a Game of Status*, 94 Am. Econ. Rev. 1085 (2004) (noting that positional effects increase as society's income increases, because the portion of income spent on conspicuous consumption increases); *see also* Birgitta Gatersleben, *The Car as a Material Possession: Exploring the Link Between Materialism and Car Ownership and Use, in* Auto Motives 137-48 (Karen Lucas, Evelyn Blumenberg & Rachel R. Weinberger eds., 2011), https://doi.org/10.1108/9780857242341-007; Bryan Lufkin, *What Google Street View Tells Us About Income*, BBC (Jan. 6, 2018), https://www.bbc.com/worklife/article/20180105-how-your-car-signals-your-income; Liza Barth, *Cars As Status Symbols*, Consumer Rep. (Dec. 18, 2007), https://www.consumerreports.org/cro/news/2007/12/cars-as-status-symbols/index.htm; *Top 14 Status Symbol Cars at Bargain Prices,* MotorTrend (May 15, 2014), https://www.motortrend.com/news/top-14-status-symbol-cars-at-bargain-prices.

[100] Theory also predicts that manufacturers will overinvest in researching status features, at the expense of non-status features. *See* Ben Cooper et al., *Status Effects and Negative Utility Growth*, 111 Econ. J. 642 (2001).

[101] Until recently, fuel economy has been a relatively low-visibility, and therefore low-status, attribute. With the rise of luxury electric vehicles, fuel economy may be increasingly becoming a status symbol among very specific segments of consumers.

[102] *See* Robert H. Frank & Cass R. Sunstein, *Cost-Benefit Analysis and Relative Position*, 68 U. Chi. L. Rev. 323, 326 (2001) ("[W]hen a regulation requires all workers to purchase additional safety, each worker gives up the same amount of other goods, so no worker experiences a decline in relative living standards. If relative living standards matter, then an individual will value an across-the-board increase in safety more highly than an increase in safety that he alone purchases.").

[103] *See generally* Carolyn Fischer, *Imperfect Competition, Consumer Behavior, and the Provision of Fuel Efficiency in Light-Duty Vehicles*, Res. for the Future (2010), https://www.rff.org/documents/1472/RFF-DP-10-60.pdf.

[104] *See id.* at 3 (explaining that "the largest four firms accounted for 75.5 percent of the value of shipments in the automobile market and 95.7 percent of the light-duty and utility vehicle market"); *see also* Winston Harrington & Alan Krupnick, *Improving Fuel Economy in Heavy-Duty Vehicles*, Res. for the Future (2012), https://media.rff.org/documents/RFF-DP-12-02.pdf (explaining that the heavy-duty trucking industry "is dominated by a small number of large manufacturers" and is even smaller than it would seem at first glance because of "affiliations, partnerships, and outright ownership of one company by another").

[105] National Research Council, Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles 318–19 (2015), http://nap.edu/21744 (explaining that manufacturers may face a first-mover disadvantage for developing new fuel-efficiency technologies, and regulation can help overcome that perceived disadvantage as well as bring down costs through economies of scale and learning, and thus may "lead to a more optimal provision of fuel economy in the marketplace").

[106] *Id.* at 319.

[107] *Id.*

[108] *Id.*

[109] *Id.*

[110] *Id.*

[111] *See supra* on short-termism and myopia and text accompanying notes 85 to 97.

[112] *See* 2016 Heavy-Duty FRIA, *supra* note 50, at 8-8 ("Manufacturers may be hesitant to offer technologies for which there is not strong demand, especially if the technologies require significant research and development expenses and other costs of brining the technology to a market of uncertain demand."); *id.* at 8-9 ("HDV manufacturers may delay in investing in the development and production of new technologies, instead waiting for other manufacturers to bear the initial risks of those investments.").

[113] Because it creates externalities and coordination issues that raise the cost of developing beneficial technologies, the first-mover disadvantage facing manufacturers may also be an independent justification for government regulation of fuel economy, beyond its contribution to the energy efficiency gap.

[114] *See* Klemick, *supra* note 63, at 12.

[115] *See id.* at 15; *see also* 2011 Heavy-Duty FRIA, *supra* note 45, at 9-3 ("[I]nformation has aspects of a public good, in that no single firm has the incentive to do the costly experimentation to determine whether or not particular technologies are cost-effective, while all firms benefits from the knowledge that would be gained from that experimentation."); 2016 Heavy-Duty FRIA, *supra* note 50, at 8-5 (noting that smaller businesses with less capacity to test new technologies in house are more likely to seek information from competitors).

[116] *See* David Vernon & Alan Meier, *Identification and Quantification of Principal–Agent Problems Affecting Energy Efficiency Investments and Use Decisions in the Trucking Industry*, 49 Energy Pol'y 266, 267 (2012) ("There are numerous market failures and barriers to investment in energy efficiency in the trucking industry. Split incentives described by principal–agent problems are an important class of existing market failures that obscure price signals.").

[117] *See id.* at 270–71 (finding that "[t]he separation of fuel cost payment and driver behavior . . . appears to be widespread. Up to 91% of trucking fuel consumption is exposed to this usage PA [principal-agent] problem); *see also* 2011 Heavy-Duty FRIA, *supra* note 45, at 9-5 (discussing both the split between truck owners, who may channel more investment into vehicle durability than fuel-efficiency, and truck operators; as well as the fact that truck renters may not readily observe fuel economy as opposed to rental costs); *id.* at 9-6 (citing a NAS report on the split incentives between tractor and trailer operators); 2016 Heavy-Duty FRIA, *supra* note 50, at 8-5 to 8-6 (summarizing the literature on splits between tractor operators and trailer owners, and between tractor operators and carrier subcontractors who pay for fuel).

[118] *See generally* Kenneth Gillingham & Karen Palmer, *Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence*, 8 Rev. Env't Econ. & Pol'y 18–38 (2014) (explaining how principal-agent problems and other market failures can explain the energy efficiency gap and provide a basis for regulatory intervention).

[119] Todd D. Gerarden, Richard G. Newell & Robert N. Stavins, *Assessing the Energy-Efficiency Gap* 24 Nat'l Bureau Econ. Res. (Jan. 2015), https://www.nber.org/system/files/working_papers/w20904/w20904.pdf.

[120] *See* Klemick et al., *supra* note 75, at 161 (explaining that a lack of infrastructure for natural gas refueling "gives rise to a classic 'chicken or egg' problem emblematic of network externalities: trucking firms hesitate to invest in natural gas vehicles due to lack of infrastructure, while fuel companies are reluctant to build the infrastructure until more vehicles are in operation").

[121] *See id.*; *see also* Shanjun Li et al., *The Market for Electric Vehicles: Indirect Network Effects and Policy Design*, 4 J. Ass'n Env't Res. Econ. 89 (2017) (analyzing how "EVs [electric vehicles] face several significant barriers to wider adoption, including the high purchase cost, limited driving range, the lack of charging infrastructure, and long charging time"); 2016 Heavy-Duty FRIA, *supra* note 50, at 8-7 to 8-8 (noting network externalities for natural gas fueling, repair facilities, and replacement parts).

[122] Resolving the coordination and informational problems facing the developers of network infrastructure may also be an independent justification for government regulation of fuel economy, beyond its contribution to the energy efficiency gap.

[123] *See Shortchanged*, *supra* note 16, at 24–28.

[124] *See id.* at 24–25.

[125] *See id.* at 26–27.

[126] *See id.* at 22 (explaining the relevant language from Circular A-4).

[127] *See generally* EPA, Guidelines for Preparing Economic Analyses 6–18, 19 (Dec. 17, 2010), https://www.epa.gov/sites/production/files/2017-08/documents/ee-0568-50.pdf [hereinafter EPA Guidelines].

[128] *See* National Research Council, *supra* note 105, at 315 ("Short payback periods imply high discount rates for fuel economy, which may indicate undervaluation of fuel economy"); *id.* at 317 (discussing studies that compared implicit consumer discount rates of 13%-42% with rational discount rate of 6%).

[129] *See* EPA Guidelines, *supra* note 127, at 6-1.

[130] *See* U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Programs 9, 13, 30 (2018), https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/14091/benefit-cost-analysis-guidance-2018.pdf.

[131] *See* Dlouhy, *supra* note 36.

[132] *See* David Shepardson, *GM Aims to End Sale of Gasoline, Diesel-Powered Cars, SUVs, Light Trucks by 2035*, Reuters (Jan. 29, 2021), https://www.reuters.com/article/us-gm-emissions-idUSKBN29X2AY.

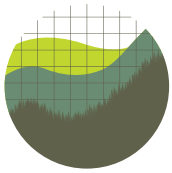
[133] *See* Anmar Frangoul, *Volvo Says It Will Be "Fully Electric" by 2030 and Move Car Sales Online*, CNBC (Mar. 2, 2021), https://www.cnbc.com/2021/03/02/volvo-says-it-will-be-fully-electric-by-2030-move-car-sales-online.html.

[134] *See* Dlouhy, *supra* note 36.

[135] *See* Draft TAR, *supra* note 29, at 4-32.

[136] *See* Erik Hille & Patrick Möbius, *Environmental Policy, Innovation, and Productivity Growth: Controlling the Effects of Regulation and Endogeneity*, 73 Env't Res. Econ. 1315, 1317 (2019) (reviewing literature supporting the Porter hypothesis and finding in an analysis of 14 manufacturing sectors across 28 OECD countries that "more stringent environmental regulation induces innovation").

[137] *See* Doug Obey, *Auto Sector GHG Stance Signals Ongoing Industry Split, Observers Say,* InsideEPA (Feb. 9, 2021), https://insideepa-com.proxy.library.nyu.edu/daily-news/auto-sector-ghg-stance-signals-ongoing-industry-split-observers-say.



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