DISCUSSION PAPER

May 2015 ■ RFF DP 15-16

New Markets for Pollution and Energy Efficiency

Credit Trading under Automobile Greenhouse Gas and Fuel Economy Standards

Benjamin Leard and Virginia McConnell

1616 P St. NW
Washington, DC 20036
202-328-5000 www.rff.org

RESOURCES FOR THE FUTURE

New Markets for Pollution and Energy Efficiency: Credit Trading under Automobile Greenhouse Gas and Fuel Economy Standards

Benjamin Leard and Virginia McConnell

Abstract

Recent changes to the Corporate Average Fuel Economy (CAFE) standards have created new opportunities for lowering the cost of meeting strict new standards through provisions for credit banking and trading. In this paper, we explore these new markets for reductions in both fuel consumption (fuel economy) and greenhouse gases (GHGs). We examine the two separate credits markets for fuel economy as regulated by NHTSA and for GHG gases under EPA and find that there are some important differences between them. For example, the market for NHTSA fuel economy credits has an effective credit price ceiling while the market for EPA GHG credits does not. We then evaluate the functionality of these markets using publicly available data on credit holdings and trades through 2013. Finally, we assess the potential for the following to interfere with well-functioning markets: overlapping regulations, lack of additionality, thin markets, and use of monopoly power. We find that features of robust trading markets are missing in these early years, and suggest reasons why. We also explore the implications of the fact that the two regulations are almost fully overlapping.

Key Words: credits, pollution markets, CAFE rules, GHG reductions

JEL Classification Numbers: Q48, Q52, Q58, R48

Contents

Introduction **1**

Description of Credit Programs under the New NHTSA and EPA Rules **3**

Overview of NHTSA and EPA Regulations and Credit Provisions and Markets 3

Defining Credits 4

Credit Flexibility Mechanisms: Averaging, Banking and Trading 6

Differences between NHTSA and EPA Credit Programs **7**

Observed Market Outcomes **10**

Evidence of Averaging, Banking and Trading 10

Credit Prices 15

Market Assessment and Lessons from Other Pollution Regulations **17**

Overlapping Regulations 18

Zero Emissions Vehicle Regulations in California and Participating States 22

Additionality of Earned Credits 22

Transparency and Thin Markets 25

Market Power 27

Conclusion **29**

References **32**

New Markets for Pollution and Energy Efficiency: Credit Trading under Automobile Greenhouse Gas and Fuel Economy Standards

Benjamin Leard and Virginia McConnell*

Introduction

Regulatory mechanisms that allow sources flexibility in meeting pollution targets have become prevalent and range from crediting and banking within sources to credit trading across sources. In the absence of a national cap-and-trade market for carbon, industry and regional market-based policies are becoming increasingly important for cost-effective carbon reduction and for energy efficiency improvements (Burtraw et al. 2014). Transportation is one sector where flexible mechanisms have not been easy to implement because of the large number of sources and the difficulty of measuring energy use or emissions from individual sources. But with recent changes to the Corporate Average Fuel Economy (CAFE) standards, new opportunities are for credit trading are emerging to meet both the greenhouse gas and fuel efficiency standards.

The new CAFE and greenhouse gas (GHG) standards from the US Environmental Protection Agency (EPA) are a dramatic departure from previous policy. From the early 1980s through 2005, CAFE standards had been relatively unchanged. The new standards were established in 2011 jointly by the National Highway Traffic and Safety Administration (NHTSA) and EPA, with increasingly strict limits on both fuel economy and GHG emissions for each manufacturer for model years 2012 through 2025. To lower the costs of these new ambitious standards, the regulations began allowing vehicle manufacturers to buy and sell fuel economy and GHG credits with one another. The potential for savings could be large because the regulations present uncertain and different costs to the various manufacturers and prohibitively large penalties in lieu of compliance under EPA rules. In addition, annual tightening of the standards until 2025, and perhaps beyond, presents particular obstacles when individual vehicle redesign schedules occur over multi-year periods.

In this review, we focus on the prospects and implications for credit trading under the new CAFE rules in the United States. A number of other countries also have light duty fuel

* Leard: fellow, Resources for the Future, leard@rff.org. McConnell: senior fellow, Resources for the Future, mcconnell@rff.org.

economy or vehicle carbon dioxide (CO_2) regulations, and some are beginning to include flexible mechanisms for compliance. In both the European Union and Japan, regulations are based on vehicle weight, while US standards are based on vehicle footprint. In the EU, manufacturers are allowed to pool their fleets to meet an aggregate standard and in Japan, a manufacturer can use credits accumulated from one weight class for use in another (Anderson et al. 2011). Both Canada and Mexico have recently adopted regulations similar to those in the United States, and Canada's program includes some credit trading provisions. In all cases, the rules around the world are becoming increasingly stringent and there is concern over the increasing costs of compliance over time. There should be useful lessons from the early experience in the United States for other countries who are considering credit trading programs to lower the costs of achieving their energy and GHG goals.

While these new markets in the United States are just emerging, they offer the promise of lowering costs of achieving the strict new CAFE and GHG standards. We find that some features of these new markets are similar to current and past pollution trading markets. For example, we find significant evidence of early credit banking, which is consistent with behavior observed in other pollution trading programs when standards were designed to become stricter over time. And, we find evidence of within firm credit trading, allowing for cost reductions from increased flexibility, even if there is little trading across companies. There have been, in fact, only a small number of trades between companies during the first two years of the market, and we identify a number of possible reasons for this lack of activity. Features of a robust trading market, such as price transparency and low information and transactions costs, appear to be missing in these early years. We find there are reasons, though, that market design and activity could increase in the future. Finally, we identify a unique feature of these regulations that will have important effects on trading and outcomes in these markets. The separate CAFE and GHG rules have created two credit markets for essentially the same asset. Using a simple conceptual framework of the two markets, we show how these overlapping regulations are likely to influence pricing and trading activity in both markets.

In the remaining sections, we will summarize the two trading programs, examine preliminary evidence from the first few years of operation, and identify both unique features of these programs and possible lessons from the experience of other market-based policies.

Description of Credit Programs under the New NHTSA and EPA Rules

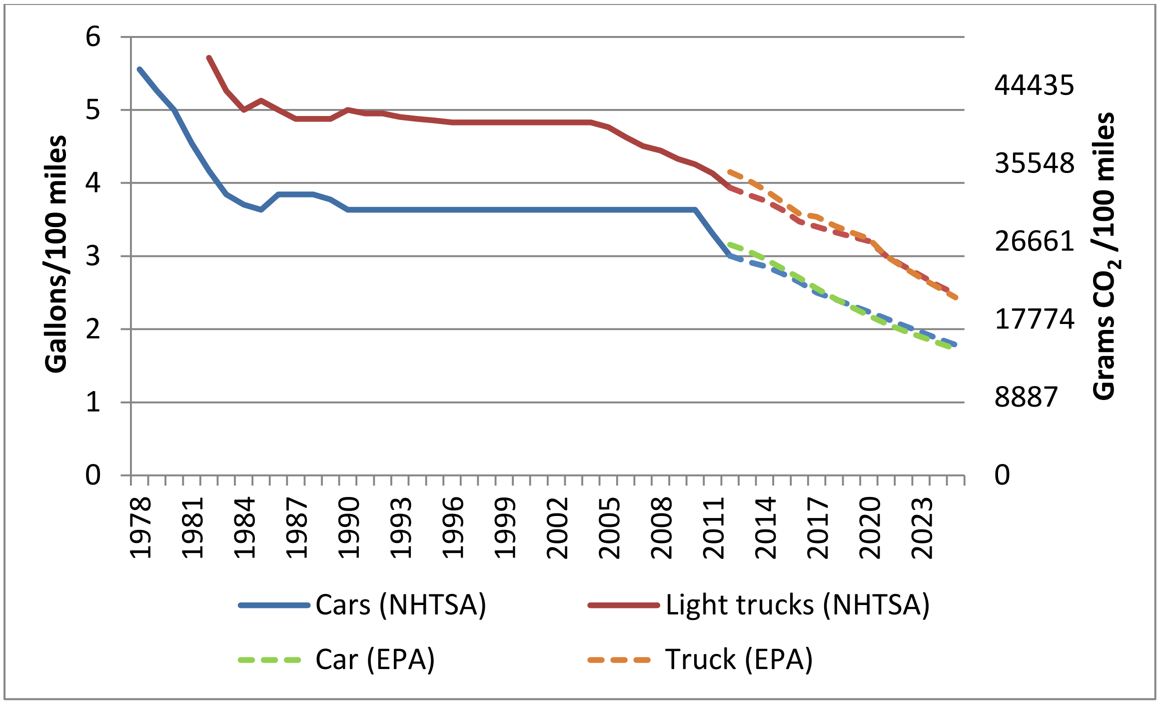
Overview of NHTSA and EPA Regulations and Credit Provisions and Markets

The CAFE standards have been in effect since the mid-1970s, and were intended to reduce energy use from light duty vehicles with the intention of improving energy security and saving consumers money.[1] The standards required each manufacturer's fleet of vehicles sold to meet a minimum average miles per gallon (mpg). Cars and light trucks faced separate standards, with trucks facing lower sales weighted average fuel efficiencies for each manufacturer's fleet than cars. Trading between cars and trucks or across manufacturers was not allowed under these early rules. There were a number of changes in 2008 under the Energy Independence and Security Act (EISA). One such change was that NHTSA was *required* to set standards for vehicle fuel efficiency each year at "maximum feasible" levels through 2030. The other major change in recent years occurred when EPA was given authority to regulate GHG emissions from vehicles for the first time.

Because of there is a linear relationship between a vehicle's gasoline consumption and its CO_2 tailpipe emissions, these policy changes led to overlap in the agencies' regulations. NHTSA and EPA subsequently developed the standards for fuel economy and GHG emissions jointly in two phases covering the 2012 to 2025 model years. Figure 1 shows the changes over time in both the CAFE standards (NHTSA) and the GHG standards (EPA). The new standards shown as dashed lines in the figure, beginning with model year 2012. The CAFE standards are displayed as gallons per mile for consistency with the EPA standards. The Figure illustrates how these recent standards are projected to roughly double in stringency by 2025 from the 2012 level. The two rules are entirely separate and are both binding on the manufacturers, but are intended to be consistent with each other (Federal Register, vol. 77, no. 199, 2012).

[1] Light duty vehicles include passenger cars and light trucks that have a gross vehicle weight rating below 8,500 lbs. These vehicles are typically used for private transportation.

Figure 1. CAFE Standards, Past and Future (Gallons per 100 Miles), and EPA GHG Standards (Grams CO_2 per 100 Miles)



Source: McConnell, 2013. Differences between the NHTSA fuel economy standards and the EPA greenhouse gas standards during the years of the new standards from 2012 – 2025 are due to differences in non-tailpipe emissions accounted for by EPA but not by NHTSA. Grams of CO_2 per mile forecasts from www.**epa.gov**/oms/climate/documents/420f12051.pdf

Due to concern over the potentially high cost of the regulations, a number of new provisions were added to both rules to give the companies more flexibility in meeting the standards. These include the ability for manufacturers to trade credits between their cars and trucks and to trade with other manufacturers. The EPA rules also allowed manufacturers to over-comply with a target before the rules went into effect and bank credits future compliance beginning in 2012. [2]

Defining Credits

Both NHTSA and EPA allow credits to be earned by the manufacturers, but the two agencies define them differently. For EPA, the greenhouse gas standards are in terms of grams of

[2] NHTSA has long allowed banking to meet CAFE standards.

CO_2e per mile (g/mile).[3] Under the current footprint standard, each vehicle sold has a different g/mile target, and each manufacturer will have a fleet g/mile standard that is a weighted average of these target levels for the vehicles it sells. Thus, each manufacturer has a different standard, depending on its mix of vehicle sizes. For example, the standard for a manufacturer in 2014 might be 232 grams per mile. That manufacturer earns credits when it produces a sales-weighted average fleet with fewer grams of CO_2e per mile than the standard. Credits are earned for grams of CO_2e saved beyond the standard over the life of the vehicles exceeding the standard. Credits are recorded in metric tons or Megagrams (Mg) of CO_2e.[4] Deficits are generated when the manufacturer's fleet emissions exceed its standard.

NHTSA rules are similar, in that each vehicle has a different mpg target depending on its footprint. Each manufacturer therefore faces a different standard depending on the sales-weighted average fuel economy of the vehicles it sells. A manufacturer earns credits when the vehicles it produces have higher weighted average mpg than its standard. A credit is earned for each $1/10^{th}$ mpg difference between the standard and the actual mpg for each vehicle. Total credits earned by a manufacturer are the sum of these differences across all vehicles produced in a given year. Deficits or shortfalls in meeting the standard are the opposite – a manufacturer producing vehicles that on average have greater fuel use than the standard face a shortfall. Trading credits under the NHTSA rules requires that these credits must be adjusted to account for differences in car and truck VMT and initial mpg.[5] In other words, credits must be traded based on fuel use. Therefore, credits are defined in a consistent way across both the EPA and NHTSA rules – there are 8.887 Mg CO_2e per gallon of gasoline.

There are additional ways to gain credits beyond fleet tailpipe emissions and fuel use. For example, both agencies grant credits for non-tailpipe fuel and emissions reductions, such as improvements to air conditioning systems that result in fuel and emissions reductions. These credits can be used to reduce a vehicle's GHG emissions rate for the EPA rules, or improve a vehicle's fuel economy under the NHTSA rules, and are thus similar to tailpipe credits. The EPA also awards manufacturers additional credits for including alternative fuel vehicles, such as

[3] CO_2e includes all GHG pollutants indexed to CO_2 level of damages.

[4] Grams/mile of CO_2e are converted to total Mg over the life a vehicle by standard assumptions about vehicles miles travelled (VMT) over the life of a vehicle. Total miles are assumed to be 195,264 for cars and 225,865 for trucks.

[5] NHTSA credits, in mpg, cannot be traded one for one between vehicles or among manufacturers because changes in fuel consumption arising from a fixed mile per gallon change depend on the base mpg. A one mpg change from 10 to 11 mpg results in a different amount of fuel reduced than a change from 30 to 31 mpg.

electric or fuel cell vehicles, in their fleets. The NHTSA rules do not allow crediting for alternative fuel vehicles.[6]

Credit Flexibility Mechanisms: Averaging, Banking and Trading

The intent of the credit program is to allow the regulatory goals of reducing GHG emissions and energy use from the light duty fleet to be achieved at the lowest possible costs to the manufacturers and to society. A large body of literature that has shown that this will occur when the marginal costs are equal across sources, or in this case when the additional cost of reducing another unit of GHG emissions (gasoline used) is equal across vehicles. When the agencies are regulating to reduce emissions (gasoline use) over time, they effectively set a limit on each manufacturer's emissions in each period. Allowing manufacturers to achieve that limit at lowest cost means that each manufacturers must be allowed to vary the emissions of vehicles in its own fleet to equate the costs of the last unit reduced. This is often referred to as averaging, and can result in large savings compared to the case where each vehicle has to meet an individual standard (Rubin, 1996). Allowing firms to bank credits in one period and use them to comply in future years will allow firms to achieve the lowest cost over time.

Further, because manufacturers have different fleets and different markets they serve, there will also be cost savings if manufacturers can trade credits or permits between themselves. Low cost firms can have better performance than the overall standard, and will earn credits, which they can then sell to firms that have higher marginal costs (Montgomery, 1972). As long as transactions costs are low, and there is no market power vested in a small number of firms, allowing firms to trade GHG emissions credits among themselves will drive the costs of compliance down (Tietenberg, 2006).

Below we outline the averaging, banking and trading provisions of the new rules, and then and present preliminary evidence on how automakers are utilizing each provision.

Credit Averaging across Car and Truck Fleets

Averaging within a manufacturer's car fleet and truck fleet has always been allowed under CAFE, and the EPA rules adopt this provision as well. The new rules now allow a manufacturer to trade credits between its car and truck fleets for the first time. Under both

[6] See Schoettle and Sivak (2014) for a summary.

NHTSA and EPA rules, a manufacturer can transfer credits between its own car and truck lines starting in the 2012 model year. For example, a manufacturer failing to meet the truck standard can over-comply in its car production and transfer the credits to the truck fleet to make up the shortfall.

Banking, Backward and Forward

Credits can be banked to offset possible future shortfalls or carried backward to cover deficits in earlier years. Both NHTSA and EPA allow credits to be traded back and forward over time. Firms can carry credits up to five years into the future and back in time for up to three years. For example, a company failing to comply with its average standard for cars this year can over-comply in one or more of the next three years to show compliance for this year. The EPA grants manufacturers with additional banking flexibility by allowing credits earned from 2010 to 2016 to be used for compliance through 2021.

To grant companies flexibilities and to further harmonize the GHG program with existing CAFE standards, the EPA created an Early Crediting Program, which allowed manufacturers to voluntarily opt in and earn early GHG credits. The program approximately mimics the existing banking mechanism in CAFE standards.

Trading between Manufacturers

Trading between companies is now allowed under the CAFE and GHG rules, and for the first time allows a market to develop that should help to equalize marginal costs between companies and lower the overall costs of meeting both standards. Companies that have high costs or the greatest difficulties in complying can purchase credits from other companies. The standards, though related, are completely separate for both the NHTSA and EPA rules, and the trading markets for credits are therefore separate. Manufacturers may need to trade in both markets, as we discuss below. In addition, there is currently no setting for trades to take place and no transparency about prices of credits. At the present time, NHTSA does not report trading activity, while EPA does.

Differences between NHTSA and EPA Credit Programs

There are a number of differences between NHTSA and EPA rules about credits and credit trading. Manufacturers must satisfy both rules, but there are differences in how they can earn and use credits for compliance. Table 1 shows some of these differences. First, credits are defined differently as described above. Credits under NHTSA's rules are defined as $1/10^{th}$ mpg.

When credits are transferred or traded, manufacturers must first adjust the credits in an attempt to account for the amount of fuel saved. Credits under EPA's program are in Mg of GHGs so they are more directly transferable between vehicles or manufacturers. Additionally, NHTSA limits how many credits can be transferred by a manufacturer between its car and truck fleets, while EPA has no limits.

To grant credits, both agencies attempt to account for emissions or fuel used over the life of the vehicles, and they assume the VMT of cars is lower than that for trucks. The assumed mileage is currently different for the two agencies. EPA intends to use the same assumptions over the life of the regulation. NHTSA has different lifetime mileage in each year, but is likely to harmonize with EPA assumptions by the 2016 model year. Credits earned for a given model year will account for the lifetime fuel savings.

There are also provisions of the CAFE and GHG programs that affect the calculation of manufacturer's average fleet fuel use and emissions. Currently, flex-fuel vehicles (FFVs) are treated in a similar way by the two agencies.[7] They are allowed to be counted as having low CO_2e emissions, even though their actual emissions may be no different from a non-FFV of the same vintage. This favorable treatment for FFVs is currently set to expire at the end 2015 under the EPA rules, but it will not change for the NHTSA rules. There are a handful of manufacturers that earn substantial NHTSA credits by producing these vehicles.

There are other expected changes to the credit market that are likely to affect the ability of some manufacturers to earn credits in the future. The EPA's Temporary Lead-time Alternative Allowance Standards (TLAAS) for manufacturers with limited product lines is only in place through the 2015 model year. Under these provisions, manufacturers with sales less than 400,000 in the United States in 2009 are allowed to meet a lower standard for model years 2012 to 2015. Manufacturers, such as Mercedes and Jaguar Land Rover are eligible for this exception and have complied with a more lenient standard. When this provision expires in 2016, complying with the standards will be even more difficult than it is now for many of these automakers. They have frequently paid penalties to NHTSA for violating CAFE standards in the past.

[7] A flex-fuel vehicle has an internal combustion engine that can run on more than one fuel, such as gasoline blended with ethanol.

Table 1. Comparison of Credit Programs under NHTSA and EPA

Regulation	**NHTSA CAFE Program**	**EPA GHG Program**
Definition of a Credit	1/10th mpg below standard manufacturer’s required mpg	1 gram per mile CO_2e below the manufacturer’s required grams per mile standard
Assumed miles traveled per year	150,922 Cars 172,552 Trucks	195,264 Cars 225,865 Trucks
Credits for alternative fuel vehicles	No credits allowed	Allows manufacturers to count each alternative fuel vehicle as more than a single vehicle. Multipliers: 2.0 to 2018, 1.6 to 2022, and 1.2 to 2025. Emissions from battery electric vehicles assumed to be zero.
Credits for non-tailpipe reductions, A/C and off-cycle	Credits allowed for A/C system efficiency improvements that reduce fuel use.	Credits granted for GHG reductions due to improved A/C efficiency, reduced A/C leakage, and other emissions reductions that are not counted in the tailpipe test.
Flex Fuel Vehicles (FFVs)	FFVs accounted for as specified under EISA, assumed to have low gasoline consumption relative to gasoline engine.	FFVs earn credits according to EISA provisions; but special treatment for FFVs ends in 2015.
Credit Banking (Carry forward)	5 year banking period	From 2009 to 2011, companies banked credits through the Early Crediting Program; 5 year banking period, with the exception that credits earned between 2010 and 2016 can be carried forward through 2021
Credit Borrowing (Carry back)	3 year carry back period	3 year carry back period
Limits on credits transfers between car and truck fleet for a manufacturer	Limits on credits that can be transferred between cars and trucks: MY 2011- 2013, 1 mpg MY 2014 -2017, 1.5 mpg MY 2018 on, 2.0 mpg	No limits on transfers between cars and trucks in each manufacturer’s fleet
Other credit usage limits	Credits cannot be used to meet the domestic minimum fuel economy standard	No differences for domestic fleets
Exemptions	No exemptions for manufacturers with limited product lines; fines can be paid.	Temporary Lead-time Alternative Allowance Standards (TLAAS) for manufacturers with limited product lines through 2015; also exemptions for operationally independent manufacturers
Non-compliance penalties	$5.50/tenth mile over standard, per vehicle	Unknown, but could be as high as $37,500 per car

A final difference between the two agencies is the penalty for non-compliance. Under NHTSA, manufacturers have been allowed to pay penalties for non-compliance. This is like a "safety valve" on the costs of the regulations. If the rules turn out to be more expensive than anticipated or fall more heavily on some firms than others, there is a limit on the cost of additional reductions. Under the EPA regulations, which are governed by the Clean Air Act, penalties are unknown at this point but they could be extremely high.[8]

Observed Market Outcomes

In this section, we analyze data from public reports published by the NHTSA and EPA to identify how automakers are utilizing the credit markets and other flexibility mechanisms to comply with the two standards. We also use this section to estimate credit prices. EPA makes more data publically available than NHTSA, including actual credit trades, so most of what we report is for EPA compliance.

Evidence of Averaging, Banking and Trading

Preliminary compliance data suggest that automakers are using the flexibility mechanisms to reduce compliance costs of both the CAFE and EPA GHG programs. We cannot determine from available data, for example, the extent of credit transfers between cars and truck fleets within each manufacturer's fleet, but our data suggest that some transfers are occurring. We do, on the other hand, observe significant banking behavior, as companies are over-complying with current standards, either because the standards are not binding on some manufacturers, or they are banking in anticipation of using the banked credits in later years under more stringent future standards. There has also been a limited amount of trading activity between companies. In the next three subsections, we present preliminary evidence on how companies are using the flexibility mechanisms to meet the standards.

Credit Transfers between Cars and Trucks

The preliminary evidence is that in the first two years of the EPA GHG program manufacturers as a whole earned many more credits in their passenger car fleets than they did

[8] Penalties under violations of the EPA standards could be as high as $37,500 per vehicle, but they could also be lower. If vehicles are sold without a certificate, they violate the Clean Air Act. The actual amount of the penalty would likely be worked out by a Consent Decree and could depend on a range of factors in practice. The details are still to be worked out.

from their light duty truck fleets.[9] Table 2 shows the total number of EPA credits earned minus deficits, denoted as net credits, by all of the manufacturers from cars and trucks produced in each of the years from 2009 to 2013. Years 2009 to 2011 were when early credits could be accumulated before the standards came into effect starting with the 2012 model year. In 2012 and 2013, some companies over-complied and some did not meet the standards (EPA, 2015). Overall, however, the industry was in compliance (net credits are positive in each year), but only by a small amount. Total industry-wide emissions were lower than required by less than 1 percent in both 2012 and 2013. But it is also clear from Table 2 that while there was industry-wide over-compliance in both the car and truck categories, the magnitude of over-compliance is strikingly different between the two. In 2012, the entire industry over-complied by 29 million Mg of CO_2e for cars, which is several orders of magnitude more than the over-compliance for trucks. The general picture is no different in 2013. However, credits earned in the early credit years, from 2009 to 2011, shown in the third row of Table 2, indicate that this was not the case before 2012. During the years when the automakers could accumulate credits they were doing so at a nearly equal rate for cars and trucks. Throughout the period, cars made up about 64 percent of the new fleet each year, and light trucks the other 36 percent.

Although we cannot directly determine firm behavior from these data because of the banking and borrowing provisions, the data suggest that in the first few years the standards came into effect, in 2012 and 2013, it was easier to over-comply for passenger cars than for trucks. Moreover, at least some companies appear to be using their surplus car credits to meet the truck standards. Rubin et al. (2009), in simulations of the credit trading provisions of the new rules, found this type of trading between cars and trucks to be the most important source of cost savings to firms.

[9] NHTSA does not report data on credits earned by manufacturer. They do report NHTSA credits held in any period but it is not always possible to infer how many were earned in a given year.

Table 2. EPA GHG Net Credits and Total Emissions, by Model Year

Model Year	Passenger Vehicles		Light Trucks	
	Net Credits (million Mg)	Total Emissions (million Mg)	Net Credits (million Mg)	Total Emissions (million Mg)
2009*	57.91	1,600.69	40.11	1,247.43
2010*	50.53	1,716.27	45.06	1,666.98
2011*	8.29	1,676.92	28.56	1,934.53
2012	29.76	2,204.51	0.52	1,699.37
2013	38.05	2,402.95	0.83	1,888.27

Source: Based on http://www.epa.gov/otaq/climate/documents/ld-ghg-credits-2009-2013.csv
Notes: (1) Net credits are defined as the sum of credits earned minus deficits.
(2) * denotes an early crediting year.
(3) Both credits earned and total emissions are calculated over the life of the vehicles produced in a given model year.

Banking

Both NHTSA and EPA allowed early banking of credits between 2009 and 2011 model years in advance of the tightening of the standards which began in 2012. Many automakers used these banking provisions under both programs. Table 3 summarizes both the total early banked CAFE credits under the NHTSA program, and the total early GHG credits earned by each manufacturer prior to the start of the new standards.

Overall, this market behavior is what we would expect with lower costs before the standards begin.[10] This is also consistent with observed banking behavior in other emissions trading programs, including the Acid Rain Program. Ellerman and Montero (2007) find that capped firms spent the first five years of the program banking permits before starting to draw down their banked supply of permits for compliance in later years when the standards were tightened.

[10] One notable feature of the banking and early crediting programs is that a small subset of the manufacturers earned a majority of the credits. Between 2009 and 2011, Toyota and Honda banked 56% of the total CAFE credits and earned 58% of the total early GHG credits while only selling about 31% of passenger cars and light trucks during the time period. The big three of Ford, GM and Chrysler sold about 44% of all passenger cars and light trucks during this period but only earned about 23% of all GHG credits. Overall, however, every manufacturer with the exception of Jaguar Land Rover has banked some credits, suggesting that significant early action has been taken in preparation for the increasingly stringent standards.

Table 3. Banked CAFE and Earned Early GHG Credits and Vehicle Sales, 2009-2011

Manufacturer	2009-2011 Banked CAFE Credits		2009-2011 Early GHG Credits		2009-2011 Vehicle Sales	
	Million Mg	Share (%)	Million Mg	Share (%)	Million Mg	Share (%)
BMW	3.5	0.3	0.9	0.4	0.4	1.2
Chrysler	0	0	7.8	3.7	3.1	9.7
Daimler	0	0	0.4	0.2	0.6	1.9
Fiat	46.1	3.3	0	0	0.01	0
Ford	140.1	9.9	15.3	7.3	4.5	14.1
GM	173.9	12.3	24.6	11.8	6.1	19.0
Honda	268.8	19	35.5	17.0	3.5	10.9
Hyundai	78.6	5.6	NA*	NA*	1.4	4.3
Jaguar Land Rover	0	0	NA	NA	0.1	0.3
Kia	46.5	3.3	NA*	NA*	0.9	2.8
Mazda	27.7	2	5.5	2.6	0.7	2.2
Mitsubishi	10.1	0.7	1.4	0.7	0.3	0.9
Nissan	18.5	1.3	18.1	8.7	2.7	9.3
Subaru	34.9	2.5	5.8	2.8	0.7	2.2
Suzuki	7.1	0.5	0.9	0.4	0.1	0.3
Tesla	NA	NA	0.05	0	0.001	0
Toyota	520.5	36.8	86.1	41.2	5.9	20.3
Volkswagen	40.0	2.8	6.4	3.1	0.9	2.8
Volvo	0	0	0.4	0.2	0.2	0.6
Total	1,412.8	100	209.2	100	29.1	100

Sources: Banked CAFE Credits data are from Light Duty CAFE Credit Status 2008-2011; Early GHG Credits data are from Greenhouse Gas Emission Standards for Light-Duty Automobiles: Status of Early Credit Program for Model Years 2009-2011; Vehicle sales data are from the June 2014 Summary of Fuel Economy Performance (Public Version).
Notes: (1) Aston Martin, Lotus and Spyker omitted because of zero balances for both standards and relatively low sales.
(2) These balances are net of deficits. For example, if Nissan earns 19.5 million CAFE credits in 2009 but has a deficit of one million in 2010 and does not earn credits in 2011, then Nissan earned 18.5 credits during 2009-2011.
* Not reported because of investigation of emissions and fuel economy testing methods

Trading across Manufacturers

Trading between manufacturers is reported by the EPA for GHG credits, but NHTSA does not report trades between companies. There has been some trading in the NHTSA credit market, but there is almost no information about specific trades.

Since 2010, there has been only a small amount of modest trading activity under the EPA GHG program. Even though the firms did not have to show compliance with either rule until the 2012 model year, they were trading in anticipation of those rules. Table 4 reports the universe of EPA GHG credit trades from 2010 to 2013. These years were marked by six trades in 2012 and four trades in 2013 that occurred among six different companies.

Table 4. EPA GHG Credit Trades Through 2013

Transaction Year	*Credit Vintage*	*Buyer*	*Seller*	*Credit Sales (Mg)*	*Buyer Credit Balance Without Trades (Mg)*
2012	2011	Chrysler	Nissan	500,000	7,478,922
2012	2010	Ferrari	Honda	90,000	-40,983
2012	2010	Mercedes-Benz	Tesla	35,580	-370,521
2012	2011	Mercedes-Benz	Tesla	14,192	
2012	2012	Mercedes-Benz	Tesla	177,941	
2012	2012	Mercedes-Benz	Nissan	250,000	
2013	2010	Chrysler	Nissan	144,383	5,586,738
2013	2013	Chrysler	Tesla	1,048,689	
2013	2010	Mercedes-Benz	Nissan	55,617	-748,401
2013	2010	Mercedes-Benz	Honda	344,383	

Sources: Author calculations based on the Greenhouse Gas Emission Standards for Light-Duty Vehicles 2012 Report, the Greenhouse Gas Emission Standards for Light-Duty Vehicles 2013 Report and http://www.epa.gov/otaq/climate/documents/ld-ghg-credits-2009-2013.csv

One notable feature of the trades is that Mercedes-Benz has been an active buyer of EPA GHG credits, being involved as a buyer in six out of ten of the transactions. On the seller side, Tesla has been an active seller in the GHG credit market, selling credits of all available credit vintages.

To understand how companies appear to be using the bought credits, in the last column of Table 4 we list credit balances of the buyers of credits, where the balances do not include credit purchases. Two companies, Ferrari and Mercedes-Benz, have been active buyers to be close to compliant in each year that we have data. Chrysler, a much larger company, has been an active buyer while substantially over-complying with the EPA regulation. Since Chrysler can bank these credits for use through the 2021 model year, they may be forecasting that they will need more credits in the future as the standards are tightened.

These credit trades represent a small fraction of the total stock of banked EPA GHG credits. Moreover, only six companies have been involved in trades, and several of the largest companies, including Ford, GM, and Toyota, have not made any trades. This suggests that the credit markets in 2012 and 2013 may have been quite thin, which is not surprising. There are a relatively small number of automakers who are subject to the regulation, and most are relying on banking and averaging within their own fleets for now. Manufacturers that are out of compliance in 2013 may still not be entering the credits market because they know they can borrow credits from future years to comply today. In fact, a company with a deficit in 2013 does not need to be in compliance until 2016. In future years, we would expect that manufacturers would be more likely to have uneven compliance rates due to stricter standards and the phase in of new technologies that occurs on a roughly 5 year time cycle for a given make and model. Compliance rates in any given year may have little effect on which firms will enter the credit market.

Nonetheless, trading activity is likely to increase in the future as banked credits will expire after five years under the NHTSA market, and by 2021 in the EPA market. In addition, over time, both the car and truck standards increase in stringency, making it more difficult for some companies to rely solely on averaging their car and truck fleet credits, or banking to meet each standard.

Credit Prices

Credit prices are currently not publicly available. Identifying credit prices is valuable for numerous reasons. Information about prices provides all potential market participants with knowledge that they can use to profit-maximize. If manufacturers do not know what the typical market price is for a GHG credit, it will be more costly for them to choose whether to hold credits or sell them.[11]

Furthermore, credit prices reveal information about marginal costs, which is useful for estimating the overall costs of the standards. Under some circumstances, market prices identify the equilibrium marginal cost of each standard. Market prices may not equal marginal costs, however, if there are market distortions or overlapping regulations, which we provide evidence on later. They do, however, reveal useful information about costs to the market participants. Given profit-maximizing behavior, manufacturers that buy credits demonstrate that their private marginal revenue from buying credits exceeds their marginal cost. Although this does not reveal exact estimates of marginal cost of the standard, this information is useful for identifying ranges for marginal costs of the market participants.

[11] The costs of finding suitable trading partners are higher in thin markets especially in the absence of a centralized trading system (Klier et al. 1997).

We found two methods for calculating transaction prices based on publicly available data. We utilize several public sources based on quantity (trading) data, manufacturer annual reports, and an EPA press release to calculate credit prices for the EPA GHG program. To the best of our knowledge, public data necessary for calculating a NHTSA price are not available. Therefore, we focus on directly calculating EPA GHG prices and convert these prices to an equivalent NHTSA credit price.

In November 2014, the EPA and the US Department of Justice reached a settlement with Hyundai and Kia resolving violations of the Clean Air Act. The initial complaint was filed in response to the companies selling about 1.2 million model year 2012 and 2013 cars and SUVs that had overstated fuel economy figures. The settlement required both companies to forego 4.75 million EPA GHG credits in 2014, which the EPA "estimated to be worth over $200 million" (EPA 2014). Assuming that the credits are worth exactly $200 million in 2014 dollars, this equates to $193.97 million in 2012 dollars. Dividing this by the quantity (4.75 million) yields a credit price of 40.84 $/Mg, in 2012 dollars.

We perform a second computation based on different data. We merge trading quantities available in the document titled "Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2012 Model year" with revenue data from Tesla Motors Inc. available in the 2013 and 2014 SEC Filing Form 10-K to compute a 2012 and a 2013 EPA GHG credit price. Dividing revenue reported from GHG credit sales that were not ZEV credits by the total sales of EPA GHG credits sold by Tesla, we find that Tesla sold each GHG credit for an average of $35. This value is close to the value we calculated based on the Clean Air Act Settlement, providing assurance that the equilibrium credit price during this period was around $35-$40.

In Table 5, we convert the EPA GHG credit values to equivalent NHTSA credit prices, based on assumptions about the CO_2e content of a gallon of gasoline, mileage for cars and a baseline level of fuel economy and obtain a NHTSA credit price of $67.76 per mile per gallon per vehicle. This value is higher than the NHTSA fine of $55 per mile per gallon per vehicle, suggesting that the EPA GHG standard is more stringent than the CAFE standard that allows manufacturers to pay a relatively low fine.

Table 5. Calculating Credit Prices

Year	*Action*	*Value (million 2012 $)*	*Quantity (million Mg)*	*EPA GHG Price ($/Mg)*	*Equivalent NHTSA Credit Price ($/ mpg/vehicle)*
2012	Hyundai and Kia Clean Air Act Settlement	193.970	4.750	40.84	77.80
2012	Tesla Sales of EPA GHG Credits	8.100	0.228	35.57	67.76

Sources: 2013 and 2014 SEC Filing Form 10-K, Tesla Motors Inc.; Table 4-1 in Greenhouse Gas Emission Standards for Light-Duty Vehicles Manufacturer Performance Report for the 2012 Model Year; EPA Press Release titled "United States Reaches Settlement with Hyundai and Kia in Historic Greenhouse Gas Enforcement case."
Notes: (1) The value of the credits forfeited by Hyundai and Kia of 193.970 million dollars is equivalent to 200 million dollars denominated in 2012 currency.
(2) To convert the price of an EPA GHG credit to 10 NHTSA credits (one NHTSA credit is 1/10 of an mpg), we make the following assumptions: increasing MPG by 1 from 30 to 31 is equivalent to reducing gallons per mile by 0.0011; there are 0.008887 Mg of CO_2e per gallon of gasoline and cars are driven 195,264 miles over their lifetime.

Market Assessment and Lessons from Other Pollution Regulations

Despite the limited number of initial trades between manufacturers, the new credit trading market has the potential to lead to more efficiency in attaining the standards, and to improving the likelihood that the standards will be met. There are large potential cost savings because the variation in marginal costs of attaining the standards across manufacturers appears to be large. One study of the NHTSA CAFE constraint from the period 1997-2001 found that the additional costs per mile per gallon to attain the standard would range from $52 to $438 per car across manufacturers (Jacobsen, 2013).[12] Evidence from the agencies' analyses about the forecast cost per vehicle of additional improvements in fuel economy and emissions reductions also shows significant variation by manufacturer (US NHTSA, 2012). Reducing costs to some manufacturers may be particularly important under the new joint fuel economy rules. Previously, under the NHTSA-only rules, manufacturers could pay penalties in lieu of compliance, and many did. But as we discussed above, fines are not a feasible option under the Clean Air Act as implemented by EPA.

[12] Anderson and Sallee (2011) find substantial variation in marginal costs as well, although they find that the magnitude of marginal costs is much lower than in Jacobsen (2013).

Compliance with the credit market is also likely to be easy to enforce, with low administrative costs. Furthermore, options for banking and borrowing will tend to spread compliance costs over time. Banking provisions under the US sulfur dioxide allowance trading program are said to have mitigated price volatility in that market (Ellerman et al., 2003). Similarly, the intention in this market is to provide the auto companies a longer-term planning horizon and to stabilize credit prices.

Despite clear opportunities in the new market for trading credits among firms, there are also potential issues that may influence how effective the market will be in practice. We explore a number of potential problems that may arise, drawing on evidence and literature from other markets in these assessments. They are: the problems of overlapping regulations, whether reductions are additional, lack of transparency and thin markets, and effects of market power.

Overlapping Regulations

One area of increasing concern for the success of emissions trading programs is the issue of either changing or overlapping regulations (Burtraw and Shobe, forthcoming, Goulder, 2013). For example, the SO_2 allowance trading market was successful for a long period, but then was essentially gutted due to changes in broader air pollution regulations and in the ability of utilities to trade ton for ton across state lines (Schmalensee and Stavins, 2013). The relationship among regulations, both across jurisdictions and over time is complex, and depends on the timing and design of the instruments (Levinson 2012, Goulder and Stavins, 2012). The joint NHTSA and EPA regulations are likely to interact with each other, and with other regulations at both the state and federal level.

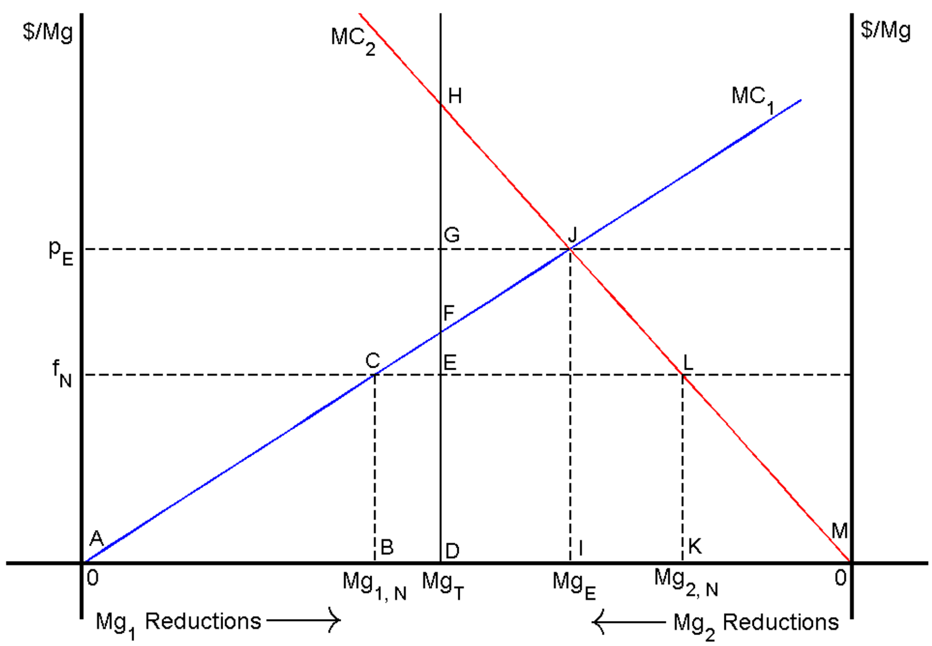
The credit trading programs as established under NHTSA and EPA are unique in that there are two separate credit markets that effectively credit the same thing. The NHTSA rule and the EPA rule have two separate goals: reductions in gasoline consumption and reduction in CO_2e emissions respectively, but the two are directly related. These regulations are overlapping, and this will have an effect on both credit markets as we show below. There are other regulations that also may have an effect on these credit markets. The most salient is the ZEV mandate in California and other participating states.

Effects of Overlapping NHTSA and EPA Rules

To illustrate the case of the overlapping NHTSA and EPA rules on the credit markets, we simplify to the case of two representative manufacturers with different marginal costs of compliance in a simple static framework.[13] Figure 2 represents these manufacturers and their costs of complying over the next few years. Each manufacturer is subject to two requirements, one from NHTSA to increase miles per gallon (mpg) of its fleet of vehicles, and the other from EPA to reduce Mg of CO_2e (or metric tons/CO_2e). If the requirements under the two rules are fully harmonized, we can show marginal cost of the requirements either in terms of CO_2e reductions or improvements in MPG. Figure 2 shows marginal costs in terms of reduced Mg of CO_2e but we will talk about the credit markets for both regulations below.

Each manufacturer is subject to a different target or standard, depending on the fleet of vehicles it produces under both regulations. Firm 1 represents a firm that is a large volume manufacturer and has midrange emissions GHG emissions initially, but has relatively low cost of reducing emissions from its fleet (MC_1). Firm 2 we assume has smaller production volumes but higher average initial emissions from its fleet, and higher costs of reducing emissions (MC_2), and represents, for example, a European manufacturer.

Figure 2. Overlapping Regulations for Reducing Greenhouse Gas Emissions



---

13 Our analysis abstracts from dynamic effects, such as the impact of the regulations on the future stringency of CAFE standards.

Starting at point A and moving from left to right, the horizontal axis measures Mg of CO_2e reduced by Firm 1 above business-as-usual (BAU) reductions (at the origin). Starting at point M and moving from right to left, the horizontal axis measures Mg of CO_2e reduced by Firm 2, where the origin (at point M) represents BAU reductions. Both vertical axes measure the marginal cost of reducing one Mg of CO_2e beyond BAU levels. The blue line that begins at point A represents Firm 1's marginal cost of reducing Mg of CO_2e, while the red line that begins at point M represents Firm 2's marginal cost of reducing Mg of CO_2e. The graph also shows the emission reduction target that each firm must meet, which is illustrated by the vertical, solid black line at the value of Mg reductions equal to Mg_T. This target or standard could be different for each firm, depending on the size and type of vehicles each firm sells.

There are separate credit markets to facilitate attainment of the required standards under the two programs. We start with the NHTSA requirements because they have been in place the longest, and firms have in the past and continue to be able to pay a fine in lieu of compliance. The NHTSA fine for an automaker is \$5.50 per 1/10th mpg or \$55 per mpg per vehicle over the standard. Since Figure 2 is in terms of Mg of CO_2e, we show the fine as f_N, which is either \$55/mpg or \$24/Mg of CO_2e.[14]

To attain the NHTSA or EPA standards, the cost for Firm 1 is shown by AFD, and the cost for Firm 2 to attain its standard is MDH. The new NHTSA rules do allow firms to trade credits, but as stated above, they also allow payment of the fine, f_N. In the past, European automakers have often paid fines, while domestic producers have usually been in compliance (Jacobsen 2013). Going forward, under the new standards that will become increasingly stricter, there is a higher probability that all firms will have costs higher than the NHTSA fine. In Figure 2 with the fine of f_N, both firms would pay the fine rather than comply with the standard. Firm 1 would reduce to $Mg_{1,N}$ or some average fleet mpg that is below the standard, with costs of ACB; Firm 2 would reduce to $Mg_{2,N}$ with costs of MKL. Firm 1 would pay BCED in fines to NHTSA and Firm 2 would pay KDEL in fines. In this case, even when trading is allowed, there would be no trading in the credit market but of course the standard would not be met by either firm. This fine represents a safety valve policy that prevents marginal costs from going above f_N.[15]

[14] Conversion from mpg to Mg is explained in note to Table 5.

[15] It is possible that the fine is higher than Firm 1's marginal costs at the target standard but still below the cost of complying for firm 2. In this case there may be a limited NHTSA market for credits, if auto companies are willing to

This discussion about the NHTSA outcome so far accounts for no other regulation. But there is also the EPA regulation which effectively allows no fine to be paid as an alternative to compliance. Firms must also now comply with the EPA CO_2e rules. In this case, with full trading of EPA credits, Firm 1 would reduce from the initial business as usual emissions level to Mg_E. Firm 2 would reduce from its business as usual to Mg_E. They would trade Mg_E – Mg_T credits at a price of P_E assuming no transactions costs and a well-functioning market. The net welfare gain from trading to Firm 1 is FGJ, and to Firm 2 the net gain is JGH.

What is the effect of the binding EPA regulation with credit trading on the NHTSA outcome? Firm 1 under the EPA rules is more than complying, and so it has already paid for reductions up to Mg_E. Firm 1 could now sell credits in the NHTSA market (Mg_E – Mg_T equivalent for NHTSA units), but the opportunity cost of these reductions is now zero. Firm 2 is reducing up to MG_E under the EPA standard with trading, and so does not meet the NHTSA standard. It could pay the fine for the additional MPG needed to meet the standard, but there are likely firms like Firm 1 that effectively have zero opportunity cost for selling credits. It is likely that a credit market for NHTSA credits will develop, but with a price close to zero.

To summarize, because the two regulations have effectively the same target, the sum of the credit prices should equal the marginal cost of reducing fuel use (or equivalent CO_2e emissions). Firms would not pay twice for essentially the same reductions. In the case where the EPA standards are binding and no fine is available, an EPA credit market with a price such as P_E per Mg is likely to develop, and the price should closely reflect marginal costs. No NHTSA fines would be paid, and the NHTSA credit price, may be close to zero.[16]

---

trade with each other at costs slightly lower than the fine. Firm 2 would still pay some in fines, but also purchase some credits from Firm 1.

[16] To the extent there are differences in credit allowances and limits to trading between the NHTSA and EPA rules, the outcomes in the credit markets will be more complex than described above. One example is there are different ways that companies can earn credits. Under the EPA rules, there are large credits for alternative fueled vehicles such as electric or fuel cell vehicles, but the NHTSA rules do allow such exceptions. Differences in how credits are granted will affect the marginal costs of complying under both standards, and it may make the uptake of certain technologies less likely than if the standards were harmonized. Another important difference in the two rules is that NHTSA restricts the number of car and truck credits an auto company can transfer between its car and truck fleet, whereas EPA has no such restriction. This restriction on trading will drive a wedge between the car and truck price of credits under NHTSA rules. Differences in the credit markets are part of the reason the companies see the two credit markets as completely separate and somewhat unrelated. These different rules will tend to make the markets less efficient and result in higher costs of meeting the goals.

Zero Emissions Vehicle Regulations in California and Participating States

The ZEV mandate in California and participating states is likely to have a significant effect on the CAFE credit markets. The ZEV mandate requires that a certain percent of vehicles sold in participating states be "zero emitting" which currently includes only pure electric or fuel cell vehicles.[17] Only large volume manufacturers are bound by this strict requirement, so manufacturers face different costs of compliance under this rule. The required percentage on the large volume manufacturers is as high as 15 percent by 2025. This has important implications for the fleet of vehicles these manufacturers will sell because the participating states make up about 25 percent of the US market.

We use Figure 2 to illustrate the likely effects of the ZEV mandate on in the credit markets.[18] Firm 1 represents the large volume manufacturing under the ZEV rule and we assume Firm 2 is unaffected by the rule. Firm 1 must produce and sell the required number of electric or fuel cell vehicles which means that their costs to comply with CAFE will be higher than they would be otherwise. The effect is to increase the price of credits and to shrink both the EPA and NHTSA credit markets. There is no change in the emissions of the national fleet, however, since they are still complying with the same standards, just achieving those standards in a different way and at higher cost. Emissions in California will be lower, but higher in non-participating states around the country. This general result of combining state regulations with a binding federal standard has been documented in previous work (Goulder et al., 2012, and Goulder and Stavins, 2012).[19]

Additionality of Earned Credits

Some automakers have historically exceeded fuel economy standards. If these companies are granted credits for exceeding the standards, these credits do not represent additional behavior

[17] Currently, ZEVs include only battery electric vehicles, such as the Nissan Leaf and Tesla Model S, and fuel cell vehicles. The required share of ZEVs in total sales is increasing from less than 1% in 2014, to 6% by 2020, and to over 15% by 2025.[17] Only the largest volume manufacturers must comply with these rules, but they are binding for the automakers affected. Compliance with these rules will influence how manufacturers comply with the NHTSA and EPA national CAFE rules. This will also have an impact on credit markets as we discuss below.

[18] Absent from this analysis is the effect that the ZEV program may have on the stringency of future CAFE standards. For example, more ZEVs in the market could make it more politically feasible to tighten future standards.

[19] This analysis does not account for potential changes in the cost of producing electric and fuel cell vehicles that may occur because of the volumes required by the regulations. The intent of the California ZEV regulations is to promote such changes.

beyond what the companies would have done without the crediting program. This is a common phenomenon in other emissions markets, including Phase 1 of the Acid Rain Program and markets for carbon dioxide from stationary sources. For example, Phase 1 of the Acid Rain Program included an opt-in provision that has since been shown to have suffered from adverse selection. Montero (1999) illustrates that many generating units that opted into the program had business-as-usual (BAU) emissions below their permit allocation and were able to sell the surplus permits to other capped firms. This had the effect of increasing overall emissions. Similar issues of over-crediting and additionality have appeared more recently in cap-and-trade systems for CO_2 that have carbon offset programs where offset project BAU emissions are unobserved by policy makers (Bushnell, 2012, and Bento et al., 2014).

Because manufacturers can now sell credits, over-crediting has the potential to reduce fuel economy and increase emissions over what they would be if there was no over-crediting. This issue parallels the problem discussed in Montero (1999) and more recent work on carbon offset markets, where market participants who are over-credited with “non-additional” reductions can sell these credits to other participants who use them to meet their own regulatory obligations. A similar situation can arise under the new CAFE and EPA GHG standards when a manufacturer is able to earn credits for fuel economy gains that they would have done in the absence of the program, then sell these credits to another manufacturer that uses them to meet a shortfall.

The early stages of the new fuel economy and GHG standards for passenger cars and light trucks show signs of over-crediting. In Figures 3 and 4, we plot average fuel economy from 2000 to 2011 for Toyota, Honda, GM, Ford and Chrysler along with the CAFE standards during this period, for cars and for trucks. The grey line in each figure represents the standards; passenger car standards stay flat throughout the period until 2011, when standards were changed to reflect vehicle footprint, while light truck standards are flat in 2005 and increase starting in 2006. Figure 3 reveals that the manufacturers appear to have increased passenger car fuel economy independent of any change in the standard. Toyota, for example, increased its passenger car fleet fuel economy from slightly less than 30 miles per gallon in 1999 to 35 miles per gallon by 2005. Ford and GM, too, increased their passenger car fleet fuel economy from slightly under the standard in 1999 to over two miles per gallon over the standard by 2007. A similar story for trucks appears in Figure 4, albeit less clearly than the passenger car case.

Figure 3. Average Fuel Economy and CAFE Standards for Passenger Car Fleets, 1999-2011

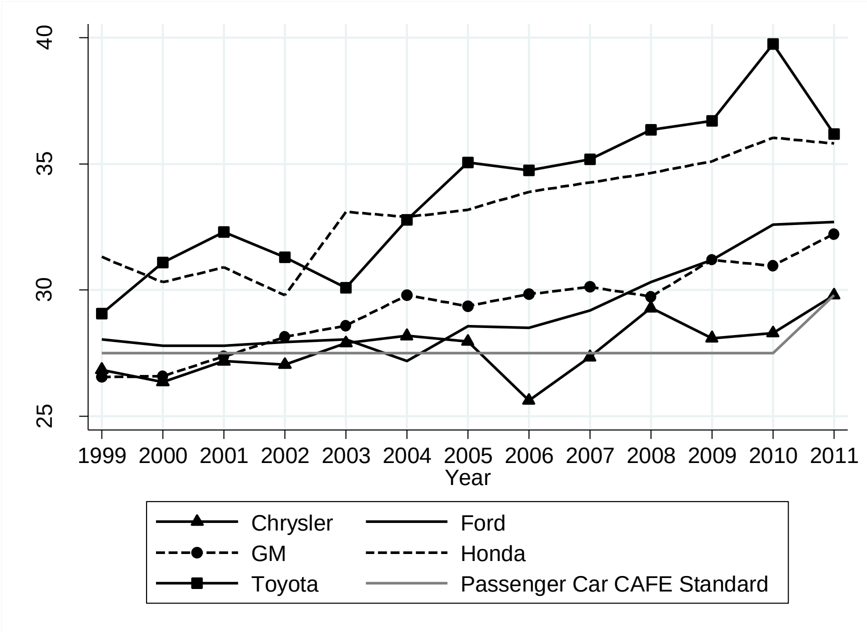
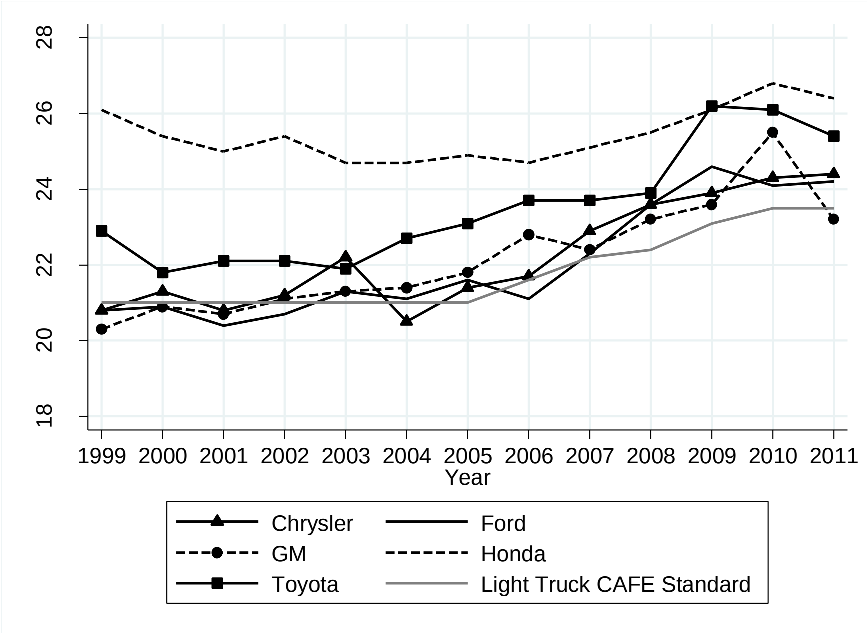


Figure 4. Average Fuel Economy and CAFE Standards for Light Truck Fleets, 1999-2011



Sources: 1999 and 2000 fuel economy data: http://www.nhtsa.gov/cars/rules/CAFE/FuelEconUpdates/2000/index.html; 2001 and 2002 fuel economy data: http://www.nhtsa.gov/cars/rules/CAFE/FuelEconUpdates/2002/index.htm; 2003 and 2004 fuel economy data: http://www.nhtsa.gov/Laws+&+Regulations/CAFE++Fuel+Economy/2004+Automotive+Fuel+Economy+Program; 2005-2011 fuel economy data: http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/June_2014_Summary_Report.pdf

What has caused this increase in fuel efficiency with no change in passenger car CAFE standards? One reason is the significant increase in gasoline prices during this time period. Between 1999 and 2008, retail gasoline prices quadrupled from a price of about $1 in June 1999 to about $4 in June 2008. Numerous studies have shown that this remarkable gasoline price increase led to consumers demanding and buying more fuel efficient vehicles in new and used automobile markets (Li et al., 2009, Busse et al., 2013, and Allcott et al., 2014).

Figures 3 and 4 suggest that manufacturers have been able to bank many credits for BAU behavior. This story parallels the findings from Montero (1999), where business-as-usual emissions were falling prior to the Acid Rain Program implementation because of a fall in low sulfur coal prices.[20]

Without a detailed model of the transportation sector, however, it is impossible to determine what fraction of early banked credits are born from BAU increases in fuel economy and how over-crediting will impact overall welfare.[21] Moreover, because NHTSA credits expire after five years and EPA credits expire after 2021, these early banked credits will not have a significant long run effect on the standards. Therefore, the impact of the existing banked credits on emissions is limited to years prior to 2022. In addition, both standards are scheduled to increase far above historical BAU fuel economies of even the most fuel efficient fleets.

Transparency and Thin Markets

A well-functioning market for trading credits between companies requires an established way for potential traders to find each other, and transparency about the price of trades that have occurred. The history of credit trading programs under vehicle programs such as the California

[20] The recent development of the Clean Power Plan under the Clean Air Act is another timely example of this phenomenon. The Clean Power Plan requires 30% emissions reductions by states by 2030, where the 30% target is relative to 2005 emissions. Stakeholders and policy makers have claimed that this supposed target is misleading because a significant portion of these reductions are “baked in” and have already happened as a result of falling natural gas prices.

[21] The overall welfare impact of the additionality problem depends on several factors. The first factor that we have already discussed is to what extent the credits earned stemmed from actions that went beyond business-as-usual behavior. The second factor is the extent to which companies that have appeared to earn significant credits for BAU behavior are able to use these credits for compliance in another category or sell these credits to other companies. The third factor is the pre-existing stringency of each regulation. The use or sale of surplus credits effectively loosens the stringency of the standards. It could be the case that the current targets for fuel economy and greenhouse gas emissions are too stringent to the point where marginal costs exceed marginal benefits. In this setting, allowing companies to earn non-additional credits improves the efficiency of the programs.

Low Emission Vehicle and Zero Emission Vehicle programs has been that buyers and sellers of credits find each other on an as-needed basis, and the agencies often report information on quantities traded but not on prices. The CAFE credit trading program is getting started in a similar way. There is public information about quantities and who bought and sold, but not about price. A well-function market would require the opposite – information about the prices of trades but not how many credits other participants traded. Currently, there is virtually no information for participants about price, and a low probability of a single trading price across trades. There are also high transactions costs to find trading partners. This will tend to make markets thin and inefficient. There is a potential role for private brokers, to help potential buyers and sellers find each other, and to establish a more formal auction setting.[22]

There are other possible reasons for thin trading markets in these programs. One may be that currently many companies hold credits, accumulating them over past years. At the moment there may be more sellers than buyers of credits, but that is likely to change in the future. The standards are increasing in stringency in future years, especially for model years 2021 to 2025. Firms are in different positions to comply with the stricter standards, and may face different prospects for their car and truck fleets. In addition, there are a small number of companies who sell vehicles in the United States and are affected by the regulations – about 20 in total. Among these companies, there is a great deal of competition, and thus reluctance for any company to reveal information about its compliance approach. Also, automobile manufacturers typically make significant capital investments vis-à-vis redesigning a vehicle model about every five years.[23] This combination of small numbers of competing firms, fierce competition and lumpy capital investment needed for compliance can lead to over investment in capital. Firms may invest in the technology to comply rather than rely on credit markets.

It is still possible that the credit trading markets may become more robust over time, as experience with trading increases. Also, a mid-term review of the standards by the agencies will take place around 2017. The outcome of this review creates uncertainty about the longer-term

---

[22] There is one such broker in the market now called Mobilis Trading, established in 2012. The firm's goal is to provide a more efficient and transparent trading process for the regulated parties. Mobilis Trading offers manufacturers an opportunity to trade credits by running forward and reverse auctions via a private online auction platform. The platform was designed such that bidding is done in an anonymous fashion and auction results are archived so that account holders can see what credits are trading for. See www.mobilistrading.com.

[23] Blonigen et al. (2013) estimate that automobile redesigns cost an average of $750 million.

stringency of the standards and will influence manufacturer decisions, including determining whether to participate in the between firm credit markets.

One potential role for the agencies in this market is to provide information about prices by establishing price ceilings. The NHTSA fine already sets a price cap of 5.5 dollars per MPG per vehicle for credits in that market. EPA cannot allow firms to pay a fee, but they could sell credits to any buyers at a fixed price to set an upper limit on credit prices and marginal compliance costs. The agencies could also consider setting a price floor on credits by offering to buy credits at a given price. This would establish a fixed range of prices for manufacturers. This approach has been suggested for other pollution markets (Pizer, 2002, and Murray et al., 2009).

Market Power

In a tradable permits market with relatively few firms, a relevant question is whether the market is susceptible to market power. In the context of a credit market, market power is the ability of small group of firms to move credit prices away from marginal costs of abatement through the control of the supply or demand for credits. The automobile market is dominated by only a handful of large companies. As a consequence, the credit markets created under the CAFE and EPA GHG programs could be susceptible to influence or manipulation by a few firms.

We can begin to understand the extent of market power in the CAFE and EPA GHG credit markets by summarizing the distribution of credits balances held by the largest manufacturers. Here we focus on the EPA GHG program since more recent data are available and because the distribution of credits is similar to that of the CAFE program.[24] Table 6 ranks the concentration of EPA GHG credits among the six largest companies as of the 2013 compliance year for credit vintages 2010-2013.[25] These credit balances are net of deficits, penalties and trades between manufacturers. Only positive credit balances are included in the rows titled All Other Manufacturers and Total.

---

[24] See Table 3 for a comparison of credits earned in each program during 2009-2011.

[25] Manufacturers can use these vintages for compliance up to the 2021 standard.

Table 6. Concentration of EPA GHG Credits, Model Year Vintages 2010-2013

(Rank) Manufacturer	Credit balance (million Mg)	Market Share (%)	Cumulative Market Share (%)
(1) Toyota	72.16	36	36
(2) Honda	36.16	18	54
(3) Ford	20.19	10	64
(4) Hyundai	18.58	9	73
(5) GM	16.18	8	81
(6) Nissan	11.15	5	86
All Other Manufacturers	28.12	14	100
Total	202.54	100	--

Source: Author calculations based on http://www.epa.gov/otaq/climate/documents/ld-ghg-credits-2009-2013.csv

The data presented in Tables 6 suggest that market power may pose a threat to the allocative efficiency of these markets as the six manufacturers with the most GHG credits own about nine out of every ten credits. Based on Hahn's (1984) analysis on the impact of market power on the efficiency of pollution markets, if a few firms have a relatively large number of pollution permits, they will exercise monopoly power by selling few permits. This has the effect of increasing the equilibrium permit price, with less abatement than there would be in a competitive environment. As a consequence, the efficiency gains from trading may be significantly lower in the presence of market power.

Early crediting and trading behavior among automakers is consistent with Hahn's prediction. One notable feature of the credit holding data in Table 6 is that virtually all of the credits earned by the large manufacturers have not been sold to other companies.[26] The lack of selling may suggest that these firms are exercising monopoly power by restricting the supply of permits to drive up the permit price in later periods. It is difficult to conclude, however, that this is the reason we are seeing so few trades. Companies may simply be holding credits in anticipation of more stringent standards. The lack of selling by the major companies may also be a function of the fact that this market is young and companies need time to become acquainted to the concept of trading credits. Or, because these markets are relatively thin, it is difficult for companies to find trading partners to make deals.

[26] The top five credit holders, Toyota, Honda, Ford, Hyundai and GM earning 81 percent of all 2010-2013 credits, have not made a GHG credit sale through 2013. The only company to make a sale among the six firms listed in Table 6 was Nissan, which sold 0.95 million credits, which is slightly less than 10% of its total credits earned.

Hahn's analysis is limited in that it assumes perfect competition in output markets. This assumption most likely does not hold in the US automobile market. A question, then, is how the introduction of credit markets will influence market power in the domestic automobile market. Kolstad and Wolak (2008) claim that electric utilities in the Nitric Oxide (NOx) permit market under the RECLAIM program used this market to increase their market power in the electricity market.[27] Rubin et al. (2009) conduct numerical simulations of an imperfectly competitive automobile market to measure the cost savings from incorporating tradable fuel economy standards. This paper finds that market power in the credit trading market between firms lowers the potential cost savings from trading, but only modestly.

Conclusion

Credit use within firms, across vehicle classes, and trading across firms will become increasingly important as the CAFE standards tighten over time. Credit averaging within firms both in a given vehicle class and across classes (cars and trucks) is likely to have an important role in lowering manufacturer costs of compliance. Restricting firms' ability to average, for example across cars and trucks as under the NHTSA rules, will reduce the efficiency gains of the credit trading programs, but will not improve outcomes in terms of fuel use or greenhouse gas emissions.

The market for credit trading credits between firms is in its early stages, and whether an efficient market will develop is still not clear. Most automakers have been able to over comply with the standards and accumulate credits, both in the early credit market and in recent years. The size of this credit pool is large as companies have utilized the banking provisions of both regulations. This behavior is to be expected, however, because the standards are becoming stricter in coming years.

Accumulated credit holding on the part of many of the manufacturers is one explanation for why there have been few trades between manufacturers to date. But there are some companies that are finding compliance with the standards difficult, even today, and others are

[27] Montero (2009), however, argues that it is difficult to glean from observed market outcomes that the introduction of permit markets exacerbates or lessens market power in output markets. Two new effects augment Hahn's original market power analysis when firms have market power in output markets: a *demand effect* that causes the large firm to sell more permits than it otherwise would, and a *rival cost effect* that induces the large firm to sell fewer permits than otherwise. Therefore the total effect for a given setting is contingent on the relative magnitudes of these two effects, which are likely to be specific for particular markets.

likely to face steeply increasing costs in the future. Another reasons for the lack of trading is likely that the current market lacks key elements of a well-functioning market including information about prices of past trades, and low transactions and search costs. There is a private brokerage that is currently attempting to establish a trading site, and there appears to be growing interest on the part of the companies to use it for trading. This market may soon become more robust, and it will be interesting to see how it unfolds.

The agencies provide information to the market, about credit holdings and quantities traded by the parties. However, the opposite strategy is likely to better enhance the functioning of the market – information about prices at which trades occur, but not about who trades. In addition, there may be some role for the agencies in establishing pricing bounds to this market. In particular, there is concern about the costs of the meeting the standards for all companies, especially in the out years, from 2021 to 2025, and beyond if the standards are extended. Currently, the NHTSA fee in lieu of compliance represents a price ceiling for NHTSA credits. The EPA might also consider establishing a price ceiling. They cannot require firms to pay a fine in lieu of compliance, but they may be able to sell credits at a certain price. The agencies could also consider buying permits at an some pre-determined price floor if the marginal costs of compliance is low. Such interventions would provide information about the range of possible prices to the market participants.

Credit holdings vary a good deal across manufacturers, even after accounting for vehicle volume. There are a number of reasons for this variation, including intertemporal cost minimization and additionality issues. Whether some firms will exert market power to influence credit or product market outcomes in the future is uncertain, and should be assessed over time. Without a formal empirical test of market power, we are unable to conclude whether this is or will eventually become a serious concern for the NHTSA and EPA credit markets.

Some of the earned credits may not be additional, as multiple manufacturers have traditionally exceeded the standards by a wide margin. But because credits expire after a relatively short time span, and because the standards are scheduled to increase dramatically over the next decade, the additionality problem is likely to have a small effect on the environmental and fuel use benefits of the rules.

Perhaps the greatest issue with the two credit markets, NHTSA's for fuel economy, and EPA's for GHG emissions, is that they are both regulating virtually the same thing. Under these conditions, two separate markets are unlikely to work well. To the extent that there are differences between the agencies on how credits are granted, having the two different rules will make investment decisions for companies more difficult, which is likely to drive up costs. A single market – and a single credit price – is also useful to NHTSA, EPA, stakeholders and researchers for understanding the costs associated with the regulations. With multiple overlapping regulations, credit transaction prices may be far from marginal costs of abatement, even without other market distortions. A single rule and a single credit market would be more efficient and more useful for understanding the cost of the regulations.

References

Anderson, Soren and Jim Sallee (2011). Using Loopholes to Reveal the Marginal cost of Regulation: The Case of Fuel-Economy Standards. *American Economic Review*, 101(4): 1375-1409.

Bento, Antonio, Kanbur, Ravi and Benjamin Leard (2015). Designing Efficient Markets for Carbon Offsets with Distributional Constraints. *Journal of Environmental Economics and Management*, 70(2): 51-71.

Blonigen, Bruce A., Knittel, Christopher R. and Anson Soderbery (2013). Keeping it Fresh: Strategic Product Redesigns and Welfare. NBER Working Paper No. 18997.

Burtraw, Dallas, Josh Linn, Karen Palmer and Anthony Paul (2014). The Costs and Consequences of Greenhouse Gas Regulation under the Clean Air Act, *American Economic Review: Papers & Proceedings* 104(5), 557-562.

Burtraw, Dallas, and William M. Shobe (2012)Rethinking Environmental Federalism in a Warming World. *Climate Change Economics*. 3(4).

Bushnell, James (2012). The Economics of Carbon Offsets, in Don Fullerton and Catherine Wolfram, eds., *The Design and Implementation of US Climate Policy*, Cambridge: National Bureau of Economic Research.

Ellerman, A. Denny and Juan-Pablo Montero (2007). The Efficiency and Robustness of Allowance Banking in the US Acid Rain Program. *The Energy Journal* 28(4), 47-71.

Ellerman, A. Denny, Pual L. Joskow, and David L. Harrison (2003). *Emissions Trading: Experience, Lessons and Considerations for Greenhouse Gases.* Washington, DC: Pew Center on Global Climate Change.

EPA (2014). Greenhouse Gas Emission Standards for Light Duty Vehicles. Manufacturer Performance Report for the 2012 Model Year. EPA-420-R-14-011.

http://www.epa.gov/otaq/climate/documents/420r14011.pdf

EPA (2013). Greenhouse Gas Emission Standards for Light-Duty Automobiles: Status of Early Credit Program for Model Years 2009-2011.

Goulder, Lawrence H. (2013). Markets for Pollution Allowances: What Are the (New) Lessons? *Journal of Economic Perspectives* 27(1), 87-102.

Goulder, Lawrence H., Marc R. Jacobsen, and Arthur van Bentham (2012). "Unintended Consequences from Nested State and Federal Environmental Regulation: The Case of the Pavley Greenhouse-Gas-Per-Mile Limits." *Journal of Environmental Economics and Management* 63(2), 187–207.

Goulder, Lawrence H. and Robert N. Stavins (2012). "Interactions between State and Federal Climate Change Policies", in Don Fullerton and Catherine Wolfram, eds., *The Design and Implementation of US Climate Policy*, Cambridge: National Bureau of Economic Research, June.

Jacobsen, Mark (2013). Evaluating US Fuel Economy Standards In a Model with Producer and Household Heterogeneity. *American Economic Journal: Economic Policy* 5(2), 148-187.

Klier, T., Rick Mattoon, Michael A. Prager (1997). What Can the Midwest Learn from California about Emissions Trading? *Chicago Fed Letter*, No. 120, August.

Kolstad, J. and F. Wolak (2008). Using Environmental Emissions Permit Prices to Raise Electricity Prices: Evidence from the California Electricity Market. *Stanford working paper*.

Levinson, Arik (2012). Comment on "Interactions between State and Federal Climate Change Policies." The Design and Implementation of US Climate Policy. University of Chicago Press.

McConnell, Virginia (2013). The New CAFE Standards: Are they Enough on Their Own? RFF Discussion paper 13-14. Washington, D.C. May. http://www.rff.org/Publications/Pages/PublicationDetails.aspx?PublicationID=22180

Montero (1999). Voluntary Compliance with Market-Based Environmental Policy: Evidence from the US Acid Rain Program. *Journal of Political Economy* 107(5), 998-1033.

Montero (2009). Market Power in Pollution Permit Markets. *The Energy Journal*. 30(2): 1-28.

Montgmery, W.D (1972). "Markets in Licenses and Efficient Pollution Control Programs". *Journal of Economic Theory* 5: 395–418.

Murray, B. Newell, R.G., and W. A. Pizer (2009). Balancing Cost and Emissions Certainty: An Allowance Reserve for Cap-and-Trade. *Review of Environmental Economics and Policy*, *Symposium: Alternative US Climate Policy Instruments*, 3(1): 84-103.

National Highway Transportation and Safety Administration (NHTSA) (2014). CAFE Credit Status 2008-2011. http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/CAFE_credit_status

Pizer, William (2002). Combining Price and Quantity Controls to Mitigate Global Climate Change. *Journal of Public Economics* 85(2): 409-434.

Rubin, J., Leiby, P. and David L. Greene (2009). Tradeable fuel economy credits: Competition and oligopoly. *Journal of Environmental Economics and Management* (58): 315-328.

Schmalensee, Richard and Richard N. Stavins (2013). The SO_2 Allowance Trading Program: The Ironic History of a Grand Policy Experiment. *Journal of Economic Perspectives* 27(1): 103-122.

Tietenberg, T.H. 2006. *Emissions Trading: Principles and Practice*. 2nd edition. Resources for the Future Press. Washington, D.C.

US NHTSA (2012). Corporate Average Fuel Economy of MY 2017-MY2025 Passenger Cars and Light Trucks, Final Regulatory Impact Analysis.