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Abstract

In this paper we analyze whether the 2009 "Cash for Clunkers" program was indeed, as U.S. Transportation Secretary Ray LaHood suggested at the time, "good news for...consumers' pocketbooks." To do so we investigate how much of the rebate benefited consumers as opposed to dealers, whether the rebate crowded out or stimulated manufacturer incentives, and whether the scrapping of a large number of vehicles affected prices in the used-vehicle market. We find that Cash for Clunkers was consistently positive for consumer welfare on all three dimensions that we measure: First, consumers received the full amount of the rebate; second, the program stimulated manufacturer rebates (thereby increasing the benefits to customers beyond the value of the Cash for Clunkers rebates alone); and third, the destruction of low-fuel-economy, old, high-mileage vehicles did not raise prices in the used-vehicle market.

1 Introduction

On June 24, 2009, President Obama signed into law the Consumer Assistance to Recycle and Save Act, creating the Car Allowance Rebate System, better known to the public as "Cash for Clunkers." Cash for Clunkers offered a government credit of either $3,500 or $4,500 toward the purchase of a new vehicle if a customer traded in a used vehicle with a fuel economy rating of 18 miles per gallon (MPG) or less, and purchased a new vehicle whose fuel economy rating was sufficiently above that of the trade-in vehicle. Policymakers enumerated three objectives for Cash for Clunkers: stimulating the economy, improving the environment, and helping out everyday consumers. For example, U.S. Secretary of Transportation Ray LaHood was quoted in a July 27, 2009, Department of Transportation press release as saying, "With this program, we are giving the auto industry a shot in the arm, and struggling consumers can get rid of their gas-guzzlers and buy a more reliable, fuel-efficient vehicle. This is good news for our economy, the environment, and consumers' pocketbooks."

The timing of the program, in the midst of the Great Recession, suggests that economic stimulus may have been particularly important to policymakers among the three objectives, specifically the potential for Cash for Clunkers to preserve American jobs.[1] Much of the early analysis of the effect of the program has emphasized the stimulus effects, including Mian and Sufi (2012) and Copeland and Kahn (2011).

In this paper, we analyze the effect of Cash for Clunkers on consumers directly. Our aim in this paper is to assess the extent to which Cash for Clunkers was indeed "good news for...consumers' pocketbooks," to borrow Secretary LaHood's phrase. We will investigate three primary channels through which Cash for Clunkers might have affected consumer welfare. First, Cash for Clunkers was a rebate directed to vehicle buyers who traded-in qualifying used vehicles and purchased qualifying new vehicles.[2] However, prices for new vehicles are negotiated between individual buyers and dealers, which means that whether the consumer obtains the full value of the rebate depends on the outcome of the negotiation with the dealer. Busse, Silva-Risso, and Zettelmeyer (2006) showed that when car manufacturers offer cash rebates to vehicle-buying customers, less than the full value of the rebate "passes through" to consumers. This is because dealers persuade customers who receive cash rebates from manufacturers to agree to a higher purchase price for the vehicle than customers who do not receive a manufacturer rebate. This means that the net-of-rebate price paid by a customer receiving a rebate is lower than the prices paid by customers not receiving rebates,

[1] The new vehicles purchased need not have been from a "Big Three" American manufacturer in order to translate into American jobs, since a number of non-U.S. nameplates–such as Toyota, Honda, and BMW–manufacture vehicles in the United States

[2] In practice, car dealers paid rebates to customers at the time of purchase, and then applied to the CARS program for reimbursement.

but not by the full value of the rebate. We will investigate whether something similar happens with Cash for Clunkers rebates. If dealers can persuade customers to agree to higher transaction prices than they would have agreed to without the rebate, then dealers will have managed to obtain some of the value of the rebate, and customers will benefit by less than the full rebate amount. In our first set of empirical results, we will estimate whether Cash for Clunkers rebates pass through fully to buyers.

A second way that customer welfare could be affected by Cash for Clunkers is through the response by manufacturers to the program. Manufacturers often offer their own rebates in order to encourage customers to purchase specific vehicles, and the average sizes of these rebates have been steadily increasing since 2001.[3] One could imagine that, in light of government subsidies for the purchase of particular vehicles, manufacturers would reduce the rebates they offered on those particular vehicles. In other words, Cash for Clunkers might have "crowded out" manufacturer rebates. If this is the case, then the incremental consumer benefits generated by the Cash for Clunkers rebates will be less than the rebate amounts. Alternatively, one could also imagine that manufacturers, faced with government subsidies to customers who bought some sort of high-fuel-economy vehicle, would add subsidies to those vehicles to make sure that customers bought *that manufacturer's* high-fuel-economy vehicle. In other words, Cash for Clunkers might have "stimulated" manufacturer rebates, increasing the incremental benefits to customers generated by the Cash for Clunkers program beyond the value of the rebates alone. In our second set of empirical results, we will estimate how manufacturer rebates changed in conjunction with Cash for Clunkers.

A third way in which customer welfare could be affected by Cash for Clunkers is through the used-vehicle market. Vehicles that were traded in in conjunction with the Cash for Clunkers program had their engines permanently, physically disabled, and then were sold for spare parts and scrap.[4] Almost 700,000 used vehicles were scrapped as a result of the program, mostly low-fuel-economy, old, high-mileage vehicles. If removing this set of vehicles from the vehicle stock also eliminated a substantial fraction of such vehicles from the used-vehicle market, a consequence of the Cash for Clunkers program may have been to increase the prices of low-fuel-economy, old, high-mileage vehicles. Such a price increase would reduce the consumer welfare of customers who typically purchase such vehicles. On the one hand, if these individuals have lower incomes, on average, than the individuals who received subsidies through Cash for Clunkers for the purchase of new vehicles, then Cash for Clunkers could have had a regressive distributional effect on consumer

[3]The September 11 terrorist attacks led GM to launch a promotion called "Keep America Rolling" on 9/19/2001. This started a wave of new promotions by many manufacturers as a way of preventing a drop in vehicle sales.

[4]The program required that the engine of traded-in vehicles be destroyed. Dealers were instructed to accomplish this by draining the oil from the vehicle, replacing the oil with a sodium silicate solution (also known as liquid glass), and running the vehicle at moderate RPM for several minutes until the engine would no longer run. After this, the dealer could sell the vehicle as scrap or for the salvage of parts that were not part of the engine or drive train.

welfare. On the other hand, if the vehicles traded in during Cash for Clunkers were mostly infra-marginal vehicles—vehicles that were not likely to have been sold in the near future—then their destruction might have had little effect on the used-vehicle market. Under this scenario, owners who would have continued to hold these vehicles for some time instead swapped them for new vehicles, having ultimately a very diffuse and maybe imperceptible effect on future used-vehicle markets. In our third set of empirical results, we will estimate the effect of Cash for Clunkers on used-vehicle markets.

Our findings are as follows: First, when we estimate how much of the Cash for Clunkers rebate ends up in buyers' pocketbooks we find that dealers passed 100% of the rebate through to consumers. This is a higher pass-through rate than that of manufacturer rebates, which had a pass-though rate of approximately 80%. This means that dealers did not use the Cash for Clunkers rebate to negotiate a higher new vehicle price.

Second, Cash for Clunkers rebates did *not* crowd out rebates offered by manufacturers. To the contrary, during the Cash for Clunkers program, more vehicles sold with a manufacturer rebate and the average rebate amount was higher than either before the program started or after it ended. Moreover, the increase in manufacturer rebates during the Cash for Clunkers program occurred only for cars that met the program's criteria. The manufacturer rebates of cars that did not qualify under the program did not change. This suggests that Cash for Clunkers "stimulated" manufacturer rebates, increasing the incremental benefits to customers generated by the program beyond the value of the rebates alone.

Third, we find no evidence that the Cash for Clunkers program, by scrapping 700,000 used vehicles, increased the prices of low-fuel-economy, old, high-mileage vehicles. We reach this conclusion by comparing the market prices of vehicles that were similar to vehicles commonly used as Cash for Clunkers trade-ins with the prices of vehicles that were unlikely to be used as Cash for Clunkers trade-ins. When we analyze the price paths for these two groups of cars during and after the end of the program, we find no systematic differences, suggesting that the destruction of vehicles had little effect on the used-vehicle market. We conjecture that owners, in the absence of the Cash for Clunkers program, would have continued to hold their used vehicles for some time.

In conclusion, Cash for Clunkers was consistently positive for consumer welfare on all three dimensions that we measure: First, consumers received the full amount of the rebate; second, the program stimulated manufacturer rebates (thereby increasing the benefits to customers beyond the value of the Cash for Clunkers rebates alone); and third, the destruction of low-fuel-economy, old, high-mileage vehicles did not perceptibly affect the used-vehicle market.

The paper proceeds as follows. In Section 2 we describe the Car Allowance Rebate System in greater detail. In Section 3, we describe the data that we use for our analysis. Section 4 presents

our analysis of the pass-through of Cash for Clunkers rebates. Section 5 presents our analysis of manufacturer responses to Cash for Clunkers. Section 6 presents our analysis of the effect of the program on the market for the types of used vehicles that were used as Cash for Clunkers trade-ins. Section 7 offers some concluding remarks.

2 The Car Allowance Rebate System

2.1 Legislative history

In an influential op-ed piece in *The New York Times* in July 2008, Alan Blinder proposed a vehicle scrappage program, calling it, "'Cash for Clunkers,' the best stimulus idea you've never heard of."[5] Blinder outlined three benefits of the program: 1) "a cleaner environment," since the oldest vehicles are also the most polluting; 2) "more equal income distribution," since clunkers are owned primarily by low-income people; and 3) "an effective economic stimulus," since it would put cash directly into the hands of individuals.

Not much progress was made toward creating such a program until the following spring, when events moved fairly quickly between the first legislative introduction of such a bill to an implemented program.

On March 17, 2009, Representative Betty Sutton of Ohio introduced a vehicle scrappage bill in Congress. On April 1, 2009, the *Washington Post* reported that lawmakers were working on a "compromise legislation to merge competing proposals" from Rep. Sutton and Senator Dianne Feinstein of California. By May 2009, lawmakers had arrived at something close to the program's final form; a "Q&A" in *USA Today* about the proposed program published on May 11, 2009, closely reflected the details of the final program. On June 9, 2009, the House approved the "Consumer Assistance to Recycle and Save Act" (CARS). On June 24, President Obama signed CARS into law. According to the regulation, transactions became eligible for CARS vouchers on July 1, 2009, a week after the program became law. However, it was not until July 24, 2009, that the National Highway Transportation and Safety Administration (NHTSA) issued an implementation rule that outlined the administrative details for how the program would actually work. NHTSA "kicked off" the Car Allowance Rebate System (whose acronym was also CARS) on July 27 by offering a dealer education webinar, launching a Website, opening a consumer hotline, and allowing dealers to submit transactions for reimbursement.

[5] Alan S. Blinder, "A Modest Proposal: Eco-Friendly Stimulus," *New York Times*, July 27, 2008.

2.2 Program conditions

In simplest terms, the Cash for Clunkers program offered a credit to customers who traded in a sufficiently low-fuel-economy vehicle in exchange for a new vehicle whose fuel economy was above an absolute threshhold and also sufficiently improved over that of the trade-in vehicle. In reality, the conditions that defined whether a transaction qualified for the program were slightly more involved, as summarized in Table 1.[6] Specifically, if the new vehicle was a passenger car, it had to get at least 22 MPG. If the new passenger car's MPG was 4-9 miles per gallon above that of the trade-in vehicle, the credit was $3,500; if it was an improvement of 10 or more miles per gallon, the credit was $4,500. If the new vehicle was an SUV, pickup, or van, the new vehicle had to have an MPG of at least 18, and the credit was $3,500 for an improvement of 2-4 miles per gallon and $4,500 for an improvement of at least 5 miles per gallon. The trade-in vehicle also had to be less than 25 years old, drivable, and had to have been registered and insured by the current owner for the previous year. The newly purchased vehicle had to be new and have a sticker price of less than $45,000. Dealers disabled the vehicles they received as trade-ins, and transported them to a designated scrappage facility.[7]

Table 1: Summary of Car Allowance Rebate System Program Conditions

If you want to buy...	The MPG of the new vehicle must be...	If the difference in MPG between the trade-in and new vehicle is...	Then credit is...
Passenger car	22 MPG or more	4-9 MPG	$3,500
		10+ MPG	$4,500
SUV, Pickup, or Van	18 MPG or more	2-4 MPG	$3,500
		10+ MPG	$4,500
Very large Pickup or Van	15 MPG or more	1 MPG*	$3,500
		2 MPG*	$4,500

* Trade-in has to be very large pickup truck or van

2.3 Implementation

Cash for Clunkers was implemented as a system of credits that dealers extended to buyers who participated in qualifying transactions. This meant that buyers could receive the value of the credit at the moment they purchased (or leased) a new vehicle. The dealer then submitted paperwork

[6] For complete program rules, see Federal Register, vol. 74, no. 126, July 2, 2009, p. 31817, which can be accessed at http://www.cars.gov/files/official-information/day-one.pdf.

[7] From NHTSA's proposed rule for implementing CARS: "The CARS Act requires that the trade-in vehicle be crushed or shredded so that it will not be resold for use in the United States or elsewhere as an automobile. The entity crushing or shredding the vehicles in this manner will be allowed to sell some parts of the vehicle prior to crushing or shredding it, but these parts cannot include the engine or the drive train." (Federal Register, vol. 74, no. 126, July 2, 2009, p. 31815)

proving that the transaction did indeed qualify for Cash for Clunkers to NHTSA for verification, and was then reimbursed for the credit extended to the buyer.[8]

Cash for Clunkers ran for one month from July 24 to August 24, 2009, until the program ran out of funding and the Department of Transportation announced its closure.[9] During that time 677,842 transactions qualified for the program, and a total of $2.85 billion was paid out in credits. The average MPG of new vehicles purchased under the program was 24.9 and the average MPG of trade-ins used in those transactions was 15.8. The average rebate for a participating buyer was $4,208. This indicates that more than half of the buyers qualified for the $4,500 credit, meaning that they chose new vehicles with a fuel economy considerably higher than that of their trade-ins.

3 Data

We will combine data from four different sources for the analysis in this paper. The first is information on individual vehicle transactions collected by a major market research firm. The data contain detailed information on every transaction that occurs in a sample of 15-20% of the new car dealerships in the United States. We will use information on transactions that occur between July 2008 and December 2010. This sample window gives us a full model year before the Cash for Clunkers program (July-August 2009), and more than a year of data after it ended.

For each transaction we observe the price of the vehicle negotiated between the buyer and the dealer. We observe the manufacturer rebates and any Cash for Clunkers credits that applied to each transaction. We observe customer demographics at the Census-block level. Finally, we observe detailed characteristics of both the new vehicle purchased, and the trade-in vehicle used in the transaction, if any. These characteristics include the make, model, model year, body type, number of doors, trim level, drive train type, number of cylinders, and engine displacement. We define the interaction of these variables as a "vehicle type." An example of a single vehicle type in our data is a 2010 Ford Escape SUV with 4 doors, XLT trim level, 2WD, 4 cylinders, and a 2.5L engine. For trade-in vehicles, we observe the odometer reading, how much the customer was paid for the trade-in, and the "actual cash value" of the trade-in as booked by the dealer in internal records.

Our second source of data is the National Highway Transportation and Safety Administration

[8] From NHTSA's proposed rule for implementing CARS: "Under the CARS Act, consumers will not receive vouchers or money directly from the government. Instead, automobile dealers would credit the applicable amount against the cost of purchasing or leasing an eligible new vehicle and then apply to NHTSA for reimbursement. NHTSA would then reimburse dealers for the amount of the credit through an electronic transfer of funds, assuming that the agency determines that all program requirements have been met." (Federal Register, p. 31813)

[9] Transactions were technically eligible for Cash for Clunkers credits as of July 1, 2009, but the Department of Transportation did not issue the program rules until July 24, 2009.

(NHTSA), which reports transactions that received credits in the Cash for Clunkers program. NHTSA reports the vehicle identification number (VIN) for the trade-in, a VIN prefix for the new vehicle purchased, and the credit amount applied to the transaction. We merge the information on Cash for Clunkers credits into our transaction data using the trade-in's VIN and the VIN prefix for the new vehicle. Our data contain 83,986 Cash for Clunkers transactions. The average new vehicle price for vehicles purchased under Cash for Clunkers, before subtracting the Cash for Clunkers credit, is $22,592. This number is less than the average price in the overall data for two reasons. First, Cash for Clunkers credits could not be applied to any vehicle with a manufacturer suggested retail price (MSRP) above $45,000. Second, vehicles had to be above a certain MPG threshold to qualify for Cash for Clunkers. Lighter, less powerful vehicles generally have higher MPG and lower prices than heavier, more powerful vehicles.

Our third source of data is the Environmental Protection Agency (EPA). We use the EPA's "combined fuel economy" rating, which was used in the Cash for Clunkers regulation. The combined fuel economy is a geometric weighted average of highway and city MPG, with 45% weight on highway and 55% weight on city. The tails of the MPG distribution fall below 10 and above 50 MPG, but 90% of the new vehicles in our sample fall between 15 and 29 MPG. As a point of reference, a Ford F150 pickup truck (which our data source categorizes as a light-duty, full-size pickup truck) is rated at 15 MPG, while a Honda Civic (categorized as a premium compact car) is rated at 29 MPG. The Cash for Clunkers program had two important cut-offs: at 18 MPG (the highest allowable MPG for a trade-in vehicle, and also the lowest allowable MPG for a new SUV, pickup, or van purchased under the program) and 22 MPG (the lowest allowable MPG for a new passenger vehicle purchased under the program). A representative 18 MPG vehicle is the Honda Pilot (a midsize SUV) and a representative 22 MPG vehicle is a Lexus ES 350 (an entry luxury car).

Our final source of data is the Energy Information Administration (EIA). EIA reports data on gasoline prices at the level of a PADD (Petroleum Administration for Defense District), of which there are seven in the country: New England, Central Atlantic, Lower Atlantic, Midwest, Gulf Coast, Rocky Mountain, and West Coast. For each transaction, we merge in that week's gasoline price in the appropriate PADD. The national average gasoline price hit its peak at above $4 in the middle of 2008. (This was a record-high real gasoline price, exceeding even the real prices during the 1970s oil shocks.) The national average gasoline price then fell precipitously through the second half of 2008, reaching a low point below $2. During the Cash for Clunkers program, the national average price of gasoline was just above $2.50 per gallon, in the midst of a period that was neither a steady rise nor a steady fall.

We use a 20% random sample of all transactions as our estimation sample.[10] Our final estimation sample contains 1,056,540 transactions. The average price of the new vehicles purchased in these transactions is $27,715. Table 10 presents additional summary statistics.

4 Pass-through results

In this section, we estimate the average fraction of the Cash for Clunker credit that "passes through" to customers as a lower price. If the prices paid by consumers whose transactions qualify for Cash for Clunkers fall by the full amount of the credit, then they are obtaining the program's full subsidy. However, if dealers can persuade customers to agree to higher transaction prices than they would have without the rebate, then dealers will have managed to obtain some of the value of the rebate, and customers will benefit by less than the full rebate amount. The logic of our empirical approach is simple: we will estimate the "pass-through rate" by regressing new vehicle prices on rebate amounts; the coefficient will estimate what by what fraction of the rebate amount (between 0%, a coefficient of 0, and 100%, a coefficient of -1) the new vehicle price falls.

In practice, we need to be careful about how we measure prices and rebates in order to estimate the effect we actually want to identify. The dependent variable we will use in our estimation is the vehicle price net of rebates. The vehicle price is the amount that the customer and dealer negotiate for a particular vehicle, not a list price (MSRP) or average price. The new vehicle price includes all options installed on the vehicle, except for those that our data provider considers as "not contributing to the resale value of the vehicle."[11]

We would like our price variable to measure the consumer's total wealth outlay for the vehicle. This requires making some adjustments to the new vehicle price. First, we need to account for any profit or loss the customer made on his or her trade-in. Dealers are willing to pay new vehicle customers more than their trade-in is worth, if that will help close a deal;[12] they will also give customers less than the value of their trade-in if they think the customer is poorly informed. We can measure the profit or loss the customer makes on the trade-in, because we observe separately in our data the price that the dealer agrees to pay the customer for the trade-in vehicle, and the market value the dealer assigns to the vehicle in its own internal records, an amount called the "actual cash value." For example, if a trade-in had an actual cash value of $10,000 and the dealer paid the consumer $10,000, we would make no adjustment to the new vehicle price. However, if

[10] The 20% sample is necessary to allow for estimation of specifications with multiple sets of high-dimensional fixed effects, including fixed effect interactions, that we use later in the paper.

[11] This includes, for example, undercoating.

[12] Sometimes this is a negotiating ploy; sometimes it helps the customer pay off the loan on the vehicle that is being traded-in.

the trade-in had an actual cash value of $10,000 and the dealer paid the consumer only $9,000, the consumer lost $1,000. We can think of this loss as an in-kind payment for the new vehicle, which should be reflected in the new vehicle price. Consequently, we add $1,000 to the price of the new vehicle. Similarly, we subtract from the new vehicle price any profit that a consumer made on the trade-in.

In order to interpret the new vehicle price as a consumer's total wealth outlay for the vehicle, we also subtract from the price any cash rebate paid to the customer by the manufacturer. Such rebates are effectively offers by the manufacturer to pay for part of the price of the new vehicle, and they offset what the customer has to pay for the vehicle.

The last adjustment we have to make to our measure of vehicle price is for Cash for Clunkers rebates to qualifying transactions during the program. This requires some care, because while the Cash for Clunkers payment is styled as a rebate, a customer qualifies only by surrendering an existing vehicle, which presumably has some market value. The net value of the rebate to the customer, therefore, is the rebate payment minus the actual cash value of the trade-in vehicle. The observable Cash for Clunkers rebate is equal to either $3,500 or $4,500 depending on the characteristics of the transaction. However, we do not have a consistent record of the actual cash value of the vehicles that were traded in during this period. Dealers were required to disable and scrap Cash for Clunkers trade-ins instead of selling them on their own lots or at auction, which are dealers' usual methods of disposing of trade-in vehicles. Perhaps as a consequence, dealers generally did not record actual cash values for Cash for Clunkers trade-ins.

We estimate the actual cash value of Cash for Clunkers trade-ins using the actual cash value of trade-ins prior to the program. Specifically, we use data on transactions that occurred between January 1, 2008, and June 30, 2009, to estimate the value of trade-ins as a function of the vehicle's odometer mileage and seasonal effects. We anticipate that both of these effects on actual cash value will vary by type of vehicle, so we regress the actual cash value of trade-ins during the subsample period on "sub-segment" $\times$ month-of-year fixed effects and trade-in "vehicle type" $\times$ "odometer bin" fixed effects. Vehicles in our data are classified into one of 19 sub-segments (compact pickups, midsize SUVs, premium luxury cars, etc.). Interacting month-of-year with subsegment allows the seasonal effects on the value of trade-ins to vary by sub-segment. The second set of fixed effects are based on indicator variables for "odometer bins" in 20,000 mile intervals, i.e., odometer bin 1 contains vehicles with odometer readings from 0 - 20,000 miles, odometer bin 2 contains vehicles with odometer readings from 20 - 40,000 miles, and so on. We interact these indicators with our vehicle type indicators, which allows odometer to have a different effect on actual cash values for each combination of make, model, model year, trim level, doors, body type, displacement, cylinders, and transmission in our data. (For example, one "vehicle type" in our data is a 2006 Honda Accord

LX 4-door sedan with a 6-cylinder, 3.0-liter engine and automatic transmission.) We then use these estimated sub-segment × season and vehicle-type × odometer fixed effects to predict the actual cash values for vehicles that were traded as part of Cash for Clunkers. By subtracting this predicted trade-in actual cash value from the Cash for Clunkers rebate, we obtain an estimate of the "net Cash for Clunkers rebate." For each transaction we subtract this net rebate from the new vehicle price.

Now we can estimate the pass-through of the Cash for Clunker rebate using the following specification:

$$\begin{aligned} \mathrm{P}_{ijt} =& \alpha_0 + \alpha_1 \mathrm{CfCPeriod}_t + \alpha_2 \mathrm{CfCRebate}_{it} + \alpha_3 (\mathrm{CfCPeriod} \cdot \mathrm{ManufRebate}_{jt}) + \\ & \alpha_4 ((1 - \mathrm{CfCPeriod}) \cdot \mathrm{ManufRebate}_{jt}) + \boldsymbol{\alpha_5} (\mathrm{GasolinePrice}_{it} \cdot \mathrm{MPG\ Bin}_j) + \\ & \boldsymbol{\alpha_6 \mathbf{Demog}}_i + \alpha_7 \mathbf{PurchaseTiming}_{it} + \mu_r + \delta_j + \tau_{ST} + \xi_{ijt} \end{aligned} \tag{1}$$

The dependent variable in this specification is the price P_{ijt} that consumer i pays for vehicle of vehicle type j at time t. *CfCPeriod* is an indicator variable that is one between July 24, 2009, and August 24, 2009, and zero otherwise, the duration of the Cash for Clunkers program. Including *CfCPeriod* allows average prices to differ between the Cash for Clunkers period and other time periods. *CfCRebate* is the "net Cash for Clunkers rebate" (Cash for Clunkers rebate minus estimated actual cash value of the trade-in) paid to a consumer who trades in a vehicle under the program. For all other transcations this variable equals zero. *ManufRebate* is the rebate (if any) paid by a manufacturer to the consumer. To allow the pass-through of manufacturer rebates to differ between the Cash for Clunkers period and other time periods, we interact *ManufRebate* with *CfCPeriod* and (1-*CfCPeriod*). We also control for any effect of the gasoline price in customer i's location at time t on new vehicle prices.[13] We interact *GasolinePrice* with miles per gallon (MPG) bins, dividing the sample into rough quintiles according to the EPA's combined fuel economy ratings.[14] **Demog** controls for a large set of demographic characteristics that are based on the Census block group in which the buyer resides. Using data from the 2000 Census we control for the income, house value and ownership, household size, vehicles per household, education, occupation, average travel time to work, English proficiency, and race of buyers. We also control for the time of purchase (**PurchaseTiming**), in particular whether the transaction occurred on a weekend (Saturday or Sunday); during the last five days of the month; or the last five days of the year. We also allow for regional variation in new vehicle prices by including region fixed effects (μ_r). The firm that collects our data splits the United States into 34 regions, based on its understanding of

[13] Busse, Knittel, and Zettelmeyer (2013) find modest effects of gasoline prices on the prices of new vehicles.
[14] The bins are [0 to 16),[16 to 19), [19 to 21), [21 to 24), and [24 to ∞) MPG.

local automobile markets.[15]

The two key controls in this specification are δ_j and τ_{ST}. δ_j represents vehicle-type fixed effects. As we have described above, a "vehicle type" is the interaction of make, model, model year, trim level, doors, body type, displacement, cylinders, and transmission. These fixed effects allow us to compare the effect of rebates among identical vehicles.[16] τ_{ST} is a week $\times$ vehicle segment fixed effect where S denotes the segment to which vehicle j belongs, and T denotes the week in which the purchase date t falls. This fixed effect implements a difference-in-differences estimator when estimating the effect of rebates. We do this to address a potential endogeneity concern in estimating the pass-through of manufacturer rebates. Manufacturers may be more likely to offer promotions when prices are declining or low due to demand conditions. As a result, prices that are observed when manufacturers choose not to offer promotions are likely to be poor counterfactuals for prices when manufacturers choose to offer promotions. Our difference-in-differences approach controls for segment-specific price changes week to week. As a result, the specification uses the prices of similar vehicles that are not being promoted in a given week to estimate the counterfactual price for vehicles that are being promoted that same week.[17]

The key coefficient in Equation 1 is α_2, which measures the fraction of the Cash for Clunkers rebate that is passed through to customers. If α_2 is equal to 0, this means that none of the CfCRebate is passed through to consumers—the dealer is able to adjust the prices of new vehicles in Cash for Clunkers transactions such that the dealer captures all the surplus from the rebate. If α_2 is equal to -1, the consumer obtains the full amount of the rebate by obtaining a price that is lower by the entire rebate amount. The coefficient $100 \cdot |\alpha_2|$ can be interpreted as the percentage of the Cash for Clunkers rebate obtained by the consumer. Similarly, α_3 and α_4 measure what fraction of the manufacturer rebate is passed through to customers. As in the case of the Cash for Clunkers rebate, $100 \cdot |\alpha_3|$ and $100 \cdot |\alpha_4|$ can be interpreted as the percentage of the manufacturer rebate obtained by the consumer during the Cash for Clunkers period and at other times, respectively.

Table 2 reports the results from estimating Equation 1. Column 1 shows that, on average, consumers obtained 101% of the Cash for Clunkers rebate (statistically not distinguishable from 100%). This result indicates that consumers obtained the full value of the Cash for Clunkers rebates for which they were eligible. In contrast, consumers obtained, on average, 82% of any

[15]The regions are a complete division of the country, despite names that seem to suggest cities and/or states: Baltimore/Washington, Charlotte, Cincinnati, Cleveland, Colorado, Columbus, Dakotas, Detroit, Georgia, Gulf, Hawaii, Illinois/Indiana, Indianapolis, Kansas City, Miami, Minneapolis, Missouri, Nevada, New England, New York, Norfolk/Virginia Beach, Northern California, Oklahoma, Orlando, Pennsylvania, Phoenix, Pittsburgh, San Antonio, Seattle/Portland, South Texas, Southern California, Tampa, Tennessee, and Texas.

[16]The presence or absence of individual vehicle options is not controlled for.

[17]Busse, Silva-Risso, and Zettelmeyer (2006) investigate the robustness of this identifying assumption for the pass-through of manufacturer rebates. They show that estimates using a difference-in-differences approach are close to those obtained using a regression discontinuity approach, which relies on a different set of identifying assumptions.

Table 2: Pass-through of Cash for Clunkers rebates and manufacturer rebates[†]

	(1)	(2)
CfC Net Rebate	-1.01**	
	(.032)	
CfC Net Rebate (Early CfC Period)		-1.03**
		(.032)
CfC Net Rebate (Late CfC Period)		-.989**
		(.032)
ManufRebate (CfC Period)	-.819**	
	(.013)	
ManufRebate (Other Periods)	-.837**	
	(.015)	
ManufRebate (Early CfC Period)		-.809**
		(.015)
ManufRebate (Late CfC Period)		-.834**
		(.011)
ManufRebate (Other Periods)		-.837**
		(.015)
Constant	28494**	28493**
	(412)	(412)
Observations	1,056,540	1,056,540
R-squared	0.963	0.963

[*] significant at 5%; ** significant at 1%; + significant at 10% level. Standard errors in parentheses are robust and clustered at the region level.

[†] Not reported: CfC period indicator, demographic controls, purchase timing controls, gasoline price controls, region fixed effects, vehicle-type fixed effects, and segment-week of sample fixed effects.

manufacturer rebate offered during the Cash for Clunkers period and 84% during other periods. This estimate is similar to the manufacturer rebate pass-through rate estimated by Busse, Silva-Risso, and Zettelmeyer (2006).

During the Cash for Clunkers program, the press reported that the most desirable of the vehicles that had high enough fuel economy to qualify for the program began to be in short supply towards the end of the program.[18] In column 1 we split up the Cash for Clunkers period into the first two-and-a-half weeks of the program ("Early CfC Period") and the last two weeks ("Late CfC Period"). The estimates indicate that dealers were able to obtain slightly more of the value of the Cash for Clunkers rebates in the second half of the program: the pass-through of the rebate was 103% early versus 99% later in the period (a difference that is significant at a 5% level). Manufacturer rebates, however, do not follow the same trend. We find that the pass-through of manufacturer rebates is slightly higher later in the Cash for Clunkers period.

Rather than rely on the timing of transactions during the Cash for Clunkers period, we can also measure directly whether the inventory of qualifying vehicles had an effect on pass-through rates. To do this we construct for each transaction the number of Cash for Clunkers qualifying vehicles that were in inventory on the day of sale at the dealership for the class of vehicle (car or truck) the customer purchased. For example, new passenger cars needed to achieve at least 22 MPG to qualify for Cash for Clunkers. Hence, if a consumer purchased a new passenger car, we count the number of passenger cars whose fuel economy exceeded 22 MPG in the dealer's inventory on the day of sale. Similarly, light-duty pickup trucks qualified for Cash for Clunkers if their fuel economy exceeded 18 MPG. If a consumer purchased a new light-duty truck, we count the number of trucks whose fuel economy exceeded 18 MPG in the dealer's inventory on the day of sale. We construct a categorical variable that codes whether the inventory at a specific dealer on a particular day for the relevant class of qualifying vehicles (passenger car or truck) is 1 or 2 vehicles, 3-5 vehicles, 6-10 vehicles, 11-20 vehicles, or 21 or more vehicles.

In column 1 of Table 3 we show how the pass-through rate of the Cash for Clunkers rebate differs by the level of qualifying inventory. We find that 100% of the Cash for Clunkers rebate passes through to consumers at most inventory levels. However, if the dealer only has one or two vehicles of the relevant class in stock, the pass-through rate drops to 88%.[19]

[18] See, for example, "Small Cars in Short Supply Due to Cash-For-Clunkers Boom," *www.thecarconnection.com* August 5th, 2009.

[19] One might be concerned about a potential endogeneity of price and inventory levels. There are several reasons why endogeneity is unlikely to pose a problem in our analysis. First, dealers cannot adjust inventory to changing demand conditions in the short run. This is because they must order inventory 60-90 days before delivery and, since they custom-configure each car, they cannot cancel orders once the car is in production. Second, our large sets of fixed effects lessen the concern that demand shocks simultaneously determine price and inventory levels. One concern, for example, is that a string of sunny days simultaneously increases price and runs down inventory for convertibles. Our week fixed effects and extensive vehicle type (and in a later specification vehicle type×dealer fixed effects) ensure

We also investigate how inventory levels affect manufacturer rebates. Since manufacturer rebates are available outside of the Cash for Clunkers period as well, we estimate the pass-through of these rebates separately for Cash for Clunkers and other periods. Moreover, these rebates were available both for vehicles that did and did not qualify for Cash for Clunkers rebates. As a result, we estimate the effect of qualifying and non-qualifying inventory within and outside the Cash for Clunkers period. Table 3 shows the results in column 1.

The table shows four sets of manufacturer rebate coefficients. The first set reports, at different inventory levels, the estimated pass-through rate for new vehicles that were eligible for Cash for Clunkers during the Cash for Clunkers period. The results show that moving from plentiful inventory (21+ vehicles) to very little inventory (1-2 vehicles) reduces the pass-through rate from 86% to 76%, a 10 percentage point decrease. This means that, when inventory was low during the Cash for Clunkers period, dealers were able to appropriate a larger share of the manufacturer rebate for new vehicles that were eligible for Cash for Clunkers. We would like to know whether this represents a typical inventory effect—prices tend to rise when inventory is unusually low— or an abnormal effect that was specific to the Cash for Clunkers program. We can answer this question by analyzing how inventory affected pass-though for new vehicles that would have been eligible for Cash for Clunkers but were sold *outside the Cash for Clunkers period*, or for new vehicles that *did not qualify* for Cash for Clunkers but sold during the Cash for Clunkers period, or for new cars that *sold neither* during the Cash for Clunkers period *nor would have qualified* under the program. The next three sets of manufacturer rebate coefficients in column 1 of Table 3 contain these estimates. The results show that moving from plentiful inventory (21+ vehicles) to very little inventory (1-2 vehicles) reduces the pass-through rate by between 9 and 12 percentage points, depending on which set of coefficients we consider.

We conclude that the inventory effect associated with the Cash for Clunkers program (a 10 percentage point decrease in pass-through) is no different from inventory effects found during other periods, or for cars that did not qualify for Cash for Clunkers although they sold during the Cash for Clunkers period.

As a robustness check we repeat the inventory specification in column 1 of Table 3 with vehicle type $\times$ dealer fixed effects. This addresses the concern that the relationship between pass-through and inventory could be driven by large dealers having simultaneously higher absolute inventory levels and lower prices because they are more cost-efficient than small dealers. The results of this specification are reported in column 2 of Table 3. Our conclusion that Cash for Clunkers rebates are passed through at a lower rate when inventory is very low remains unchanged.

that we identify inventory effects based on only short-term variations in inventory within vehicle type and dealership combinations. This makes it less likely that our results are driven by demand shocks.

Table 3: Inventory effects on pass-through[†]

Dependent Variable: Price net of rebates	(1)	(2)
CfC Net Rebate, Qual Inv. 1-2	-.88**	-.83**
	(.036)	(.073)
CfC Net Rebate, Qual Inv. 3-5	-1**	-1.1**
	(.039)	(.06)
CfC Net Rebate, Qual Inv. 6-10	-1**	-1**
	(.027)	(.049)
CfC Net Rebate, Qual Inv. 11-20	-1**	-1**
	(.037)	(.051)
CfC Net Rebate, Qual Inv. 21+	-1**	-1**
	(.034)	(.042)
ManufRebate, CfC Period, Qual Inv. 1-2	-.76**	-.83**
	(.02)	(.045)
ManufRebate, CfC Period, Qual Inv. 3-5	-.82**	-.87**
	(.02)	(.031)
ManufRebate, CfC Period, Qual Inv. 6-10	-.81**	-.87**
	(.017)	(.018)
ManufRebate, CfC Period, Qual Inv. 11-20	-.87**	-.93**
	(.015)	(.016)
ManufRebate, CfC Period, Qual Inv. 21+	-.86**	-.93**
	(.013)	(.016)
ManufRebate, CfC Period, Non-Qual Inv. 1-2	-.61**	-.64**
	(.035)	(.072)
ManufRebate, CfC Period, Non-Qual Inv. 3-5	-.65**	-.67**
	(.036)	(.055)
ManufRebate, CfC Period, Non-Qual Inv. 6-10	-.64**	-.77**
	(.035)	(.059)
ManufRebate, CfC Period, Non-Qual Inv. 11-20	-.68**	-.83**
	(.032)	(.045)
ManufRebate, CfC Period, Non-Qual Inv. 21+	-.73**	-.83**
	(.03)	(.057)
ManufRebate, Other Period, Qual Inv. 1-2	-.76**	-.86**
	(.021)	(.023)
ManufRebate, Other Period, Qual Inv. 3-5	-.82**	-.88**
	(.011)	(.015)
ManufRebate, Other Period, Qual Inv. 6-10	-.83**	-.9**
	(.013)	(.017)
ManufRebate, Other Period, Qual Inv. 11-20	-.84**	-.91**
	(.013)	(.013)
ManufRebate, Other Period, Qual Inv. 21+	-.85**	-.93**
	(.014)	(.0091)
ManufRebate, Other Period, Non-Qual Inv. 1-2	-.74**	-.81**
	(.025)	(.038)
ManufRebate, Other Period, Non-Qual Inv. 3-5	-.79**	-.79**
	(.015)	(.026)
ManufRebate, Other Period, Non-Qual Inv. 6-10	-.81**	-.84**
	(.014)	(.019)
ManufRebate, Other Period, Non-Qual Inv. 11-20	-.81**	-.87**
	(.016)	(.018)
ManufRebate, Other Period, Non-Qual Inv. 21+	-.86**	-.91**
	(.02)	(.019)
Constant	28,424**	28,441**
	(423)	(218)
Observations	1,056,540	1,056,540
R-squared	0.963	0.981

[*] significant at 5%; ** significant at 1%; + significant at 10% level. Standard errors in parentheses are robust and clustered at the region level.

[†] Not reported: CfC period indicator, demographic controls, purchase timing controls, gasoline price controls, region fixed effects, vehicle-type fixed effects (column 1), vehicle-type × dealer fixed effects (column 2) and segment-week of sample fixed effects.

In summary, Cash for Clunkers rebates are fully passed through to consumers, except in cases where inventory is very low. Such low levels of inventory are present in less than 1% of transactions. Manufacturer rebates are passed through at about 80%, irrespective of whether a vehicle sold during the Cash for Clunkers period or qualified for the Cash for Clunkers program. While inventory also affects manufacturer rebates, its effect seems not to be related to the Cash for Clunkers program.

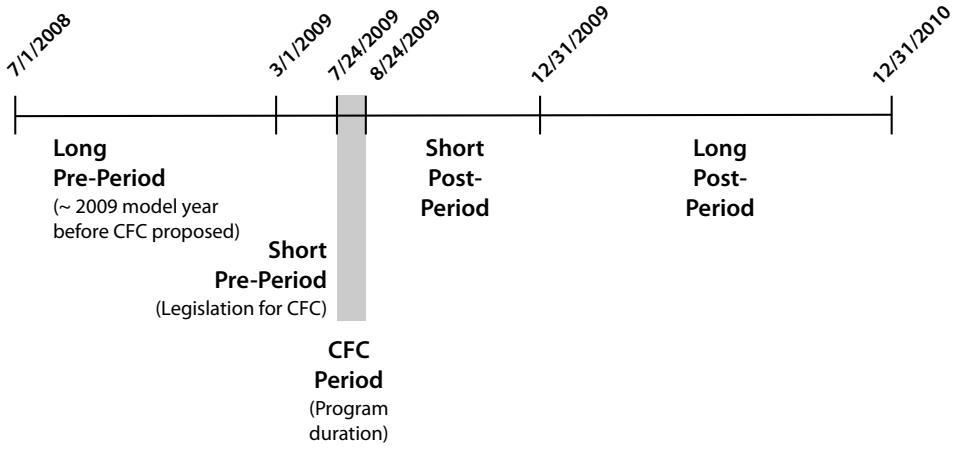
5 Manufacturer response

In this section we investigate manufacturers' responses to the Cash for Clunkers program. We are particularly interested in whether Cash for Clunkers crowded out rebates that manufacturers otherwise would have offered or whether Cash for Clunkers stimulated manufacturer rebates, increasing the total benefits to customers arising from the Cash for Clunkers program.

5.1 Manufacturer rebates

We divide our sample into five periods, as shown in Figure 1. We refer to the first period as the "long pre-period." This period runs from July 1, 2008, through February 29, 2008, and corresponds to the 2009 model-year before the CARS legislation gets underway.[20]

Figure 1: Timeline of data periods



Next comes the "short pre-period," which lasts from March 1, 2009, through July 23, 2009. This period contains the initial introduction of the CARS legislation on March 17, its signing into law on June 24, and the preparations for NHTSA's implementation of the Car Allowance Rebate System.

[20] A model-year is not a precisely defined time period since not all manufacturers introduce models at the same point in time. New models are generally introduced between mid-summer and early fall, which means that a model-year runs roughly from summer to summer.

The third, the "Cash for Clunkers (CfC) period," is the period of interest. This period lasts from July 24, 2009, (the date the CARS rule was published) to August 24, 2009, the last date on which transactions were eligible for Cash for Clunkers credits. The fourth is the "short post-period," which lasts from August 25, 2009, through December 31, 2009. The fifth and final period, the "long post-period," covers January 1, 2010, through December 31, 2010.

We begin with a simple investigation of how manufacturer rebates evolved over these five periods. To do so we estimate the following specification:

$$\text{ManufRebate}_{ijt} = \beta_0 + \beta_{\mathbf{1}}(\mathbf{Period}_t) + \beta_{\mathbf{2}}(\text{MonthOfYear}_t \cdot \text{Make}_j) + \mu_r + \delta_j + \nu_{ijt} \quad (2)$$

$ManufRebate_{ijt}$ is the manufacturer rebate available to customer i who purchases vehicle j at time t. $Period_t$ denotes indicator variables for the five time periods portrayed in Figure 1. Different manufacturers seem to have different strategies in the use of manufacturer rebates, and even different strategies for different nameplates.[21] For this reason we include month-of-year fixed effects interacted with indicators for each nameplate (or "make") in our data ($MonthOfYear_t \cdot Make_j$). μ_r are controls for the 34 regions in our data. δ_j represents the same vehicle type fixed effects we used in the pass-through specification, with one exception. Since we are interested in measuring the evolution of manufacturer rebates over a two-and-a-half-year period, we exclude the model year from the fixed effect. Otherwise the fixed effect would absorb year variation in manufacturer rebates. Hence, this fixed effect describes individual vehicle types such as a Honda Accord LX 4-door sedan with a 6-cylinder, 3.0-liter engine and automatic transmission over multiple model years.

Column 1 of Table 4 reports the results from estimating Equation 2. The estimated constant term of $1,342 represents the average manufacturer rebate in the long pre-period for the omitted vehicle type in the omitted region. The estimates show that average manufacturer rebates were slightly higher (by $132) during the short pre-period than in the long pre-period, substantially higher (by $671) during the CfC period, and that they fell and then returned to the long pre-period level after the Cash for Clunkers period ended. This suggests that manufacturers substantially increased rebates concurrently with the Cash for Clunkers program.

It is important to note, however, that manufacturer rebates are not offered on every vehicle. To investigate whether the increase in the average rebate during the Cash for Clunkers period was driven by a higher incidence of rebates or by higher rebate amounts conditional on being offered, we estimate how likely manufacturers were to offer rebates during our periods of interest. We repeat the specification in Equation 2 replacing the *ManufRebate* dependent variable with an indicator

[21] Many manufacturers produce vehicles under multiple nameplates. For example, Honda and Acura are both nameplates of Honda; Volkswagen and Audi are both nameplates of Volkswagen; and Ford, Lincoln, and Mercury vehicles are nameplate of Ford.

Table 4: Manufacturer rebates by period†

	(1)	(2)	(3)
Dependent Variable:	Manufacturer Rebate	I(Manufacturer Rebate > 0)	Manufacturer Rebate if Manuf. Rebate > 0
Short Pre-Period (3/1/2009 - 7/23/2009)	132**	.068**	1.0e+02**
	(18)	(.0045)	(35)
CfC Period (7/24/2009 - 8/24/2009)	671**	.12**	785**
	(94)	(.015)	(124)
Short Post-Period (8/25/2009 - 12/31/2009)	-93**	.0074	-309**
	(23)	(.0061)	(38)
Long Post-Period (1/1/2010 - 12/31/2010)	17	.021**	-38+
	(16)	(.0057)	(20)
Constant	1,342**	.49**	2,604**
	(20)	(.0037)	(25)
Observations	1,056,540	1,056,540	486,574
R-squared	0.612	0.526	0.584

* significant at 5%; ** significant at 1%; + significant at 10% level. Standard errors in parentheses are robust and clustered at the region level.

† Not reported: Month-of-year×make fixed effects, region fixed effects, vehicle-type (excluding model year) fixed effects.

variable that is equal to 1 if a manufacturer rebate was available for purchase i of vehicle j at time t. The results are in column 2 of Table 4. The constant of 0.49 is the fraction of vehicles that were sold with a manufacturer rebate in the long pre-period for the omitted vehicle type in the omitted region. We find that a higher fraction of vehicles were sold with manufacturer rebates in the short pre-period (by 6.8 percentage points) than in the long pre-period. During the Cash for Clunkers period, the fraction of vehicles sold with manufacturer rebates increased to 12 percentage points more than in the long pre-period. Following the Cash for Clunkers period, the fraction of vehicles sold with manufacturer rebates moved back toward the long pre-period level. The final column of Table 4 shows estimated changes in the size of manufacturer rebates, conditional on a rebate being offered. Again, during the Cash for Clunkers period manufacturer rebates were much higher than during other periods. Overall, we conclude that manufacturer rebates were both more likely to be offered and larger during the Cash for Clunkers program than during other periods.

Recall that we are interested in whether Cash for Clunkers crowded out or stimulated manufacturer rebates. So far we have only shown that during the Cash for Clunkers program, a higher fraction of vehicles sold had manufacturer rebates and that the rebates were larger. Of course, Cash for Clunkers only applied to a subset of vehicles, namely those that exceeded certain fuel-economy thresholds. We can see whether manufacturers increased their rebates for vehicles that were eligible for Cash for Clunkers by allowing the period-specific estimates of manufacturer rebates to differ by whether a vehicle did or did not have an MPG that would have qualified it for Cash for Clunkers.

Column 1 of Table 5 reports the results. To make the estimates easier to interpret we graph the average manufacturer rebate for Cash for Clunkers-qualifying and non-qualifying vehicles during the periods of interest in Figure 2. The estimates imply that Cash for Clunkers-qualifying vehicles

Table 5: Manufacturer rebates by period and vehicle type†

	(1)	(2)	(3)
Dependent Variable:	Manufacturer Rebate	I(Manufacturer Rebate > 0)	Manufacturer Rebate if Man. Rebate > 0
Non-Qual., Short Pre-Period (3/1/2009 - 7/23/2009)	-11	.037**	-137**
	(43)	(.0083)	(40)
Non-Qual., CfC Period (7/24/2009 - 8/24/2009)	-4	.039**	-228**
	(40)	(.011)	(63)
Non-Qual., Short Post-Period (8/25/2009 - 12/31/2009)	-164**	.047**	-586**
	(45)	(.0091)	(54)
Non-Qual., Long Post-Period (1/1/2010 - 12/31/2010)	-268**	.016*	-611**
	(46)	(.0074)	(42)
CfC Qual., Long Pre-Period (7/1/2008 - 2/29/2009)	-437**	-.0093	-782**
	(43)	(.0081)	(38)
CfC Qual., Short Pre-Period (3/1/2009 - 7/23/2009)	-241**	.03**	-449**
	(30)	(.009)	(37)
CfC Qual., CfC Period (7/24/2009 - 8/24/2009)	381**	.085**	447**
	(91)	(.012)	(122)
CfC Qual., Short Post-Period (8/25/2009 - 12/31/2009)	-332**	-.059**	-392**
	(29)	(.0097)	(41)
CfC Qual., Long Post-Period (1/1/2010 - 12/31/2010)	-64*	-.0016	-28
	(31)	(.0075)	(43)
Constant	1,689**	.51**	3,197**
	(47)	(.0088)	(42)
Observations	1,056,540	1,056,540	486,574
R-squared	0.614	0.527	0.589

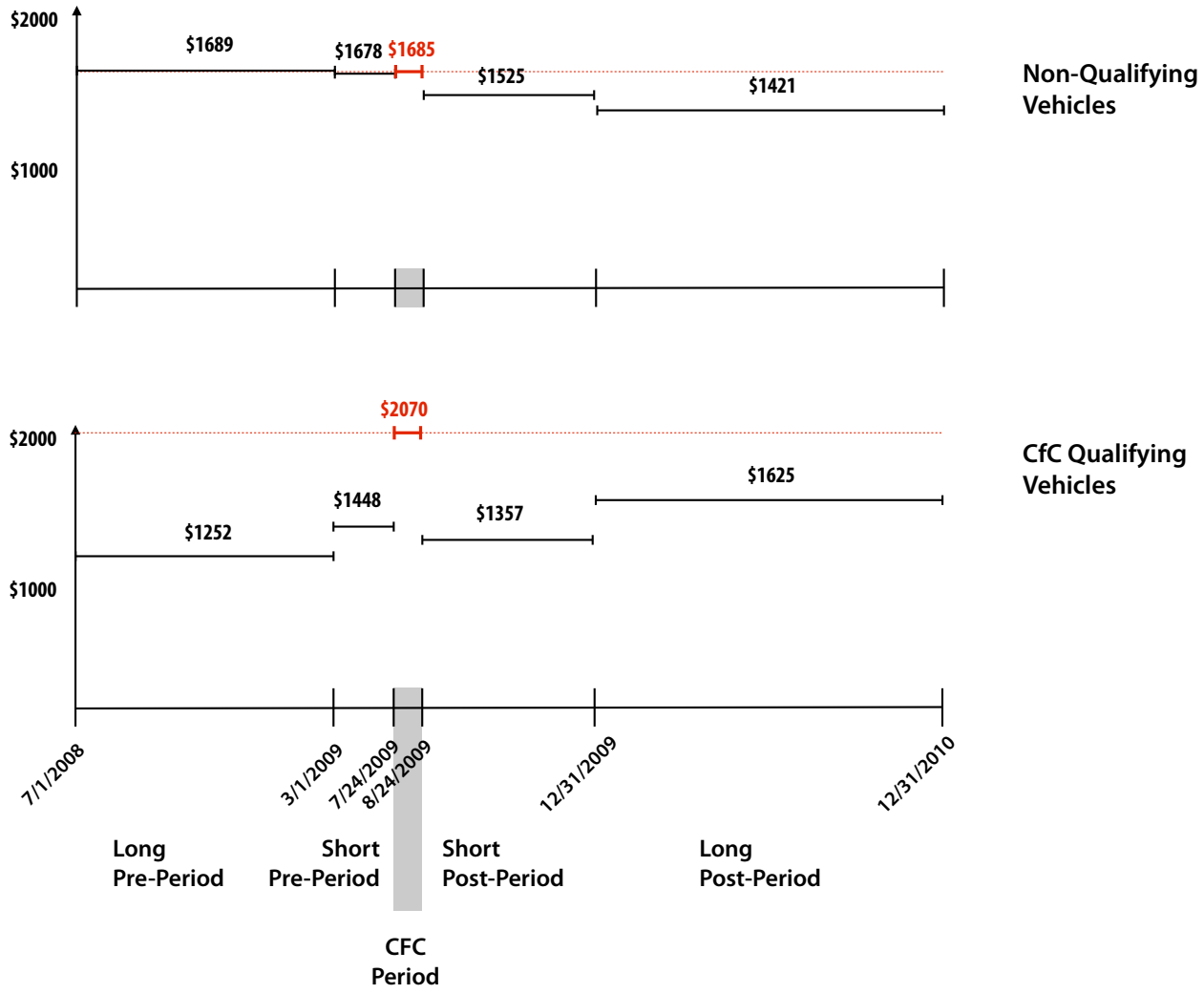
* significant at 5%; ** significant at 1%; + significant at 10% level. Standard errors in parentheses are robust and clustered at the region level.

† Not reported: Month-of-year×make fixed effects, region fixed effects, vehicle-type (excluding model year) fixed effects.

(passenger cars with at least 22 MPG, and SUVs, pickups, and vans with at least 18 MPG) had much lower average rebates than did non-qualifying vehicles during the pre-period, but that during the Cash for Clunkers period, manufacturers increased their rebates on qualifying vehicles both above what they had been, and above the rebates that they offered on non-qualifying vehicles at the same time. However, this lasted only for the month of the Cash for Clunkers program, after which rebates returned to roughly their previous levels.

Columns 2 and 3 of Table 5 show that the incidence of manufacturer rebates for Cash for Clunkers-qualifying vehicles, and for the magnitude of such rebates conditional on being offered both increase during the Cash for Clunkers period. For non-qualifying cars, the result in column 1 that average manufacturer rebates were no different during the Cash for Clunkers period than in the long pre-period obscures what columns 2 and 3 reveal, which is that for non-qualifying vehicles, the incidence of manufacturer rebates goes up, but the average rebate size conditional on a rebate being offered goes down. What is clear, however, in both column 1 and columns 2 and 3 is that Cash for Clunkers coincided with an increase in manufacturer rebates offered on Cash for Clunkers-qualifying vehicles, an increase that is not echoed for non-qualifying cars. We conclude, therefore, that Cash for Clunkers appears, on average, to have stimulated rather than crowded out manufacturer rebates for qualifying vehicles.

Figure 2: Average manufacturer rebates by period and vehicle type



5.2 Heterogeneity in rebates

In this section we analyze whether manufacturer rebates differed between classes of qualifying vehicles, between different weeks of the Cash for Clunkers program, and by manufacturer. We begin by distinguishing between cars and trucks that qualified for the Cash for Clunkers rebate. To simplify the exposition, we collapse all periods other than the Cash for Clunkers period into an "other period." Column 1 of Table 6 reports the interactions between whether a vehicle did not qualify for Cash for Clunkers, qualified as a car, or qualified as a truck, and whether it sold during the Cash for Clunkers period or other periods. The left-out category is a non-qualifying vehicle during other periods. As the estimates show, while trucks generally have somewhat lower average rebates, the increase in manufacturer rebates during the Cash for Clunkers period relative to other periods is almost the same for qualifying cars and trucks ($740 for cars and $770 for trucks).

In column 2 of Table 6 we split up the Cash for Clunkers period into five individual weeks.[22] We distinguish between qualifying and non-qualifying vehicles (we again combine cars and trucks). We find that rebates were fairly uniform over the weeks of the Cash for Clunkers program, except for the first full week of the program (week 2 in the estimates) where rebates were higher for qualifying vehicles by approximately $200 to $300 relative to other weeks in the program.

Finally, we analyze whether different manufacturers reacted differently to the Cash for Clunkers program. We focus on the largest 11 manufacturers. If a manufacturer sells vehicles of different makes, we combine these under the manufacturer's name. For example, the "BMW" estimates in Table 7 encompass both BMW and Mini vehicles. Similarly, Chrysler, Dodge, Jeep, etc., are listed under "Chrysler." The estimates in Table 7 show that all major manufacturers with the exception of Mercedes-Benz increased their manufacturer rebates for qualifying vehicles during the Cash for Clunkers period. Other than Mercedes-Benz, BMW had the next smallest increase in average manufacturer rebate ($440), followed by Ford ($482) and VW ($540). A cluster of firms all increased their average manufacturer rebates by $600-$700, including Hyundai ($607), Toyota ($616), Honda ($685), and Nissan ($700). The three manufacturers with the biggest increase in manufacturer rebates were GM ($808), Mazda ($1006), and the largest by a large margin, Chrysler ($1957). What seems clear is that the increase in manufacturer rebates in response to the Cash for Clunkers program reflects an industry response, not just a response by a few manufacturers.

[22] "Week 1" in this specification is not a full week. It covers Friday 7/24/2009 to Sunday 7/26/2009.

Table 6: Manufacturer rebates by vehicle segment and week of Cash for Clunkers period†

Dependent Variable: Manufacturer Rebate	(1)	(2)
Non-Qual, CfC Period	110**	
	(28)	
CfC Qual Car, CfC Period	565**	
	(103)	
CfC Qual Truck, CfC Period	399**	
	(113)	
CfC Qual Car, Other Period	-175**	
	(48)	
CfC Qual Truck, Other Period	-371**	
	(48)	
CfC Qual, CfC Week 1		383**
		(68)
CfC Qual, CfC Week 2		624**
		(95)
CfC Qual, CfC Week 3		359**
		(114)
CfC Qual, CfC Week 4		299*
		(112)
CfC Qual, CfC Week 5		403*
		(148)
Non-Qual, CfC Week 1		169**
		(59)
Non-Qual, CfC Week 2		242**
		(45)
Non-Qual, CfC Week 3		1.7
		(41)
Non-Qual, CfC Week 4		1.5
		(40)
Non-Qual, CfC Week 5		52
		(39)
Constant	1,543**	1,582**
	(35)	(35)
Observations	1,056,540	1,056,540
R-squared	0.613	0.613

* significant at 5%; ** significant at 1%; + significant at 10% level. Standard errors in parentheses are robust and clustered at the region level.

† Not reported: Month-of-year×make fixed effects, region fixed effects, vehicle-type (excluding model year) fixed effects.

Table 7: Manufacturer rebates by manufacturer†

Dependent Variable: Manufacturer Rebate	(1)
BMW ManufRebate, Non-Qual, CfC Period	145**
	(41)
BMW ManufRebate, CfC Qual, CfC Period	440**
	(104)
Chrysler ManufRebate, Non-Qual, CfC Period	563**
	(99)
Chrysler ManufRebate, CfC Qual, CfC Period	1957**
	(88)
Ford ManufRebate, Non-Qual, CfC Period	-81
	(81)
Ford ManufRebate, CfC Qual, CfC Period	482**
	(115)
GM ManufRebate, Non-Qual, CfC Period	174**
	(59)
GM ManufRebate, CfC Qual, CfC Period	808**
	(149)
Honda ManufRebate, Non-Qual, CfC Period	2.4
	(15)
Honda ManufRebate, CfC Qual, CfC Period	685**
	(113)
Hyundai ManufRebate, Non-Qual, CfC Period	-334**
	(95)
Hyundai ManufRebate, CfC Qual, CfC Period	607**
	(130)
Mazda ManufRebate, Non-Qual, CfC Period	616**
	(140)
Mazda ManufRebate, CfC Qual, CfC Period	1,006**
	(156)
Mercedes ManufRebate, Non-Qual, CfC Period	4
	(18)
Mercedes ManufRebate, CfC Qual, CfC Period	-18
	(30)
Nissan ManufRebate, Non-Qual, CfC Period	-106**
	(36)
Nissan ManufRebate, CfC Qual, CfC Period	700**
	(133)
Toyota ManufRebate, Non-Qual, CfC Period	-18
	(48)
Toyota ManufRebate, CfC Qual, CfC Period	616**
	(143)
VW ManufRebate, Non-Qual, CfC Period	2.7
	(92)
VW ManufRebate, CfC Qual, CfC Period	540**
	(121)
Constant	1,432**
	(17)
Observations	998,815
R-squared	0.609

* significant at 5%; ** significant at 1%; + significant at 10% level. Standard errors in parentheses are robust and clustered at the region level.

† Not reported: Month-of-year×make fixed effects, region fixed effects, vehicle-type (excluding model year) fixed effects.

6 Effects on the used-vehicle market

We know that the Cash for Clunkers program led to the destruction of 677,842 vehicles. We now investigate whether the reduction in supply of such vehicles affected the market prices of low-fuel-economy, old, high-mileage vehicles, i.e., the types of vehicles that were most commonly used as Cash for Clunkers trade-ins.[23] Since the supply of used vehicles is constrained by the stock of such vehicles, a significant reduction in stock may have constrained supply, thereby increasing the market prices of such vehicles following the Cash for Clunkers period.

To analyze how the price of the types of vehicles commonly used as Cash for Clunkers trade-ins changed after the program, we need to solve two problems. First, we need a source of data that allows us to observe the prices of low-fuel-economy, old, high mileage vehicles. Our data are not useful for this purpose because the used-vehicle transactions in the data come exclusively from sales at new car dealers. The used vehicles sold at new car dealers are, on average, much newer and more expensive than Cash for Clunkers trade-ins. As a result, we will use a dataset of transactions from wholesale used-vehicle auctions to measure price changes in used vehicles. This dataset covers 90% of all used vehicles sold at wholesale auction in the United States, including vehicles that dealers have received as trade-ins that are too old or to high-mileage to bother selling at the dealership.

The second problem we have to solve is to identify in the auction data vehicles that most closely resemble vehicles used as Cash for Clunkers trade-ins and those that would have been unlikely to be Cash for Clunkers trade-ins. We solve this problem by using the vehicles that were traded in at new car dealers during the Cash for Clunkers period to create a score based on observable attributes that will enable us to classify used vehicles as vehicles that would have been likely or unlikely to have been used as Cash for Clunkers trade-ins. This approach is similar in spirit to a propensity score approach. Specifically, we use a logit specification to estimate the probability that a trade-in with particular attributes used during the Cash for Clunkers period was used as a trade-in for the Cash for Clunkers program. The dependent variable is an indicator variable equal to 1 for Cash for Clunkers transactions. The independent variables are (1) a linear spline of the trade-in's odometer, where the knots are set at 20,000 mile intervals; (2) the EPA combined fuel economy rating of the trade-in; (3) fixed effects for the model year of the trade-in; and (4) fixed effects for seven geographic areas: New England, Central Atlantic, Lower Atlantic, Midwest, Gulf Coast, Rocky Mountain, and West Coast.[24]

[23] Since the maximum rebate available under the Cash for Clunkers program was $3,500 or $4,500, customers would have lost money if they had traded in a vehicle that wasn't old enough or didn't have high-enough mileage for its market value to be below these thresholds. Other program conditions dictated that the trade-in have low fuel economy.

[24] We use these areas instead of the more granular 34 regions we used in previous specification because we will use the estimates from the logit to create a score for observations in the auction data, which uses a coarser geographic

Since we observe all the covariates used to estimate the logit in our wholesale auction data as well, we are able to assign each observation in the auction data a score equal to the predicted value generated by our estimated logit coefficients. This score will measure how similar the attributes of a particular used vehicle are to the attributes of vehicles traded in during the Cash for Clunkers period that were actually Cash for Clunkers trade-ins. Table 8 presents the distribution of these scores for used vehicles sold at auction between July 1, 2008, and December 31, 2010.

Table 8: Distribution of scores in wholesale auction data

Percentile	CfC Trade-in score
1st	0
5th	0
10th	0
25th	0
50th	0
75th	0.01
90th	0.45
95th	0.73
99th	0.9

This classification allows us to analyze whether auction prices for the types of vehicles that were popular Cash for Clunkers trade-ins rose during or after the Cash for Clunkers period.[25] Specifically, the auction prices of vehicles with high Cash for Clunkers trade-in scores should rise (or fall less) relative to the auction prices of vehicles with low Cash for Clunkers trade-in scores following the Cash for Clunkers period. To see whether this is the case we calculate for each week in the sample the average auction price for six ranges of propensity scores as suggested by the distribution in Table 8: [0], (0 to 0.01], (0.01 to 0.45], (0.45 to 0.73], (0.73 to 0.9], and [0.9 to 1.00]. Figure 3 graphs these average auction prices over time. We also apply a lowess smoother to the averages and graph it along with weekly averages.

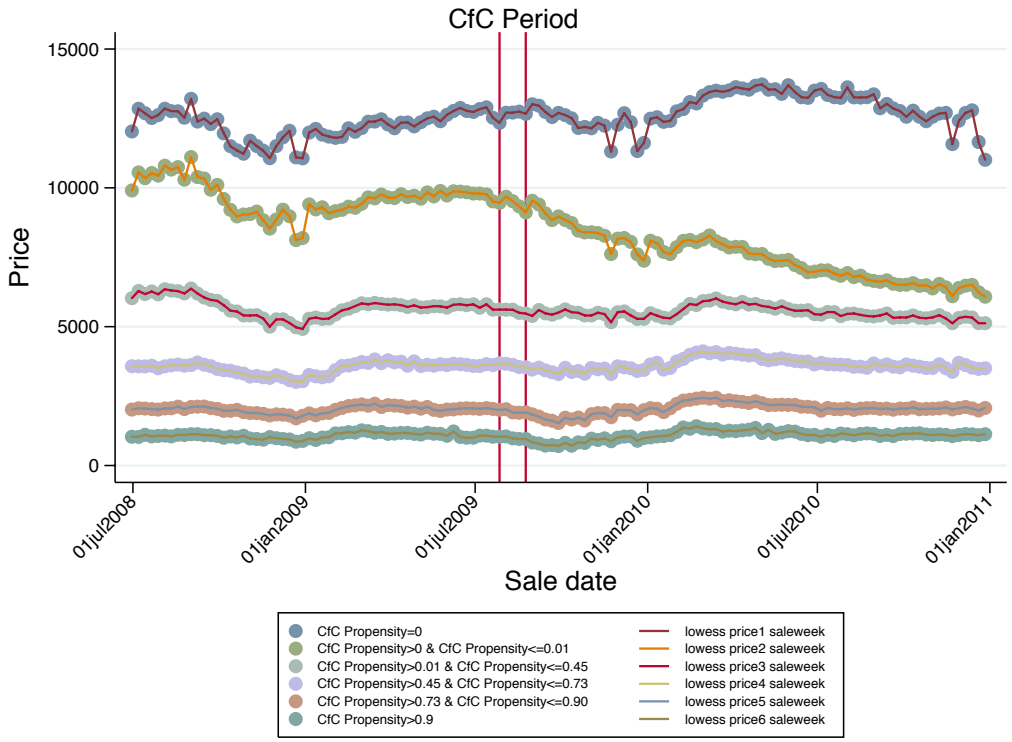
In the figure, the series of average prices over time turn out to be ordered by score, with the lowest Cash for Clunkers trade-in score vehicles at the top of the figure (with the highest average prices) and the highest Cash for Clunkers trade-in scores at the bottom (with the lowest average prices). Since the rebates offered as part of the Cash for Clunkers program were fixed at $3,500 or $4,500, independent of the condition of the trade-in vehicle, it is not surprising that vehicles with higher Cash for Clunkers trade-in scores also have lower-than-average prices.[26] The important insight from Figure 3 lies in the price path of vehicles with different Cash for Clunkers trade-in

classification.

[25]The requirement that a Cash for Clunkers trade-in have been registered for a year to the person conducting the Cash for Clunkers transaction would have discouraged the arbitrage of qualifying trade-ins before or during the program.

[26]The only program conditions that set a lower bound on the trade-in vehicle price were that the trade-in could not be older than 25 years, and that it had to be drivable and insured.

Figure 3: Average auction prices by score



scores during and shortly after the program period. It is hard to argue that vehicles with a high Cash for Clunkers trade-in score experienced price changes during or after the Cash for Clunkers period that differ from vehicles unlikely to have been used as Cash for Clunkers trade-ins. We can confirm this more formally by estimating the following specification:

$$\mathrm{P}_{ijt} = \delta_0 + \delta_{\mathbf{1}}(\mathbf{Period}_t \cdot \mathbf{CfCScoreRange}_j) + \delta_2 \mathbf{CfCScoreRange}_j + \psi_{ijt} \tag{3}$$

where P_{ijt} is the wholesale auction price of vehicle j sold in auction transaction i at time t. We consider the same time periods as defined in Figure 1, with the exception that we split the short post-period into the month following the Cash for Clunkers period, i.e. August 25, 2009, to September 26, 2009, and the remainder of the short post-period, i.e. September 27, 2009, to December 31, 2009. To describe how prices change during and after the Cash for Clunkers period, we use the short pre-period as the omitted category in the regression. This means that the coefficients $\delta_{\mathbf{1}}$ will measure, for vehicles in each of the six ranges of Cash for Clunkers trade-in scores, the change in transaction price in some period, relative to the short pre-period. The indicator variables $\mathbf{CfCScoreRange}_j$ absorb the average price difference associated with vehicles of different Cash for Clunkers trade-in score ranges.

Column 1 of Table 9 presents the results of this specification. Of particular interest are the Cash for Clunkers period (July 24, 2009 to August 24, 2009) and the month following the Cash for Clunkers period (August 25, 2009 to September 26, 2009). We find that, relative to the short pre-period, prices of vehicles in the highest Cash for Clunkers trade-in score range decrease by $146 during the program period. In the month after the Cash for Clunkers period, prices fall by an additional $222 (for a total of $368 relative to the short pre-period). These decreases are similar to or larger than the changes for any other Cash for Clunkers trade-in score range, except for the 0 to 0.01 range. These results indicate that for vehicles of the types that were likely to be Cash for Clunkers trade-ins, prices *fell* just after the Cash for Clunkers program, not *rose* as a sharp reduction in used-vehicle supply would suggest. One explanation for these results is that many of the trade-ins used during Cash for Clunkers were inframarginal to the used-vehicle market, meaning that they would have been likely to stay in the stock of used vehicles, but not have show up in used-vehicle markets, had Cash for Clunkers not been available. This would be good news for the stimulus effect of the program, because it would mean that the Cash for Clunkers transactions were truly incremental transactions and not conducted by vehicle owners who were about to sell their current vehicle and buy a new vehicle instead.

One concern is that vehicles in different Cash for Clunkers trade-in score ranges are likely to contain vehicles of different fuel economies and vehicles from different segments. Since vehicle prices change with gasoline price fluctuations, in column 2 of Table 9 we control for MPG-specific gasoline price effects. We also control for seasonal price effects by including month-of-year fixed effects. This confirms our conclusion, namely that vehicles in the highest Cash for Clunkers trade-in score range experienced price decreases during the program period and during the month after that are similar to or larger than in any other Cash for Clunkers trade-in score range.

We conclude that vehicles with a high Cash for Clunkers trade-in score seem not to appreciate relative to vehicles that were unlikely to be used as Cash for Clunkers trade-ins. One caveat is that this conclusion arises, at least in part, from the time limit imposed on the Cash for Clunkers program.[27] Had the program been designed to run indefinitely, absent transaction costs, we would expect the program to give rise to a price floor of at least $3,500 in the used car market for cars that would qualify for the program.

7 Concluding remarks

Policymakers had three objectives in mind when they designed the 2009 Car Allowance Rebate System, popularly known as "Cash for Clunkers:" stimulating the economy, improving the envi-

[27] The program had a set budget and expired when the budget had been exhausted.

Table 9: Used vehicle prices by period and score†

Dependent Variable: Wholesale Auction Price	(1)	(2)
7/24/09 - 8/24/09, Prob(CfC Trade-in)=0	140+	568**
	(70)	(115)
7/24/09 - 8/24/09, Prob(CfC Trade-in) =0-0.01	-298**	-173
	(61)	(106)
7/24/09 - 8/24/09, Prob(CfC Trade-in) =0.01-0.45	-205**	-511**
	(47)	(73)
7/24/09 - 8/24/09, Prob(CfC Trade-in) =0.45-0.73	-61	-597**
	(37)	(93)
7/24/09 - 8/24/09, Prob(CfC Trade-in) =0.73-0.9	-145**	-690**
	(40)	(81)
7/24/09 - 8/24/09, Prob(CfC Trade-in) =0.9-1	-146**	-649**
	(19)	(84)
8/25/09 - 9/26/09, Prob(CfC Trade-in) =0	320**	847**
	(66)	(64)
8/25/09 - 9/26/09, Prob(CfC Trade-in) =0-0.01	-504**	-227**
	(80)	(65)
8/25/09 - 9/26/09, Prob(CfC Trade-in) =0.01-0.45	-293**	-458**
	(66)	(66)
8/25/09 - 9/26/09, Prob(CfC Trade-in) =0.45-0.73	-229**	-659**
	(39)	(1.0e+02)
8/25/09 - 9/26/09, Prob(CfC Trade-in) =0.73-0.9	-373**	-823**
	(51)	(103)
8/25/09 - 9/26/09, Prob(CfC Trade-in) =0.9-1	-368**	-771**
	(32)	(103)
9/27/09 - 12/31/09, Prob(CfC Trade-in) =0	-215+	561**
	(114)	(153)
9/27/09 - 12/31/09, Prob(CfC Trade-in) =0-0.01	-1,346**	-650**
	(50)	(138)
9/27/09 - 12/31/09, Prob(CfC Trade-in) =0.01-0.45	-299**	-173
	(49)	(140)
9/27/09 - 12/31/09, Prob(CfC Trade-in) =0.45-0.73	-229**	-231+
	(43)	(132)
9/27/09 - 12/31/09, Prob(CfC Trade-in) =0.73-0.9	-310**	-327*
	(51)	(134)
9/27/09 - 12/31/09, Prob(CfC Trade-in) =0.9-1	-270**	-260+
	(34)	(135)
1/1/10 - 12/31/10, Prob(CfC Trade-in) =0	575**	486**
	(144)	(136)
1/1/10 - 12/31/10, Prob(CfC Trade-in) =0-0.01	-2,482**	-2,163**
	(139)	(175)
1/1/10 - 12/31/10, Prob(CfC Trade-in) =0.01-0.45	-228**	-836**
	(48)	(131)
1/1/10 - 12/31/10, Prob(CfC Trade-in) =0.45-0.73	59*	-788**
	(28)	(113)
1/1/10 - 12/31/10, Prob(CfC Trade-in) =0.73-0.9	59**	-815**
	(19)	(108)
1/1/10 - 12/31/10, Prob(CfC Trade-in) =0.9-1	39+	-796**
	(20)	(113)
Prob(CfC Trade-in) =0-0.01	-2,781**	-5,308**
	(103)	(106)
Prob(CfC Trade-in) =0.01-0.45	-6,735**	-11,593**
	(193)	(314)
Prob(CfC Trade-in) =0.45-0.73	-8,832**	-14,533**
	(239)	(375)
Prob(CfC Trade-in) =0.73-0.9	-10,409**	-16,106**
	(267)	(398)
Prob(CfC Trade-in) =0.9-1	-11,365**	-16,800**
	(268)	(382)
Month of Year Fixed Effects		✓
Gasoline Price · MPG Fixed Effects		✓
Constant	12,499**	13,167**
	(269)	(283)
Observations	13,053,023	13,053,023
R-squared	0.212	0.466

* significant at 5%; ** significant at 1%; + significant at 10% level. Standard errors in parentheses are robust and clustered at the region level.

† Not reported: Coefficients for the long pre-period.

ronment, and helping out consumers. The timing of Cash for Clunkers in the midst of the Great Recession suggests that economic stimulus was the central motivation. Nonetheless, studying this policy provides a useful setting for us to understand whether policies such as Cash for Clunkers can indeed have consumer benefits. As a result, in this paper we have analyzed the consumer effects of Cash for Clunkers.

We have focused on three questions: First, what percentage of the Cash for Clunkers rebate benefited consumers as opposed to dealers, i.e., what was the pass-through of the Cash for Clunkers rebate? Second, did the Cash for Clunkers rebates crowd out private incentives by reducing manufacturer rebates? Third, did Cash for Clunkers have unintended consequences by increasing vehicle prices for low-fuel-economy, old used cars?

Our results suggest that the Cash for Clunkers program was successful in delivering consumers benefits on several dimensions. First, consumers received the full benefit of the Cash for Clunkers rebates, i.e., the rebate payments passed through entirely to consumers. Second, instead of crowding out manufacturer rebates on eligible vehicles, Cash for Clunkers appears to have increased such rebates. This increased the benefit of Cash for Clunkers for consumers beyond the value of the Cash for Clunkers rebate alone. Finally, the program does not appear to have had the unintended consequence of increasing price in the used-car market for the types of cars that were destroyed in conjunction with Cash for Clunkers.

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Table 10: Summary Statistics Transaction Data

Variable	N	Mean	Median	SD	Min	Max
Price	1,056,540	27,715	24,900	12,091	4,623	201,295
CfCRebate	10,634	2,390	2,515	1,098	-8,439	5,666
ManufRebate	486,574	2,714	2,215	1,855	1	10,000
MPG	1,056,540	22	22	5.8	10	50
GasolinePrice	1,056,540	2.7	2.7	.56	1.5	4.5
PctBlack	1,056,540	.07	.018	.15	0	1
PctAsian	1,056,540	.041	.014	.079	0	1
PctHispanic	1,056,540	.096	.035	.16	0	1
PctLessHighSchool	1,056,540	.14	.11	.12	0	1
PctCollege	1,056,540	.39	.36	.19	0	1
PctManagment	1,056,540	.16	.15	.083	0	1
PctProfessional	1,056,540	.23	.22	.098	0	1
PctHeath	1,056,540	.016	.012	.018	0	1
PctProtective	1,056,540	.019	.015	.021	0	1
PctFood	1,056,540	.04	.035	.032	0	1
PctMaintenance	1,056,540	.026	.019	.027	0	1
PctHousework	1,056,540	.026	.023	.021	0	1
PctSales	1,056,540	.12	.12	.048	0	1
PctAdmin	1,056,540	.15	.15	.054	0	1
PctConstruction	1,056,540	.048	.041	.039	0	1
PctRepair	1,056,540	.036	.032	.028	0	1
PctProduction	1,056,540	.066	.051	.056	0	1
PctTransportation	1,056,540	.05	.044	.038	0	1
Income	1,056,540	59,032	53,897	27,170	0	200,001
MedianHHSize	1,056,540	2.7	2.7	.49	0	7.7
MedianHouseValue	1,056,540	173,913	141,300	130,582	0	1,000,001
VehPerHousehold	1,056,540	1.8	1.9	.39	0	4
PctOwned	1,056,540	.75	.82	.23	0	1
PctVacant	1,056,540	.065	.043	.083	0	1
TravelTime	1,056,540	27	26	7.1	0	200
PctUnemployed	1,056,540	.044	.034	.043	0	1
PctBadEnglish	1,056,540	.034	.011	.067	0	1
PctPoverty	1,056,540	.078	.052	.083	0	1
Weekend	1,056,540	.27	0	.44	0	1
EndOfMonth	1,056,540	.27	0	.44	0	1
EndOfYear	1,056,540	.032	0	.18	0	1