Cash for Clunkers: A Missed Opportunity for Fuel Economy Gains

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EXECUTIVE SUMMARY

This report investigates consumers' vehicle purchase decisions under the 2009 Consumer Assistance to Recycle and Save (CARS) program, which offered financial incentives for the scrapping of older, inefficient cars and light trucks and their replacement with new, more fuel-efficient vehicles. Our research focuses on the question of whether the program led consumers to purchase vehicles more fuel-efficient than those they otherwise would have bought.

We found that vehicles purchased under the program were in fact more efficient than the typical vehicle in the market, due to both superior fuel economy within vehicle class and shifts between classes. Notably, program participants bought more passenger cars and fewer trucks than they reported they would have in the absence of the program, and a smaller share of trucks than were bought in the light-duty market as a whole.

These differences translated to only modest fuel economy gains, however: the nearly 677,000 participants in the program bought vehicles with fuel economies that were on average 2.4 miles per gallon (mpg) higher than the market as a whole, a 10% difference, and 2.9 mpg higher than they would have otherwise purchased.

Moreover, the government paid a lot for these gains. Results from our analysis show that it was quite easy for a CARS program participant to find a qualifying vehicle: approximately 68% of the new car and light truck market was available to the average participant, and more of the market was available for the higher $4500 voucher than for the $3500 voucher. On average, the program paid $4200 for a 2.4–2.9 mpg fuel economy gain, several times higher than other estimates of per-vehicle cost for additional fuel economy.

The primary aim of CARS was economic stimulus, rather than fuel economy improvement, and the program did indeed provide a short-term boost to manufacturers. In addition, it accelerated the retirement of hundreds of thousands of inefficient vehicles. Our analysis indicates, however, that by setting more demanding eligibility requirements for the vehicles purchased, lawmakers could have increased the fuel economy benefits of the program while preserving its stimulative effect on the economy.

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INTRODUCTION

The purpose of the Consumer Assistance to Recycle and Save (CARS) program, more commonly known as "Cash for Clunkers," was two-fold: to stimulate the economy in an effort to keep the vehicle market afloat during the financial crisis; and to put more fuel-efficient light-duty vehicles on the road. CARS was a vehicle retirement program in which consumers with low fuel efficiency vehicles could receive a credit of either $3500 or $4500 toward purchase of a new, more fuel-efficient vehicle. The program was in effect from July 27 to August 25, 2009.

According to the Government Accountability Office's assessment of the program (GAO 2010), it achieved both of these broad objectives, although the extent to which each was met remained unclear at the time of that report. Here we focus on the latter goal of putting more fuel-efficient vehicles on the road. We offer a new analysis of the program's stringency and resulting impact on the fuel economy of the new vehicles purchased under the program.

Program Structure

Four categories of vehicles were eligible for the CARS program. The "passenger cars" category includes, by definition, all passenger cars (e.g., Toyota Camry). "Category 1 trucks" (e.g., Ford Escape) include all SUVs, and pickup trucks and vans weighing less than 8,500 lbs. with wheelbases (i.e., distance between axles) 115 in. or less and 124 in. or less, respectively. "Category 2 trucks" (e.g., Ford F-150) include pickups and vans weighing 8,500 lbs. or less and having wheelbases of greater than 115 in. and 124 in., respectively. "Category 3 trucks" (e.g., Dodge Ram 2500) are work trucks weighing 8,500–10,000 lbs., including very large pickup trucks (those with cargo beds at least 72 in. long) and vans (NHTSA 2009a).

The program specified fuel economy requirements for both trade-in and new vehicles. Trade-in vehicles in all categories were only eligible if they had a combined city/highway fuel economy (label value) of 18 mpg or less. New passenger cars were required to be at least 22 mpg, new Category 1 trucks at least 18 mpg, and new Category 2 trucks at least 15 mpg. In addition, new vehicles were required to show a minimum increase in fuel economy over the trade-in, depending on the category of the new vehicle. The fuel economy of new Category 3 trucks is not yet rated by the EPA (though fuel efficiency standards for these vehicles were adopted in August 2011), so there was no requirement specified under the program for this class.

The magnitude of the difference in fuel economy for each combination of trade-in and new vehicle determined the amount of the voucher that consumers received. Those purchasing a passenger car with a 4–9 mpg improvement over the trade-in could receive a $3500 voucher. A 10+ mpg difference qualified for $4500. For Category 1 trucks, a 2–4 mpg difference received $3500 and 5+ mpg received $4500. For Category 2 trucks, a 1 mpg difference received $3500 and 2+ mpg received $4500. For Category 3 trucks, there was no fuel economy requirement, but consumers could receive $3500 if the new vehicle had a gross vehicle weight less than or equal to that of the trade-in vehicle.

Table 1: CARS Transactions by Incentive Amount and Category

		New Vehicle Category				
		Passenger Car	*Truck Cat. 1*	*Truck Cat. 2*	*Truck Cat. 3*	*Total*
$3500 Trade-In Category	*Passenger Car*	38,498 5.7%	7,683 1.1%	9 0.0%	0 0.0%	46,190 6.8%
	Truck Cat. 1	65,245 9.6%	55,968 8.3%	119 0.0%	6 0.0%	121,338 17.9%
	Truck Cat. 2	5,893 0.9%	5,606 0.8%	10,096 1.5%	3 0.0%	21,598 3.2%
	Truck Cat. 3	83 0.0%	138 0.0%	4,857 0.7%	2,235 0.3%	7,313 1.1%
	Subtotal	109,719 16.2%	69,395 10.3%	15,081 2.2%	2,244 0.3%	196,439 29.0%
$4500 Trade-In Category	*Passenger Car*	47,336 7.0%	8,755 1.3%	13 0.0%	0 0.0%	56,104 8.3%
	Truck Cat. 1	199,753 29.5%	126,433 18.7%	116 0.0%	0 0.0%	326,302 48.2%
	Truck Cat. 2	39,974 5.9%	25,733 3.8%	32,162 4.8%	16 0.0%	97,885 14.5%
	Truck Cat. 3	66 0.0%	46 0.0%	129 0.0%	13 0.0%	254 0.0%
	Subtotal	287,129 42.4%	160,967 23.8%	32,420 4.8%	29 0.0%	480,545 71.0%

Note: The total number of transactions reported here (676,984), based on official data available at www.cars.gov as of November 10, 2010, is slightly lower than the 677,842 transactions reported in NHTSA's December 2009 report to Congress. Valid transactions are highlighted.
Sources: NHTSA (2010); ACEEE analysis

Table 1 shows transactions under the CARS program (valid transactions are highlighted) and the associated incentive level. Percentages in each column represent the percentage of total transactions comprised by that combination of trade-in and new vehicle. [1]

The structure of the incentive program was, by and large, in line with the goal of encouraging consumers to purchase a more fuel-efficient vehicle while preserving their ability to buy a vehicle of another category, as long as it was more efficient than the vehicle they traded in (see Table 1). Consumers trading in passenger cars or Category 1 trucks were able to cross classes and still qualify for the program, but they could not purchase a Category 2 or 3 truck. Those who traded in a Category 2 truck were able to purchase any vehicle except for a Category 3 truck.

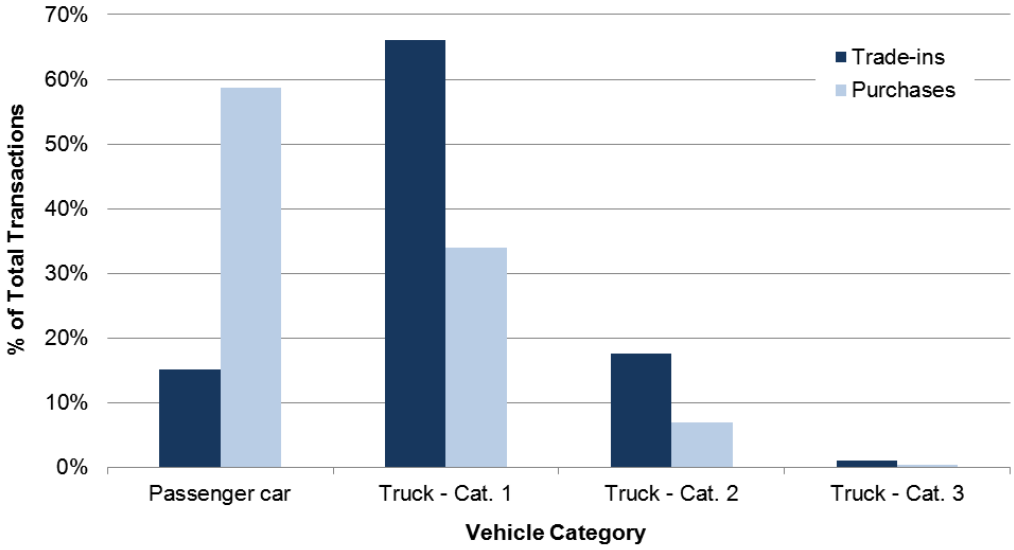
The one inconsistency of the incentive structure was that those trading in Category 3 vehicles were not able to buy much smaller vehicles; they were able to buy only a Category 2 or Category 3 truck, and were only eligible for a $3500 voucher.

Program Results

As Figure 1 below shows, Category 1 trucks made up approximately 66% of all trade-ins, followed by Category 2 trucks (18%) and passenger cars (15%) (NHTSA 2010).

[1] Data from the National Highway Traffic Safety Administration (NHTSA) shows that there was a small percentage of transactions (1243 or 0.18%) that appear to be ineligible according to the program criteria, including cases where a Category 3 truck was apparently traded in for a Category 1 truck or passenger car. These may have been due to misclassification by the dealer or errors in data entry.

Figure 1: CARS Transactions by Category



Source: NHTSA (2009b), ACEEE analysis

By way of comparison, passenger cars accounted for 57.5% of light-duty vehicles on the road in 2008, with the remaining 42.5% accounted for by two-axle, four-tire trucks (DOE 2010, Tables 4.1 and 4.2), i.e., Category 1, 2, and 3 trucks under the CARS program. The much higher share of trucks traded in than of trucks on the road shows that CARS participants were disproportionately truck owners, not surprising given that few cars fall at or below the 18-mile-per-gallon cutoff for trade-in vehicle fuel economy.[2] We explore the implications of this below.

Passenger cars accounted for 59% of new vehicle sales under the program, followed by Category 1 trucks (34%) and Category 2 trucks (7%). The vast majority of vehicles purchased were model years 2009 and 2010.[3] In comparison to 2009 and 2010 sales overall, sales under Cash for Clunkers were slightly skewed towards passenger cars, despite the high percentage of trade-ins that were trucks. According to data from Automotive News (2011), cars accounted for about 55% of total sales of calendar year 2009 vehicles, while trucks comprised 45%. In the 2010, the split was approximately 52% cars and 48% trucks.

The higher level of passenger car purchases under the program than in the market as a whole provides some evidence that it encouraged some of those who traded in a Category 1 truck to purchase a passenger vehicle instead of replacing their truck.

Participant Survey

The NHTSA surveyed program participants to determine what portion of purchases made while the program was in operation could be attributed to the program. For our purposes, the survey also provides insight into the purchase decisions of participants, specifically the difference between what they said they would have bought absent the program and what they actually did buy under the program.

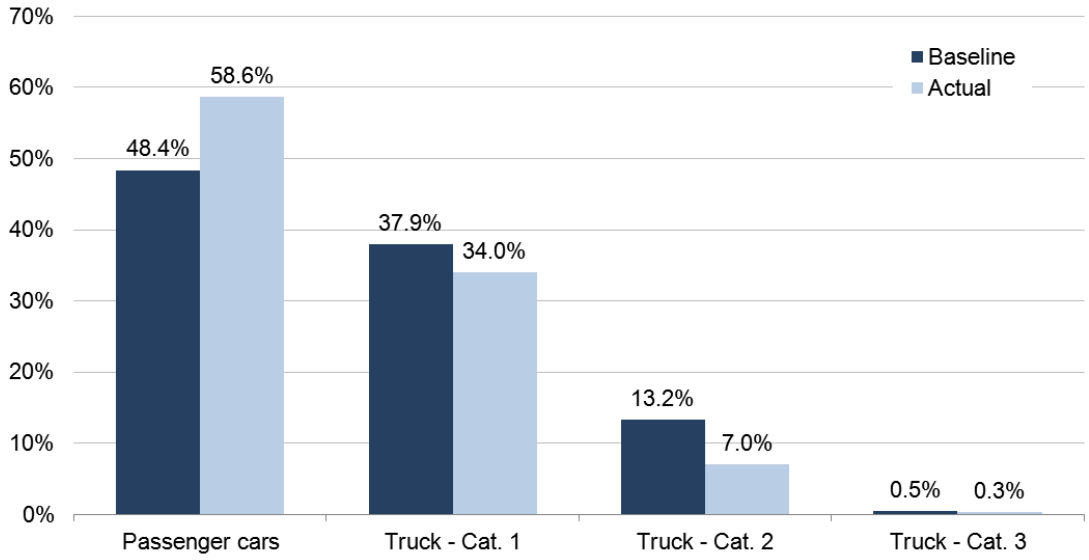
[2] The Energy Tax Act of 1978 imposed a "gas guzzler tax" on cars achieving less than 22.5 mpg CAFE fuel economy, which translates to about 17.4 mpg label value. Few car models other than luxury imports and sports cars are sold in this mpg range and below.

[3] The sales breakdown by model year under the CARS program is MY 2010 (23.4%), MY 2009 (75.3%), MY 2008 (1.2%), and MY 2007 (0.2%) (NHTSA 2010).

The survey received 143,998 valid responses out of 185,342 total, a 21% valid response rate. Thirty percent of respondents said they would have bought a new vehicle in the absence of the program. Of those, 23% said they would have bought a larger car than they actually did, and another 29% would have bought a car of the same size.

Figure 2 compares the breakdown by category of the vehicles respondents said they would have bought in the absence of the program with the breakdown of actual purchases.[4]

Figure 2: Baseline vs. Actual Purchases



Source: NHTSA 2009b, ACEEE analysis

Actual purchases of passenger cars exceeded hypothetical purchases by approximately 21%, while actual purchases of Category 1 and Category 2 trucks trailed what survey respondents expected they would have purchased by approximately 10% and 47%, respectively. These responses give evidence that, in the aggregate, the program shifted consumer purchase decisions in favor of smaller vehicles.

In its evaluation of the CARS program, the GAO (2010) raised several questions about the quality of the survey. The agency found problems with NHTSA's data collection, data analysis, and survey design. In particular, the GAO's report noted that NHTSA did not follow up with survey non-respondents to increase the response rate and to identify reasons for non-response. These issues are of concern because, if respondents were systematically different from non-respondents in some way, it calls into question the ability to generalize from the survey results to the entire population of CARS program participants.

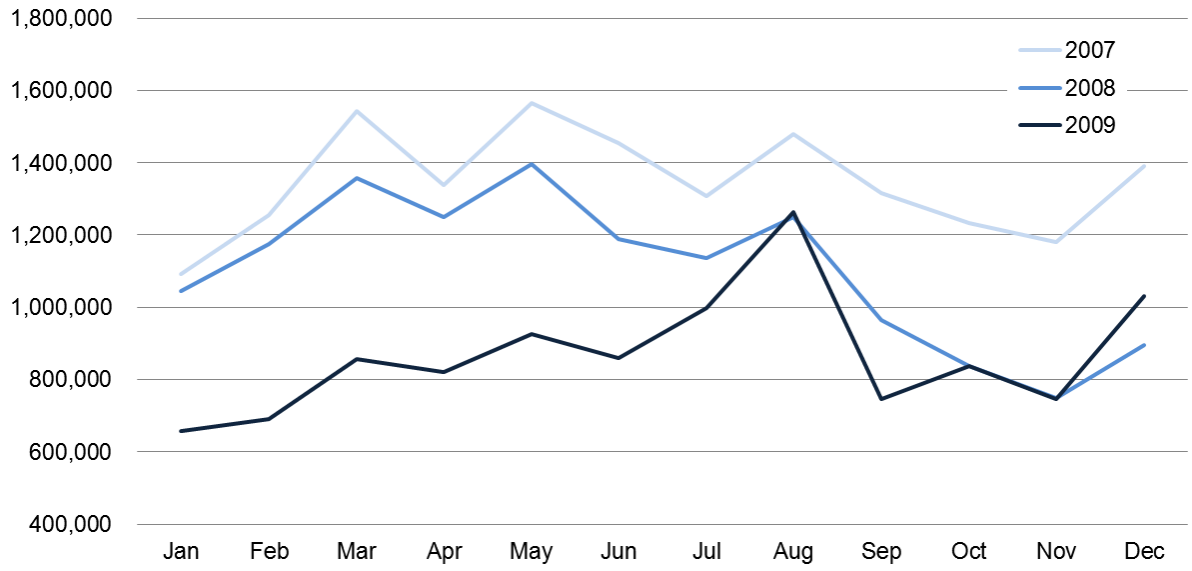
In its report to Congress, however, NHTSA does offer a comparison of survey respondents to non-respondents on the basis of location, MSRP, odometer reading, trade-in vehicle age, voucher amount, and new vehicle combined fuel efficiency, finding that respondents and non-respondents were similar in these characteristics. The agency concluded that the survey reasonably reflects the responses of the average CARS program participant (NHTSA 2009a).

[4] When answering the question about what type of vehicle they would have bought in the absence of the CARS program, survey respondents could choose from fourteen vehicle categories. These fourteen categories were sorted into the four categories specified under the CARS program for the purpose of this analysis.

VEHICLE SALES AND THE STIMULATIVE EFFECT OF THE CARS PROGRAM

Light-duty sales vary substantially from month to month. As Figure 3 shows, from 2007 to 2009, monthly sales spiked in March, May, August, and December, followed by declines. The majority of the sales under the CARS program took place in August 2009, which is shown as a large spike past 1.2 million vehicles. Sales in that month exceeded those for the same month in 2008 by approximately 1% (Automotive News 2011), in contrast to sales in January through July of 2009, which trailed sales in the same months the previous year by 32% on average.

Figure 3: Monthly Light-Duty Vehicle Sales, 2007–2009



Source: Automotive News (2011), ACEEE analysis

A total of 676,984 valid transactions were processed under the CARS program. Of these, the NHTSA estimates that about half (346,000) were net incremental sales,[5] based on the results of its survey and the Council of Economic Advisers' estimate of the normal rate of "clunker" trade-in (NHTSA 2009b). Assuming a constant rate of vehicle purchases over the 30 days of the program, approximately 1.1 million vehicles were sold while it was in effect.[6] Therefore, CARS accounted for 62% of all vehicle sales in that period while increasing total vehicles sales an estimated 31%.

The Council of Economic Advisers (CEA) estimated[7] the program's effect on the gross domestic product (GDP) in the second half of 2009 to be between $2.5 and $6 billion (CEA 2009). Applying the CEA's methodology to updated sales data and results from the program survey, NHTSA estimated that Cash for Clunkers had a net impact on GDP of approximately $6.8 billion (NHTSA 2009b).

[5] In other words, this is net of sales pulled forward due to the program from succeeding months.
[6] Calculated by adding July and August total purchases and dividing by 62, the number of days in these two months. This gives an average daily purchase of 36,456 vehicles. Multiplying this by the 30 days of the program yields approximately 1.1 million vehicles.
[7] The CEA estimate was based on: 1) the portion of extra cars sold under the program that reflects domestic production; the domestic value-added of a domestically produced car; the amount of domestic value-added associated with each domestic sale of a foreign-produced car; and the time frame over which an extra unit sold translated into an extra unit produced.

EFFECT ON FUEL ECONOMY

The CARS program had the immediate benefit of encouraging the replacement of some of the oldest, most inefficient vehicles on the road with more fuel-efficient ones. NHTSA reports that new vehicles purchased under the program had an average combined fuel economy rating 9.2 mpg higher than the trade-in vehicles, an improvement of almost 60% (NHTSA 2009b). Overall, NHTSA estimates that CARS will save 824 million gallons of fuel over the next 25 years, an amount equivalent to 0.6% of current annual motor gasoline usage in the U.S. transportation sector (EIA 2010). This is due in part to the retirement of high-consuming vehicles.

This framing of the program results, however, does not tell us how CARS affected the fuel economy of new vehicles. In order to answer this question, we compared the fuel economy of vehicles purchased under CARS to the sales-weighted average fuel economy of model year 2009 and 2010 vehicles. The results of this analysis are presented in Table 2.[8, 9]

Table 2: Fuel Economy (mpg) of New CARS Vehicles vs. MY2009–10

Category of New Vehicle	New Vehicles under CARS	MY2009	MY2010
Passenger Car	27.9	25.2	26.0
Truck—Cat. 1	21.6	19.4	19.8
Truck—Cat. 2	16.2	16.5	16.3
All Categories	25.0	22.6	22.6

Sources: NHTSA (2010, 2011), Automotive News (2011), ACEEE analysis

The fuel economy of vehicles purchased under the program averaged 25 mpg (excluding Category 3 trucks), compared to average fuel economy values of 22.6 mpg for both MY2009 and MY2010 as a whole, a difference of 2.4 mpg. CARS purchases' fuel economy advantage has two components: better fuel economy within category plus a larger share of cars, which tend to have higher fuel economies than trucks have. Table 3 offers a comparison of sales under the program by vehicle category to sales in 2009 and 2010.

Table 3: Vehicle Sales by Category under CARS and in Calendar Years 2009–10

	CARS Purchases (all MY)		Light-Duty Vehicle Sales (2009–10)	
Passenger Cars	396,848	58.6%	11,680,968	53.0%
Truck Cat. 1	230,362	34.0%	7,360,825	33.4%
Truck Cat. 2	47,501	7.0%	2,979,990	13.5%
Truck Cat. 3	2,273	0.3%	—	—
Total	676,984		22,021,783	

Sources: NHTSA (2009b, 2010), Automotive News (2011), ACEEE analysis

[8] Calculations are based on data from several sources. Fuel economy values for new vehicles purchased under the CARS program were taken from the paid transactions database at www.cars.gov (DOT 2011). NHTSA values are converted from CAFE to label fuel economies and reflect combined city/highway values. They were sales-weighted based on data from NHTSA and Automotive News (GM trucks only). See Appendix A for a discussion of the methodology underlying this table.

[9] Although harmonic averages are typically used to calculate fuel economy, because data from the program was officially reported as a simple average, we have used that calculation method here. For reference, however, the harmonic average of fuel economy was 23.8 mpg for CARS purchases, 21.4 mpg for MY2009 vehicles, and 21.2 mpg for MY2010 vehicles. The difference between these harmonic averages was 2.4–2.6 mpg, slightly more than the difference based on the simple weighted average calculation.

With regard to the fuel economy differential within category, new passenger cars under the program averaged 28 mpg, compared to MY2009 and MY2010 average fuel economies of 25.2 and 26 mpg, respectively. New Category 1 trucks under CARS averaged 21.4 mpg, exceeding model year 2009 and 2010 values of 19.4 mpg and 19.8 mpg, respectively. Category 2 trucks, however, averaged 16.2 mpg under the program, falling below model year 2009 and 2010 values of 16.5 and 16.3 mpg, respectively. This may be an artifact of the method used here to fill in data gaps due to the unavailability of final NHTSA data for GM trucks (see Appendix A), sales of which comprise approximately half of total Category 2 sales (NHTSA 2011).

To bring the effect of the CARS program on fuel economy within category into sharper focus, we present in Appendix B case studies of the sales of various trims of two popular nameplates under the program: the Ford F-150 and Toyota Camry. We find in these cases that shifts toward higher efficiency within nameplate were very slight.

The analysis above omits two considerations important to understanding the fuel economy impacts of the CARS program. First, among car buyers who owned eligible inefficient vehicles, those already planning to purchase new vehicles qualifying for a voucher under CARS presumably were more likely to participate in the program than those planning to buy less efficient vehicles. Hence the higher fuel economy of CARS purchases to some extent reflects purchases of efficient vehicles that would have occurred even without the program. We are unable to estimate the number of such participants. However, as noted previously, NHTSA estimates that about half of the sales under the program were net incremental sales, and any fuel economy gains due to these purchases clearly would not have been realized without the CARS program.

The second consideration serves to increase our estimate of the likely fuel economy impact of the CARS program. As noted previously, CARS participants were overwhelmingly (85%) truck owners, so their purchase choices absent the program might not have reflected the car/truck split in the market as a whole. Indeed, NHTSA's survey shows that participants who would have bought new vehicles in the absence of the CARS program purchased more cars (59% vs. 48%) and fewer Category 1 trucks (33% vs. 38%) and Category 2 trucks (7% vs. 13%) under the program than they reported they would otherwise have purchased.

Readjusting the weights of vehicle categories to reflect what CARS participants would have purchased according to the survey, rather than actual market shares for those categories, yields a lower expected fuel economy of 22 mpg in the absence of the incentive and brings the incremental fuel economy of CARS purchases up to 2.9 mpg. We calculate that higher fuel economy within category accounted for 2 mpg of the total 2.9 mpg increment; fuel economy gains from mix shift alone contributed 0.8 mpg.

Clearly the modestly higher fuel economy of new vehicles purchased under the CARS program was not sufficient to substantially raise average fuel economy of the new vehicle fleet as a whole for the year. Comparing the fuel economy of vehicles purchased under the program with the average fuel economy for MY2009 shows that the MY2009 vehicles purchased under the CARS program increased MY2009 fuel economy by 0.1 mpg.

VEHICLE AVAILABILITY AND PROGRAM STRINGENCY

As we have seen, the CARS program spent $4200 per participant and resulted in the purchase of vehicles that were, on average, 2.4 mpg more fuel-efficient than the market and 2.9 mpg more than was to be expected based on the mix of vehicles the participants would have otherwise purchased. These more efficient vehicles will consume 10% less fuel than the average vehicle purchased in model years 2009 and 2010. As a point of reference, Bunch and Greene (2010) estimate that a feebate program for California, in its first year, will induce car buyers to purchase vehicles that consume approximately 5% less fuel at an average rebate of $600. That is, the feebate would deliver half the per-vehicle gain in fuel economy at one-seventh the cost of the CARS program. On the other hand, the feebate would not be expected to produce a similar

increase in vehicle sales, nor would it require the scrappage of inefficient vehicles as the CARS program did.

Nonetheless, the question arises: given the size of the CARS incentives, could the program have been designed to better promote fuel-efficient vehicles while preserving the stimulative effect on vehicle sales? To answer this question, we consider the stringency of the program. One proxy for program stringency is the percentage of the vehicle market that was available to the average program participant. The greater the percentage of the market that was available for a voucher, the less stringent was the program.

A given vehicle's eligibility for the incentive depends not only on its own characteristics, but also those of the vehicle to be scrapped. Table 4[10] shows the sales-weighted percentage of the entire market available to the average program participant by incentive level, both overall and by vehicle category. We use sales-weighted data in Table 4 because we believe it better reflects the choices that consumers would have *tended* to make absent the CARS program, based on vehicle sales in 2009 and 2010, rather than the full set of choices they *could have* made.

Table 4: Sales-Weighted Percentage of New Vehicle Market Available to Average Program Participant

	Passenger Car	Truck—Cat. 1	Truck—Cat. 2	Total
$3,500	20%	9%	0.5%	29%
$4,500	26%	12%	1.2%	39%
Total	45%	21%	1.7%	68%

Sources: NHTSA (2010), ACEEE analysis

Overall, approximately 68% of the vehicle market[11] was available for a voucher to the average participant in the CARS program: 45% of the market was eligible passenger cars; 21% was eligible Category 1 trucks; and 1.7% was eligible Category 2 trucks. As noted above in the section on program results, the majority of purchases made under the CARS program were passenger cars, which is not surprising given that the bulk of eligible vehicles fell into that category. The percentages of vehicles within each class that were available on average were: 85% of cars; 63% of Category 1 trucks; and 13% of Category 2 trucks.

What does this imply about the stringency of the program's fuel economy requirements? Most obviously, that it was very easy to find an eligible vehicle. Even the $4500 voucher was available for a large percentage of the market (39%). Wide eligibility is likely to have contributed to a large number of participants receiving an incentive to purchase the same vehicle, and at the same time, that they would have without the program. In these cases, the fuel economy benefit of the program was limited to ensuring that the trade-in vehicle was removed from the road—and for larger trucks purchased under the program, even that benefit is questionable. In particular, those who traded in and also bought Category 3 trucks received $3500 without having to meet any requirements for fuel efficiency improvement.

The large percentage of eligible vehicles together with high per-vehicle cost of the program and the speed with which its funds were depleted all suggest that the fuel economy requirements for the program should have been more stringent, both at the $3500 and at the $4500 levels. This would have increased fuel savings per vehicle while providing the same stimulus to the auto industry. Stretching the available funds over several months rather than one seems likely to have produced a more beneficial sales boost.

[10] Based on fuel economy of participant vehicle trade-in. See Appendix A.

[11] The numbers in this table are based on the sales-weighted fuel economy of model year 2009 and 2010 light-duty vehicles. Due to rounding errors, rows and columns may not add correctly. See Appendix A for a discussion of the methodology underlying this table.

Table 4 points to an alternative measure of the cost of fuel economy increases associated with the CARS program: How much fuel economy gain was "purchased" by the $1000 difference between the two incentive levels ($3500 and $4500)? As shown, the average participant had access to 29% and 39% of the vehicle market under the two incentive levels, respectively. A breakdown of program transactions in Table 1 shows, however, that of the 676,984 total valid transactions, 71% qualified for the more stringent $4500 voucher. The difference between the expected distribution of purchases under each incentive level (43% and 57%),[12] based on availability, and the actual distribution (29% and 71%) suggests that the thousand-dollar difference did influence purchase decisions.

In order to quantify any mpg gain resulting from offering the $4500 incentive level, we compared the average increment in fuel economy (trade-in vs. new) under the program to the average increment between trade-in vehicles and all eligible vehicles on the market (sales-weighted).[13] The difference was negligible (0.05 mpg). Even though program participants purchased $4500 vehicles at a disproportionately high rate (71% rather than 57%), the percentage of trucks purchased (especially Category 2 trucks) under the program (41%) was higher than the percentage of trucks among eligible vehicles (33%). Since trucks are on average less fuel-efficient than cars, these two factors (more $4500 vehicles and more trucks) effectively cancelled each other out.

This does not mean that the program promoted the purchase of larger vehicles, however. As noted previously, participants purchased smaller vehicles on the whole under the program than they would otherwise have purchased. Scaling the percentages of the market available to the average participant in each vehicle category to match the mix actually purchased under the program yields a better estimate of the impact of the higher incentive level. With this approach, we found that the $1000 bought 1.2 mpg worth of fuel economy. This was a fuel economy increase substantially less expensive than the $4,200 for 2.4–2.9 mpg for the program as a whole.

Summary and Recommendations

We have shown that the average fuel economy of vehicles purchased under the CARS program exceeded the average for the light-duty fleet overall and for each vehicle category (except Category 2) by 8–11%. This was true even though the share of participants that were truck owners was disproportionately large. It was not possible, however, to quantify how much of the increment in fuel economy could be attributed to the CARS incentive, and how much reflected transactions that would have taken place in the absence of the program.

Program participants bought more passenger cars and fewer trucks than they reported they would have in the absence of the program. They also bought more cars and fewer trucks than buyers in the light-duty market as a whole. This is somewhat surprising given that the program offered large incentives for only slightly more fuel-efficient trucks, and that there were a large number of eligible trucks to choose from. The available data do not allow us to pinpoint why this shift took place.

Table 5 summarizes data presented earlier and provides three comparative perspectives on consumer purchase behavior under CARS. "Survey Baseline Vehicles" shows the mix of vehicles, by category, that survey respondents indicated they would have bought absent the program, while "Share of Market Availability" shows the mix of vehicles available to the average participant for an incentive.

[12] Here the total percentages for each incentive level are expressed relative to the 68% of the market available to the average program participant.

[13] Fuel economy of vehicles purchased under the program could not be directly compared to fuel economy of eligible vehicles because eligibility was defined in relation to the trade-in vehicle.

Table 5: Comparison of Vehicle Sales by Category

	CARS Purchases (all MY)	Survey Baseline Vehicles	Light-Duty Vehicle Sales (2009–10)	Share of Market Availability (MY09–10)[14]
Passenger Cars	58.6%	48.4%	53.0%	67.0%
Truck Cat. 1	34.0%	37.9%	33.4%	30.5%
Truck Cat. 2	7.0%	13.2%	13.5%	2.5%

Sources: NHTSA (2009b, 2010), Automotive News (2011), ACEEE analysis

Yet despite the large incentives offered, the fuel economy improvement from the CARS program was modest, a result that could have been improved upon by more stringent requirements for fuel economy differentials between trade-in and new vehicles. Doing so would have reduced the number of qualifying vehicles, but would also have "bought" higher fleet fuel economy—and associated fuel savings for consumers—while at least preserving, and perhaps enhancing, the program's macroeconomic stimulus effects. Indeed, a three-month program with more challenging fuel economy thresholds would likely have yielded a better outcome from all perspectives.

Direct incentive programs like Home Star (aka "Cash for Caulkers") were proposed following the enthusiastic consumer response to the Cash for Clunkers program. The current focus in Congress on deficit reduction and spending cuts makes such programs less likely in the immediate future, but product replacement programs are sure to be considered again at the state or federal level, or in other countries, at some point. We hope that the analysis presented here will provide a starting point for improving the design of any future programs so as to maximize energy savings while meeting other program objectives.

[14] Share of market availability was calculated by dividing each category's share of the portion of the market eligible for a voucher by the total share of the market; e.g., for passenger cars this means 45% divided by 68%, which equals 67% (given rounding errors).

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APPENDIX A: METHODOLOGY FOR ESTIMATION OF MARKET AVAILABILITY OF VEHICLES

In developing our estimate of the percentage of the market available to the average CARS program participant, we relied on two primary data sources: 1) trade-in fuel economy figures from the CARS program paid transactions database (NHTSA 2010); and 2) 2009 and 2010 Corporate Average Fuel Economy (CAFE) data from the National Highway Traffic Safety Administration (NHTSA 2011).

CAFE data from NHTSA was sorted into three of the four categories of vehicles eligible for vouchers under the CARS program: passenger cars, category 1 trucks and category 2 trucks.[15] Passenger cars are comprised of vehicles categorized under the following NHTSA vehicle classes: two-seater, minicompact, subcompact, compact, midsize and large sedans, and midsize and large wagons. Category 1 trucks include midsize passenger vans, all SUVs ("special purpose"), and midsize pickups with wheelbases less than or equal to 115 inches. Category 2 trucks include large cargo and passenger vans with wheelbases greater than 124 inches and large pickups with wheelbases greater than 115 inches.

Because CARS program thresholds were defined in terms of label fuel economy values, the CAFE data required a conversion. In 2009 and 2010, most manufacturers reported label fuel economy values, pursuant to EPA's 2006 labeling rule, using the "derived 5-cycle" approach, which allows manufacturers to compute city and highway label values from city and highway lab fuel economy values (40 CFR 600.210-12). These relationships can be used to approximate the combined label fuel economy (derived 5-cycle method) in terms of the combined lab fuel economy and the ratio of city to highway lab fuel economy values. This ratio varies by model, ranging from 0.53 to 1.15.[16] Substituting an intermediate value of this ratio for 2011 model year vehicles, 0.73, yields the approximation:

combined label fuel economy = 1 / (0.002412 + 1.242473 / combined lab fuel economy).

This approximation deviates from the actual label value at most by 1 mile per gallon, and for the vast majority of vehicles, much less.

Flex fuel vehicles (FFV) required an additional treatment to be able to compare them to gasoline-only vehicles. In this case, the flex fuel vehicle's CAFE value was divided by 1.65,[17] the result of which was then converted to a label value with the formula above.

We then determined the sales-weighted fuel economy distributions of the vehicles traded in under the CARS program and of vehicles from the NHTSA (2011b) CAFE dataset. Any vehicles not meeting program fuel economy requirements were excluded, i.e., 2009 and 2010 nameplates[18] with a combined fuel economy of less than 22 miles per gallon (mpg); and trade-ins with fuel economies greater than 18 mpg for passenger cars and 15 mpg for category 1 trucks.

At the time we received CAFE data from NHTSA, sales data for GM trucks was unavailable. Because GM trucks constitute approximately one-quarter of total light truck sales, we attempted to fill this gap with sales data from Automotive News (2011). Automotive News data does not

[15] NHTSA does not measure fuel economy of Category 3 trucks, so these vehicles have been excluded from the analysis.
[16] Calculated from a MY2011 dataset obtained from the U.S. EPA.
[17] Under CAFE, fuel economy of an FFV is defined by (49 USC 32905):
FFV fuel economy = 1/(0.5/gasoline fuel economy + 0.5/(E85 fuel economy/0.15)).
Since the energy content of a gallon of E85 is about 71 percent that of a gallon of gasoline (ANL 1999), we assume that E85 fuel economy is 71 percent of gasoline fuel economy (the actual percentage will vary by model). Substituting back into the FFV fuel economy formula, this yields the 1.65 factor cited above to convert CAFE fuel economy in the NHSTA database to an estimated gasoline fuel economy for the FFV.
[18] The vast majority (98.7%) of vehicles purchased under the program were from model years 2009 (75.3%) and 2010 (23.4%) (NHTSA 2010). We did not consider the market availability of older model year vehicles in the analysis.

include sales information for each trim level of a particular vehicle, so we had to assign all the sales for a particular vehicle (e.g., GMC Yukon) to the trim that reflected the average fuel economy of all trims. Although this method of weighting sales data is not ideal, we believe doing this will skew the market availability calculation less than simply excluding all GM truck sales data.

Because the CARS data set reported integer values for trade-in fuel economies, we rounded NHTSA model year fuel economies to the nearest whole integer to maintain consistency between both data sets and with program eligibility requirements, which are based on integer mpg values.

Next, we determined the probability for each combination of trade-in and new vehicle by setting up a two-way array (as shown in the example figure below). The left-most column of the array lists the fuel economy range of the trade-in vehicle category (in this case, Category 1 trucks). The column to the right of this is the relative percentage of vehicles in this trade-in category that have the specified fuel economy. Likewise, the second and third rows of the array consist of the fuel economy range and relative share of new vehicles with the specified fuel economy.

Multiplying each of these percentages together gives the values in the center of the array. Yellow cells indicate the combination of trade-in and new vehicle that is eligible for a $3500 voucher. Orange cells indicate the combination eligible for a $4500 voucher. Non-colored cells marked by an “X” indicate an ineligible combination under the program. Adding all cells of the same color together then yields a raw figure for market availability for that particular combination of trade-in and new vehicle for each voucher level.

To combine the raw sums from each year, we then weighted the percentage of all new vehicles sold under the CARS program constituted by each model year (see footnote 4). Adding together the resulting totals for each category of new vehicle yields the values for market availability in Table 4 (in the main body of the report).

Table A-1: Example of Array Used in Market Availability Calculation

		% of MY 2009 Cat. 1 Trucks with specified MPG															
		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Trade-in MPG	%	5.0%	4.4%	4.8%	2.2%	2.1%	2.3%	2.2%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
11	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12	1.8%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
13	4.0%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	6.5%	0.3%	0.3%	0.3%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	13.1%	0.7%	0.6%	0.6%	0.3%	0.3%	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	16.7%	0.8%	0.7%	0.8%	0.4%	0.4%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
17	8.8%	0.4%	0.4%	0.4%	0.2%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
18	15.2%	0.8%	0.7%	0.7%	0.3%	0.3%	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

APPENDIX B: FUEL ECONOMY CASE STUDIES

Case Study #1—Ford F-150

Table B-1 shows total and percentage sales of Ford F-150 trims under the CARS program, compared to overall model year 2009 and 2010 sales. The most important point to note is that in model years 2009 and 2010 all four-wheel drive models accounted for 59% of total sales and all two-wheel drive models accounted for 41% of sales. Under the CARS program, sales ranking of these two trims flip-flopped, with the two-wheel-drive drives accounting for 59% of sales and the four-wheel-drives 41%. Two-wheel-drive vehicles typically have higher fuel economy than their four-wheel-drive counterparts.

Table B-1: Ford F150 Sales under CARS and in Calendar Years 2009 & 2010

	CARS		2009–2010	
Trim	Sales	% of F-150 sales under CARS	Sales	% of F-150 sales in 2009–10
F-150 Pickup 2WD	8,127	52%	180,938	28%
F-150 Pickup 2WD FFV	1,048	7%	85,291	13%
F-150 SFE 2WD	118	0.8%	2,866	0.4%
F-150 Pickup 4WD	3,103	20%	90,443	14%
F-150 Pickup 4WD FFV	3,307	21%	290,760	45%
All 2WD	9,293	59%	269,095	41%
All 4WD	6,410	41%	381,203	59%
All trims	15,703		650,298	

Sources: NHTSA (2010, 2011)

The reduced share of flex-fuel vehicles under the program may have been due to several factors. Although guidance on vehicle eligibility was available online, there may have been some consumer confusion about whether flex-fuel vehicles qualified for the program, considering their lower fuel economy ratings when running on ethanol. Another possible factor is the varying production of these vehicles throughout the year, as manufacturers seek to maximize their FFV credits within the allowed cap.

Table B-2, which shows the fuel economy of F-150 trims under CARS and model years 2009 and 2010,[19] may also provide some insight into this shift. The two-wheel-drive pickup, which had the largest percentage sales gain under the program, is the second-most efficient F-150 trim, a fact that may have encouraged the shift away from four-wheel drive vehicles. The "superior fuel efficiency" (SFE) two-wheel-drive pickup (most efficient of the trims) also doubled its share of sales under the program when compared to the market as a whole.

[19] Fuel economy figures for model years 2009 and 2010 were based on data from fueleconomy.gov and weighted by sales. Flex-fuel vehicle fuel economy was calculated based only on gasoline operation.

Table B-2: Ford F-150 Fuel Economy under CARS Compared to Model Year Sales-Weighted Average[20]

Trim	CARS (all MY)	MY 2009	MY 2010
F150 Pickup 2WD	16.5	16.4	16.6
F150 Pickup 2WD FFV	16	16	16
F150 SFE 2WD	17	17	—
F150 Pickup 4WD	15.7	15.7	16.0
F150 Pickup 4WD FFV	15	15	15
All 2WD	16.4	16.3	16.4
All 4WD	15.3	15.2	15.2
All trims	16.0	15.7	15.7

Sources: NHTSA (2010, 2011), fueleconomy.gov

These various shifts in consumer F-150 purchases had a small effect on the overall fuel economy of the F-150 fleet sold under CARS, raising it three-tenths of one mpg compared to the market as a whole.

Case Study #2—Toyota Camry and Camry Hybrid

As Table B-3 shows, sales of the 2.4L (MY 2009) and 2.5L (MY 2010) regular Camry accounted for the bulk of sales in the market (83%), followed by the 3.5L regular Camry (10%) and the Camry Hybrid (7%).

Table B-3: Toyota Camry Sales under CARS Compared to Calendar Years 2009 & 2010

	CARS (all MY)		2009–2010	
Model & Trim	Sales	%	Sales	%
Camry 2.4L/2.5L	22,654	85.2%	729,139	82.9%
Camry 3.5L	2,108	7.9%	85,691	9.7%
All Reg. Camry trims	24,762	93.2%	814,830	92.7%
Camry Hybrid	1,818	6.8%	64,520	7.3%
All models & trims	26,580		879,350	

Sources: NHTSA (2010, 2011)

Under CARS, sales of the 2.4L/2.5L represent a 3% larger share than in the market, while sales of 3.5L are about 19% lower than in the market. Sales of the Camry Hybrid were 7% lower under CARS than in the market. This suggests that CARS participants bought relatively fewer of the Hybrid, the most fuel-efficient of the Camry models (see Table B-4), instead opting for the second-most fuel-efficient 2.4L/2.5L regular Camry. The price premium of the Camry Hybrid—approximately $7000 for the 2011 model (Edmunds 2011)—may have been too high for large numbers of consumers to consider buying one, even with a $4500 voucher and state incentives.

As Table B-4 shows, the fuel economy of Camrys sold under CARS exceeded that of the market as a whole by 1–2%. The fact that the fuel economy of all models and trims under CARS was higher than that of either model year 2009 or 2010 suggests that the shift towards the 2.4L/2.5L

[20] All values are sales-weighted harmonic averages. Vehicles with only one trim have integer fuel economy values.

regular Camry under the program more than offset the slight shift away from the hybrid model, leading consumers to realize a fuel economy gain of 0.2–0.6 mpg on average.

Table B-4: Toyota Camry & Hybrid Camry Fuel Economy under CARS Compared to Model Year Sales-Weighted Average[21]

Model & Trim	CARS (all MY)	MY 2009	MY 2010
Camry 2.4L/2.5L	26	25	26
Camry 3.5L	23	23	23
All Reg. Camry trims	25.7	24.8	25.7
Camry Hybrid	34	34	34
All models & trims	26.1	25.5	25.9

Sources: NHTSA (2010, 2011), fueleconomy.gov

[21] All values are sales-weighted harmonic averages.