“HOW CASH FOR CLUNKERS HAS AFFECTED LOW-END USED CAR PRICES”

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Dedication

This project is dedicated to my mother and father. The importance of their support and wisdom throughout this project cannot be overstated.

Abstract

On June 24, 2009, President Obama enacted the Consumer Assistance to Recycle and Save Act of 2009. The goals of this act were to increase the average fuel efficiency of vehicles on the road, to reduce vehicle emissions pollution, and to stimulate the economy (NHTSA, 2009). Within the act was the creation of the Car Allowance Rebate System (CARS) that offered consumers the opportunity to turn-in their less fuel efficient vehicles in exchange for credit toward a new vehicle purchase. The CARS program became more widely known across the United States as the Cash for Clunkers program.

This study aims to look at a potential unintended side effect of the program—the increase in affordable used car prices as a result of the Cash for Clunkers program's impact on the supply of used vehicles, and in turn what this price increase could mean to low-income families looking to low-cost used vehicles as a solution to their transportation hardships.

This research will examine the effects of Cash for Clunkers on the retail price of the top ten vehicles turned in by participants of the program. Automobile characteristics and other economic indicator variables were placed into pooled OLS, random effects, and fixed effects panel studies in order to separate out the effects of the program on used car prices after the program's initialization in July, 2009.The results of the studies show that despite obvious increases in used car prices since the program's initialization, the Cash for Clunkers program has had a minuscule impact on the price of used cars. On average, used car prices increased $13 as a result of the program.

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1 Introduction

On June 24, 2009, President Obama enacted the Consumer Assistance to Recycle and Save Act of 2009. The goals of this act were to increase the average fuel efficiency of vehicles on the road, to reduce vehicle emissions pollution, and to stimulate the economy (NHTSA, 2009).

In order to achieve these goals, the National Highway Traffic and Safety Administration (NHTSA) established and administered the Car Allowance Rebate System (CARS) that was known more commonly across the nation as the Cash for Clunkers program. The program started on July 1, 2009 and provided consumers the opportunity to receive credit toward the purchase of a new more fuel efficient vehicle upon trading in their less fuel efficient used vehicles. The credits were worth either $3,500 or $4,500 depending on the fuel efficiency level of the new vehicle purchased.

The response to the program was unprecedented. Initial funding for the program was $1billion including $50 million for administration. The act permitted transactions to occur between July and November of 2009.The overwhelming response to the program, however, only allowed for transactions to be permitted through August before funding was exhausted. In the end, the program cost an additional $2 billion for a total of $3 billion (NHTSA, 2009). By the end of the program on August 25, 2009, over 677,000 used automobiles were turned in to dealerships as a result of the program (NHSTA, 2009). The used vehicles were destroyed and scrapped once in dealer custody so as to keep them from reentering the supply of used vehicles. In total, of the new vehicles

purchased during the program approximately 401,000 were passenger cars, 274,000 were light trucks, and 2,000 were heavy trucks (NHSTA, 2009).

It is estimated by the NHSTA that the program "resulted in a $3.8 billion to $6.8 billion increase in GDP and over 60,000 jobs created or saved" (NHSTA, 2009). As for the environmental impact of the program, it was estimated by NHSTA using the program's impact on fuel consumption that "the reduction in carbon dioxide emissions and related greenhouse gases over the next twenty-five years is 9 million metric tons, a reduction with an estimated social benefit of $278 million over 25 years (in 2008 dollars)"(NHSTA, 2009).

This study does not aim to disprove any of the positive effects of the Cash for Clunkers program as presented by the NHSTA or any private researcher or research company. This study aims to look at a potential unintended side effect of the program—the increase in affordable, low-end used car prices as a result of the Cash for Clunkers program's impact on the supply of low-end used vehicles and what it could mean to low-income families looking to low-end used vehicles as an answer to their transportation hardships . Affordable private transportation has been cited by many studies as a means to "promote work if employment opportunities and job searches are enhanced by reliable transportation" as would be the case for those who could afford a reliable, low cost used vehicle (Baum, 2009, as well as Fletcher et al., 2005, Sandoval et al., 2011).

This project examines the effects of Cash for Clunkers on the retail price of low-end (meaning high mileage, low quality) used vehicles using a sample representing the top ten vehicles turned in by participants of the program. Automobile characteristics and

other economic indicator variables were placed into pooled OLS, random effects, and fixed effects panel studies in order to separate out the effects of the program on used car prices after the program's initialization in July, 2009.

The results show that despite obvious increases in automobile prices, the Cash for Clunkers program has had a minuscule impact on the price of low-end used vehicles. On average, the price of a low-end used vehicle increased by $13. The small impact of the Cash for Clunkers program on used car prices may be due to the relative size of the portion of cars destroyed compared to the overall population of used automobiles on the road (an estimated 194 million light vehicles were registered in 2009 (DOT, 2009)). The remainder of the paper is organized as follows: Section 2 provides the motivation behind the research, Section 3 reviews literature related to other Cash for Clunkers research and automobile pricing, Section 4 describes the data, Section 5 presents the model, Section 6 reviews the results of the model, and Section 7 summarizes the conclusions that can be drawn from this study.

2 Motivation

Most of the research conducted on the results of the Cash for Clunkers program has focused on the effects associated with industry sales, job retention and creation, environmental impacts, and the program's overall affect on GDP. In December of 2009, the NHTSA completed their report on the outcome of the Consumer Assistance to Recycle and Save Act of 2009 for the House Committee on Energy and Commerce, the Senate Committee on Commerce, Science, and Transportation and the House and Senate Committees on Appropriations. While most of the report gave a glowing review of the program's successes in all of these areas, one area in particular was given little attention—the effects of the program on the used vehicle market. The report mentioned that used vehicle prices for more desirable vehicles (those not turned in for the program) have increased over the past 9 months "while used vehicle pricing in the lower price tiers ($5,000 and below) has remained steady in September 2009" (NHTSA, 2009). The pricing of these low cost vehicles, however, has not been revisited by any research group since the end of 2009.

In the NHTSA's report it is mentioned as a potential cost to society that those who cannot afford to purchase new vehicles may be at a disadvantage. As a result of the program eliminating 677,000 vehicles from the secondary market, those looking for replacement parts or older vehicles for transportation may be faced with a more difficult search and higher prices in light of a shrinking supply (NHTSA, 2009).

The loss in availability of low cost used vehicles can have potentially unforeseen consequences. Several research studies have shown that the accessibility of affordable

used vehicles and its impact on geographic limitations on job accessibility are significant (Baum, 2009; Blumenberg and Ong, 1998). The effects of owning a vehicle have been estimated to be as significant as doubling the likelihood of employment for single mothers with no more than a high school education, and that single mothers on welfare are more likely to leave the program within a few months if they own a car (Baum, 2009).

Studies that focus on welfare to work programs reveal special disadvantages among minorities that live within job-poor, inner-city neighborhoods (Blumenberg and Ong, 1998). These spatial discrepancies in job availability can be addressed by several types of government policies relating to economic development, housing, and transportation including increasing support for families in need of affordable used cars for transportation. A study by Fletcher, Garasky and Nielson reveals that transportation hardships are one of the most common complaints among low-income families. One in three families surveyed complained of transportation hardships including being unable to afford payments on automobiles or automobile repairs, or limited accessible alternative transportation (Fletcher et al., 2005).

Another study by Dr. Paul Ong of the University of California-Los Angeles reveals that "Owning an automobile is instrumental to employment", and that welfare programs should be providing support for car ownership (Ong, 2002). Interestingly "…eligibility requirements for new [Aid to Families with Dependent Children] recipients prevent an individual from owning an automobile worth more than $1,500. This policy forces a person with a higher-valued automobile to sell or exchange it for a less-valued

one before qualifying for benefits" (Ong, 2002). These types of programs would force people to look for the older used vehicles that are now limited in supply by the Cash for Clunkers program. However, since welfare reform in 1996, many states have increased or eliminated their asset limitations for vehicles (Bansak et al., 2010). Minnesota, for example, imposes no vehicle asset limitation for households below 165% of federal poverty line (MDHR, 2011).

The current state of the used automobile market makes the search for affordable used vehicles even harder. The National Automotive Dealers Association (NADA)—a big supporter of the Cash for Clunkers program and an influential player in its design—reveals through several press releases and their "NADA Used Car Industry Updates" that the short supply of used cars is leading to higher prices. The shortage of used vehicles has been attributed to several sources including a pull-back in leasing automobiles that began in 2007 and extended through the recession and fewer trade-in vehicles as a result of a slump in new car sales in 2008 and 2009 (Cyrill, 2011). A ten percent increase in the price for two to five year old trucks and sport utility vehicles was estimated by AuctionNet over the past several years (Cyrill, 2011).[1] But the question still remains, what effect did the removal of the older vehicles (those valued at $5000 or less) from the secondary market have on the price of these affordable used vehicles?

[1] AuctionNet represents over 80 percent of the automobiles sold at auction on the wholesale market.

3 Literature

Cash for Clunkers

As mentioned earlier, much of the research regarding the effects of the Cash for Clunkers program deals with concerns surrounding industry sales, job retention and creation, environmental impacts, and the program's overall affect on GDP. Aside from the report generated by the NHSTA in 2009 (and confirmed by the President's council of economic advisers' report in September, 2009), several private research groups and independent researchers have conducted evaluations on the program since its completion. Much of the research regarding this recent policy is still ongoing and is limited in the literature.

In March, 2010 Maritz Automotive Research Group conducted a study measuring the overall success of the CARS program. It was determined by Maritz researcher that

> "The comprehensive consumer research that comprises this study provides strong evidence that CARS achieved its objectives. The program created significantly more incremental sales than previously estimated without negatively impacting future sales."

Using their New Vehicle Customer Study (NVCS), a private database containing the survey results from over 200,000 new car buyers a year, Maritz was able to tailor their survey to address consumer motivation, demographics, and psychographics of 35,983 new car buyers over the duration of the Cash for Clunkers program. The NVCS study revealed that the estimated sales associated with the program were even greater than those predicted by government studies. In total, it was estimated that there were over 765,000 incremental sales as a result of the program (including cars purchased by those who qualified for the program and those who did not but chose to buy a new car despite

not qualifying) (Fish, 2010). Maritz's study goes on to say that the program did not create a pull-forward effect in sales (meaning that cars sold today were cars meant to be sold in the future and in turn will reduce future car sales). They argued that despite seeing a slight dip in sales in September 2009, "the Seasonally adjusted Annual Rate from October through December 2009 shows that automobiles continued to sell at a higher pace than before the CARS program was implemented, according to statistics from the U.S. Department of Commerce's Bureau of Economic Analysis." The pull-forward effect of the program, however, is one of the more contested effects among researchers.

A paper by Mian and Amir (forthcoming in the *Quarterly Journal of Economics*) argues against findings by Maritz that indicate a lack of pull-forward effects on future car sales. In an effort to highlight the ability of government to "increase consumption", Mian and Amir looked at the Cash for Clunkers program's effects on short and medium run auto purchases. Mian and Amir's study revealed that "almost all of the additional purchases under the program were pulled forward from the very near future; the effect of the program on auto purchases is almost completely reversed by …March 2010." Mian and Amir's study "exploits across-city variation in exposure (measured in participation) to CARS to assess the broader economic impacts of the program." The study uses the number of clunkers per city (as identified by the authors though sorting city automobile records by model year and "clunker" qualifications) and the participation level in the CARS program across cities to "assess the counter-factual level of auto purchases in the absence of the program" (Mian and Amir, 2010). The study was set up as a thought experiment that controls for variables likely to be correlated with auto purchases in a

given city including earnings for a household, credit card utilization, default rates and others. Comparing clunker trade-ins in 2004 in a give city with the actual participation rate in the program in 2009 revealed the propensity for a particular city to participate in the program. Mian and Amir were able to further show that the program shows no evidence of having an impact on employment, house prices, or household default rates across cities with high exposure to the program. The conclusions, however, are somewhat restrictive do to the assumption that the effects of the program are treated as local and do not include the effects on distant economies (Mian and Amir, 2010).

In a study by Li, Linn, and Spiller out of Cornell University a difference-in-differences framework was used to see the effects of CARS on auto sales and the environment (Canada was used as the control group). The study by Li et al. concluded that for new vehicles that qualified for the program sales decreased in subsequent months after the program revealing a pull-forward effect on sales. Overall it was revealed that the program had a short-lived positive effect on sales meaning that the program contributed little to no economic stimulus (Li et al., 2010).[2]

A paper by Adam Copeland and James Kahn (2012) reveals that the impact of the program on production was not significant and that statistics on spending are not the only relevant factors in determining the efficiency of such stimulus policies. Using forecasting and varying assumptions about automobile inventory behavior, Copeland and Kahn were

[2] An important economic factor determining the success of a discount such as the Cash for Clunkers rebate is the varying effects such discounts have on the durable goods market. Consumers in a durable goods market are more inclined to take advantage of discounts because of the long shelf-life of a durable good. Durable goods shoppers also have considerably more time to make purchase decisions because of this long shelf-life. Because of these factors, it is not unlikely that there would be a large response to a subsidy with depletions in sales before and after its availability (Copeland and Kahn, 2012).

able to "obtain estimates of what production would have been [in the automobile sector without the Cash for Clunkers program]. The difference between actual automobile sales and production and these counterfactuals provides estimates of the net impact of the program" (Copeland and Kahn, 2012). The results of the study show that the program had

> "negligible direct effect on GDP, shifting less than roughly $2 billion (or less than one tenth of 1% of GDP) into 2009Q3 from the subsequent two quarters. This contrasts starkly with a study released by the Department of Transportation (DOT) in the immediate aftermath of the program, which concluded that CARS had given a substantial boost to both GDP and employment" (Copeland and Kahn, 2012).

As we can see, the literature on the effects of Cash for Clunkers has produced very different results on the success of the program. Among all of the research conducted, however, the effects of the program on the pricing of low-end used vehicles have not been addressed.

Automobile Pricing

Much of the automobile pricing literature deals with complex techniques aimed at understanding the underlying demand and supply of automobiles that are differentiated across producers in the industry (Berry et al., 1995). A lot of what has been studied involves the effects of changes in influential factors, such as gasoline prices or qualities of the automobile, on their demand (Kilian and Sims, 2006; Griliches, 1961).

One of the most cited works on automobile pricing is Berry, Livensohn, and Pakes' "Automobile Prices in Market Equilibrium". The research by Berry et al. relies on aggregating a discrete choice model of individual consumer behavior that analyzes demand and supply in the automotive industry (an oligopolistic industry) taking into consideration cost as a function of product characteristics as well as demand as a function

of own- and cost-price elasticities as well as elasticities related to vehicle characteristics (Berry et al., 1995). Berry et al. develops techniques that can then be applied to obtain "cost and demand parameters for (essentially) all models in differentiated product markets". The article brings up important points surrounding unobservable characteristics causing potential bias in traditional ordinary least squares demand estimations (like the one used in this study). Berry et al. also gives important justifications behind using certain vehicle attributes in his calculations that will be used in this paper.

Kilian and Sims' paper studies changes in demand for used automobiles as a result of changing gas prices. The paper offers insight as to what factors related to automobile pricing are important to include when studying event shocks such as a drastic increases in gas prices or the implementation of programs like Cash for Clunkers. Using a data set similar to the one created for this paper, Kilian and Sims lay out important assumptions about models of the automobile market that were also taken into consideration here including: assuming the market is always in equilibrium and that characteristics, including MPG of an automobile, are time invariant (meaning that they do not deteriorate with the age and usage of the car). Kilian and Sims' study goes on to reveal that major increases in gas prices have a much more significant impact on used car pricing than major decreases in gas prices.

In order to understand the effect of the Cash for Clunkers program on the prices of low-end used vehicles, this study has adopted an approach similar to that of Zvi Griliches in his paper on hedonic price indexes for the National Bureau of Economic Research. In his 1961 paper, Griliches uses OLS models to assess quality change as part

of price indexes. Using available information on automobile standard features and automobile pricing, Griliches develops price indexes across periods that take into account changes in availability of features of automobiles. In this study, automobile characteristics, prices, and other economic indicators are utilized in a similar fashion to understand the underlying demand for low-end used vehicles. Griliches' analysis also reveals some of the limitations of using a linear model to explain demand for vehicles. These limitations will be addressed later in the paper.

4 Data Description

In order to assess the effect of Cash for Clunkers on used car prices, I assembled a panel data set using a number of automobile models that accounted for a large number of the vehicles turned in by the program's participants. The NHSTA government web page for the CARS program (not available since December 2011) offered a comprehensive list of all of the automobiles turned in over the course of the program. I focus on the 10 most popular models listed in the NHSTA's database. The 10 most popular vehicles account for 6% of the total number of cars turned in over the course of the program. Table 1 contains a list of all of the cars used in the study including their maker, model, and year of production. As one can see, the sample is made up of sport utility vehicles and minivans—the most highly scrapped vehicles during the program because of their low MPG ratings. Each car in this study was considered a class two vehicle by the NADA, meaning that deterioration as a function of mileage across all of the automobiles is considered similar. Using class two vehicles allows us to hold depreciation for all of the vehicles in the sample constant. All of the cars in the sample are also assumed to be turned in to the dealer in what NADA defines as "clean" condition. Because we are unable to assess the quality of the used vehicles being turned in, we are forced to make this assumption in order to hold vehicle quality constant across the sample. This assumption may be considered poor in light of the fact that the condition of vehicles turned in during the program are likely to be poor.

Table 1: Car Sample Details

Maker	Model	Year	Type	# in Sample
Ford	Explorer	1994	SUV	1
Ford	Explorer	1995	SUV	1
Ford	Explorer	1996	SUV	1
Ford	Explorer	1997	SUV	1
Ford	Explorer	1998	SUV	1
Ford	Explorer	1999	SUV	1
Jeep	Grand Cherokee	1995	SUV	1
Jeep	Grand Cherokee	1996	SUV	1
Jeep	Grand Cherokee	1997	SUV	1
Dodge	Grand Caravan	1999	Minivan	1
			Total # of Vehicles in the sample:	10

Like that of the Kilian study, the primary sources of data for pricing used automobiles were the NADA Used Car Guide (the Midwest edition) and the NADA Older Used Car Guide.[3] These guides have been an industry standard used by dealers and average citizens to assess vehicle retail and trade-in prices for the past 79 years. The pricing data from the Use Car Guides are generated from surveys of transaction data from dealers throughout the Midwestern region of United States. The Older Used Car Guides are based on national level transaction data. For each automobile, retail prices were generated by hand on a monthly basis for dates ranging from January 1998 through April 2012 (172 months in total). In order to account for the effect of mileage on price and variations in usage across vehicle owners[4], each automobile's listed retail prices were adjusted using the guidebook's mileage adjustment tables at three different levels of mileage: low, medium, and high. Low, medium, and high mileage was defined relative to

[3] NADA Used Car Guides were released on a monthly basis. NADA Older Used Car Guides were released at 4 month intervals over the calendar year.

[4] "Variations across owners" specifically means variation in the amount of miles a user puts on their odometer. Some cars will maintain low mileage during their useful life and others will experience high levels of usage.

the level of mileage of the typical car turned in for the program. Low mileage was considered anything between 80,000 and 90,000 miles, with medium mileage being between 100,000 and 115,000 miles, and high mileage being between 130,000 and 150,000 plus miles. Therefore, each car would have price data at each of these three mileage levels for every month through the entire time series.[5] In total there were 5161 observations (516 observations per vehicle). [6]

Figure 1 shows how retail prices of our sample vehicles have changed over the duration of the study. As we can see, there is a definite increase around the time of the implementation of the Cash for Clunkers program (July 1, 2009). When we zoom into 2008-2012 in Figure 2 we can see that the average increase is $450 (an increase of approximately 13% of the retail price).

[5] Mileage adjustments were either added or subtracted from the retail price of the vehicle. Subtractions were not allowed to exceed 40% of the trade-in price listed. Additions were not to exceed 50% of the trade-in price listed.

[6] NADA Guide Books changed mileage ranges in their tables over time. High, medium, and low mileage intervals were adjusted accordingly. Prices are given in nominal dollars.

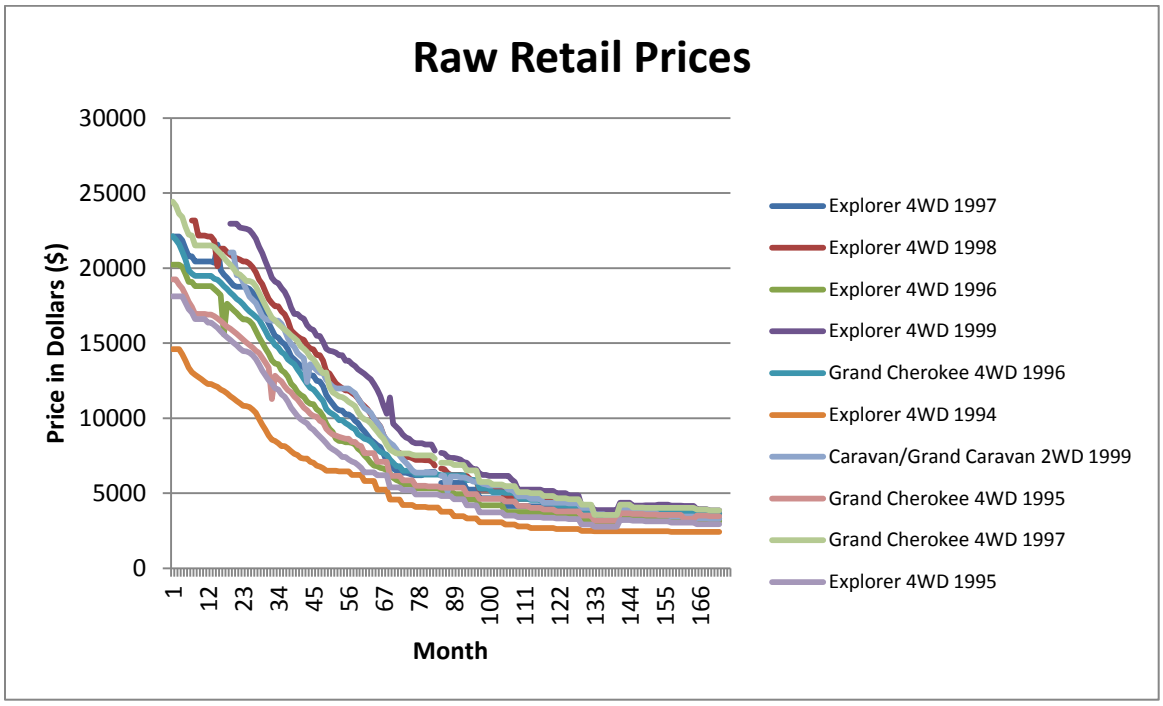

Figure 1: Raw retail Price Trends (price not adjusted for mileage)

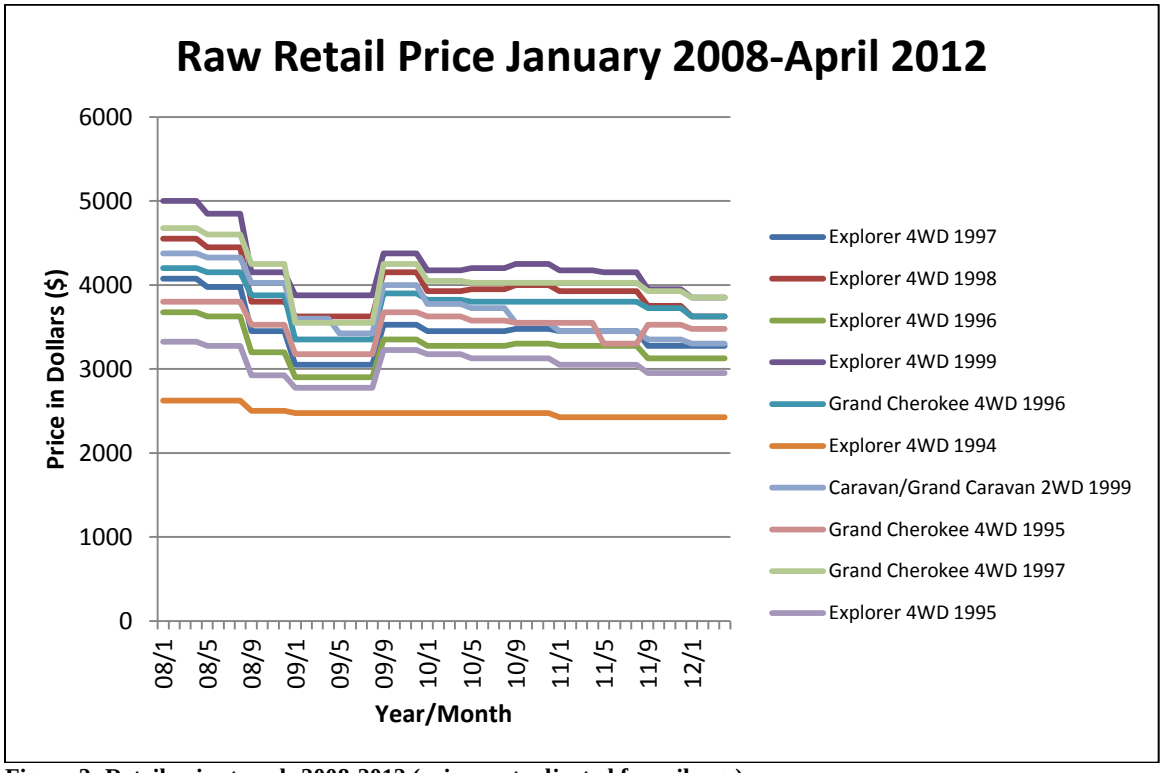

Figure 2: Retail price trends 2008-2012 (prices not adjusted for mileage)

Several other variables were added to the model in order to control for other factors affecting car price besides mileage level. In order to account for differentiation across vehicle types, standard features of each car were documented in the data set.[7] Standard features acquired in the data set are listed in Appendix 1. Like Griliches' study, standard features that were not quantifiable were treated as dummy variables. Variables will take the value of one when the car in the sample has a particular standard feature and zero when it does not (these characteristics are assumed to be held constant over time). By using dummies we are able to "derive the average contribution of the 'quality' to the price of the item" (Griliches, 1961). Miles per dollar (MP$) of fuel was also calculated for each vehicle across the time period.[8] MP$ represents the level of fuel efficiency of a vehicle and allows for the control of the effect of gasoline prices on automobile prices over time (the fuel efficiency of a vehicle is assumed to be held constant over time). Overall, MP$ is a measure of the cost of driving for a consumer (Berry et al., 1995). Features of the automobiles, as discussed in the study by Berry, Levinsohn, and Pakes, can be seen as proxies for certain characteristics desired by consumers. For example horsepower and MP$ can be seen as proxies for power and efficiency respectively (Berry et al., 1995). In addition to features, a variable for age of the automobile in years was

[7] Standard feature information came from the web page Edmonds.com. Edmonds.com is a popular car valuation site that offers vehicle specific information to both dealers and interested private buyers and sellers.

[8] Average combined MPG for each vehicle in the sample was found using fueleconomy.gov. Weekly average U.S. regular fuel prices was found using www.eia.gov. The weekly data was used to calculate average monthly price for regular fuel. Average combined MPG was then divided by the monthly average price of fuel to find MP$. Prices are given in nominal dollars.

included to account for changes in price associated with vehicle age. The age variable was formulated as the current year minus the model year of the vehicle.

Dummy variables for each year of the study were also used to account for changes across time periods that may not be picked up by other time variant predictors such as car age or price. The factors being controlled for in this model are inflation and economic instability that may cause the distribution of car prices to change across years. Prices given by the Used Car Guides are not given in real dollars; it is the job of the year dummy variables to account for inflation. With recent economic turmoil it is important to include inflation as a proxy for the changing economic climate surrounding the pricing of used automobiles. A dummy was created for every year (1998-2012), and the year 1998 was left out of the model as the base year for comparison. A dummy variable was also used to account for the beginning of the Cash for Clunkers program through the end of the study (April, 2012). A one for the Cash for Clunkers variable means that the data was collected passed the July 1, 2009 start date of the Clunkers program. A zero indicated that the data was collected before that time. This is the main variable of focus for the model. A percent increase would indicate an average percent increase over the span of July1, 2009 - April 2012.

Categorical dummies for mileage level were also created. A low, medium, or high mileage dummy variable allows us to control mileage level effects on car pricing holding all other criteria constant. Including this categorical variable can reveal potential non linear relationships between different mileage levels and their effects on price. For example, the difference in price between a low mileage vehicle and a medium mileage

vehicle may be greater than the difference in price between a medium mileage vehicle and a high mileage vehicle. The dummy variable for low mileage vehicles was not included in the model so as to be the base year for comparison.

The final variable considered in the sample was a reflection of vehicle popularity and its effect on used car prices. In the January, 2012 "NADA Used Car Guide Industry Update", industry trends showed that the supply of mid to large sized sport utilities and vans has been down relative to small compact automobiles. Some of the shortage was presumed to be in response to the increased popularity of expensive crossover utility vehicles (CUVs) over the past several years. Figure 3 shows the industry share of new car sales for the SUV and the CUV sectors.[9] As we can see the popularity of CUVs has been increasing. It is hypothesized that the popularity of CUVs and SUVs may be correlated with the increase in pricing associated with low-end used vehicles in our sample. The small bodies and truck like features of the CUV can be closely substituted by small bodied older SUV models like those in our sample. Our sample is made up of potential substitutes for those shoppers who would like to purchase the popular CUV models, but cannot afford to buy them. In order to control for this potential substitution effect, the percent of industry new car sales devoted to SUV and CUV sales per month is added to the model.

[9] Industry sales statistics were provided by Wards Auto, a company that manages information systems and services that have been collecting data on the global automobile industry for the past 80 years.

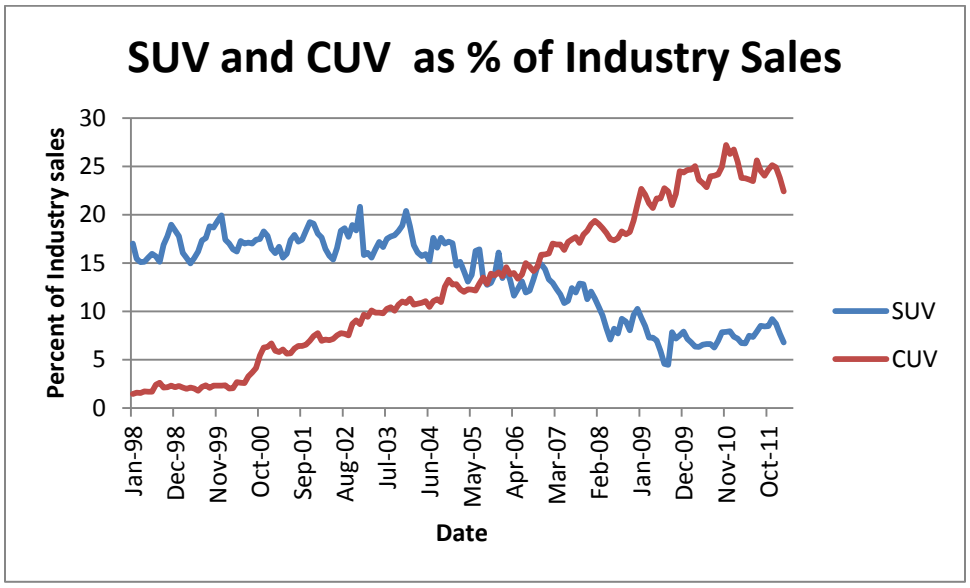

Figure 3: SUV and CUV as % of Industry Sales

Tables 2 and 3 provide descriptive statistics for those variables chosen to stay in the model. As with Griliches' regression results, a high level of multicollinearity across automobile features forces the model to be reduced to only those features that were the most critical to used car price theory.

As one can see in the descriptive statistics, there is a small window of variation across some of the variables including vehicle weight and length which may affect estimates of their impact on price. The descriptive statistics also reveal that the minivan vehicle type and Dodge model type are both small portions of the sample population. This may bias our estimates as these vehicle types and models are underreported.

Table 2: Descriptive Statistics for Numeric Variables

	mean	median	st.dev.	min	max
Car age (years)	8.29	8	4.29	0	18
Weight (lbs.)	3833.70	3871	110.32	3674	3981
Length (in.)	180.35	178.60	6.62	174.40	199.60
Horsepower (hp.)	168.40	161.50	12.09	158	190
Miles per dollar of fuel	9.14	8.48	3.69	3.75	21.12
SUV (as % of industry sales/month)	13.56	12.29	4.27	4.49	20.81
CUV (as % of industry sales/month)	12.84	12.29	7.72	1.47	27.22

Table 3: Descriptive Statistics for Dummy Variables

	Frequency	Percent
Cash for Clunkers	630	12.21
Low mileage level	1720	33.33
Medium mileage level	1720	33.33
High mileage level	1720	33.33
Individual year dummies	360	6.98
Car type:		
Minivan	516	10
SUV	4644	90
Car maker:		
Ford	3096	60
Dodge	516	10
Jeep	1548	30

5 The Model

The goal of this study is to determine the effects of the Cash for Clunkers program and other factors on low-end used car prices. As the data show, there is a clear increase in price that occurs at the point of implementation of the program; however, one cannot assume that the increase in price was simply the response of the market to changes in supply as a result of the program. There are several other influences to consider including economic influences on the market as well as consumer vehicle preferences and market trends. In order to estimate the effect of the program on used car prices, a pooled ordinary least squares (OLS) model was estimated as well as random effects and fixed effects models.

The estimated models were similar to Griliches model in the study on hedonic price indexes. For any time (t) and automobile (i) we are able to express price (P_{it}) as a function of vehicle characteristics and other variables which are believed to have an impact on automobile pricing over time. The following model is in semi-logarithmic form with the log of price as a function of vehicle characteristics (x), dummies representing time (d), dummies representing mileage level (m), measures of SUV and CUV popularity (suv, cuv), and, our variable of interest, a dummy representing pricing data after the implementation of the Cash for Clunkers program (c):

$$Log\ P_{it} = a_0 + \sum b_j x_{it} + \sum y_j d_{it} + s_1 suv_{it} + s_2 cuv_{it} + d_2 m_{2it} + d_3 m_{3it} + p_1 C_{it} + \varepsilon_{it}$$

a_0 represents the intercept which is not meaningful in this study, and ε_{it} is the error term. Semi-logarithmic form is used for its simple interpretation.

The first attempt at running the OLS model included all dummy variables and numeric variables (see Appendix 1) representing vehicle characteristics. However, due to multicollinearity the model was modified to include only those characteristics that were most essential to the theory of auto pricing. These characteristics are listed in Tables 2 and 3 in the data portion of the paper. Additional challenges arose with the presence of heteroskedasticity in the model. Heteroskedasticity was found after conducting the White and Breausch-Pagan tests on the OLS model. The presence of heteroskedasticity violates the assumption that the variance of the error term (ε_{it}), conditional on the explanatory variables, is constant. There is also potential for missing variable bias in this equation. For example, disposable income as a determinant of vehicle purchases by customers is a characteristic that may influence sales and in turn the price of low-end used automobiles, but it is not included in this model because individual data was not available. It is important to note that this model assumes that those individuals interested in vehicles of this quality are of similar socioeconomic status.

In order to address the issues surrounding heteroskedasticity within the model, heteroskedasticity-robust procedures were employed. Specifically, the OLS model uses White standard errors (heteroskedasticity-robust standard errors) in order to calculate robust t statistics that are used to determine the statistical significance of the explanatory variables in the model. Using these procedures is made valid due to large sample size.

In addition to the pooled OLS regression, fixed effects and random effects models were estimated in order to account for the idiosyncratic nature of each car. The purpose of using these models is to address the variation across cross-sectional units (in this case

a car in the sample is a cross-sectional unit). The OLS regression averages out the effects of all cross-sectional units giving a single intercept and slope. The fixed and random effects models control for those variables that are not included in the model that cause each individual cross-sectional unit to have a different intercept. There is a possibility that the OLS model generated for this data would not be consistent if those variables that are not included in the model were correlated with the explanatory variables in the model (Kennedy, 2003).The fixed effects and random effects models are alternative ways of looking at the issue of missing variables and their relationship with the explanatory variables. The fixed effects model assumes that the unobserved variables that cause differences in intercepts across cross-sectional units are correlated with explanatory variables included in the model. To produce a fixed effect model, the model generates a dummy variable for each cross-sectional unit and omits the overall intercept from the model allowing all cross-sectional units to have its own intercept. The drawbacks to this procedure are a massive reduction in degrees of freedom (one less for every dummy created) and non time-variant variables cannot be included (such as car type, horsepower, and weight) because they do not vary between individuals and are then subtracted out of the model.[10]

The random effects model, on the other hand, is designed to overcome the drawbacks of the fixed effects model by treating the idiosyncratic effects as random and includes them in the disturbance term of the model. The random effects model is then

[10] The transformation of the fixed effect model is as follows: The observation of the *i*th individual in the *t*th time period is written: $y_{it} = a_i + Bx_{it} + \varepsilon_{it}$. Average observations on the ith individual over T time periods: $\bar{y} = a_i + B\bar{x_i} + \bar{\varepsilon_i}$. Subtract the first equation from the second equation: $y_{it} - \bar{y_i} = B(x_{it} - \bar{x_i}) + (\varepsilon_{it} - \bar{\varepsilon_i})$. As one can see the intercept is gone and all non time-variant explanatory variables would be dropped (Kennedy, 2003).

made up of explanatory variables, an overall intercept, and a composite error term made up of the traditional error term component and a component that measures the difference between the individual unit's intercept with the overall intercept (Kennedy, 2003). The assumption made under the random effects model is that the unobserved individual characteristics are not correlated with the explanatory variables in the model (they are random). Using the random effects model saves on degrees of freedom and can lead to more efficient estimates of slope coefficients than the fixed effects model; however, if one cannot assume that the unobserved characteristics across cross-sectional units are not correlated with the included explanatory variables, a fixed effects model may be more appropriate. [11]

For this study, a fixed effects model may be more appropriate due to the nature of used automobiles. In the case for this model, it cannot be reasonably assumed that all cars turned in for the program were of similar condition, and this condition is correlated with the car's age and mileage level. Condition is a major factor that determines the price of used vehicles, but condition was not available in the data. The fixed effects model allows us to control for this type of endogeneity in the model.

[11] Model information was gathered from Wooldridge, 2009 and Kennedy, 2003.

6 Results

The results of the OLS regression, random effects, and fixed effects models are represented in Table 4. The estimated coefficients for all three models are almost identical indicating that we have controlled well for unobservable characteristics across cross-sectional units. The similar outcomes across all three models allow us to use any one of the models for interpretation. As one can see using any of the three models presented, the variable of interest, the dummy representing Cash for Clunkers, indicates that a car valued after the implementation of the program has a three percent increase in price holding all other factors constant. This price difference, however, represents the average price change over the entire duration of the program and its residual effects in the months that followed (all dates after the July 1, 2010 start date through April 2012). In order to see the overall effect of the program on price, the prices in the sample were modeled with and without the influence of Cash for Clunkers as implied by the models. Figure 4 shows the pricing trend for the 1997 Ford Explorer with low mileage with the influence of the program on pricing in red and the pricing trend without the influence of the program in light pink. As one can see, the impact of the program is very slight. Overall, the impact of the Cash for Clunkers program was only to increase the price of low-end used vehicles on average by $13.

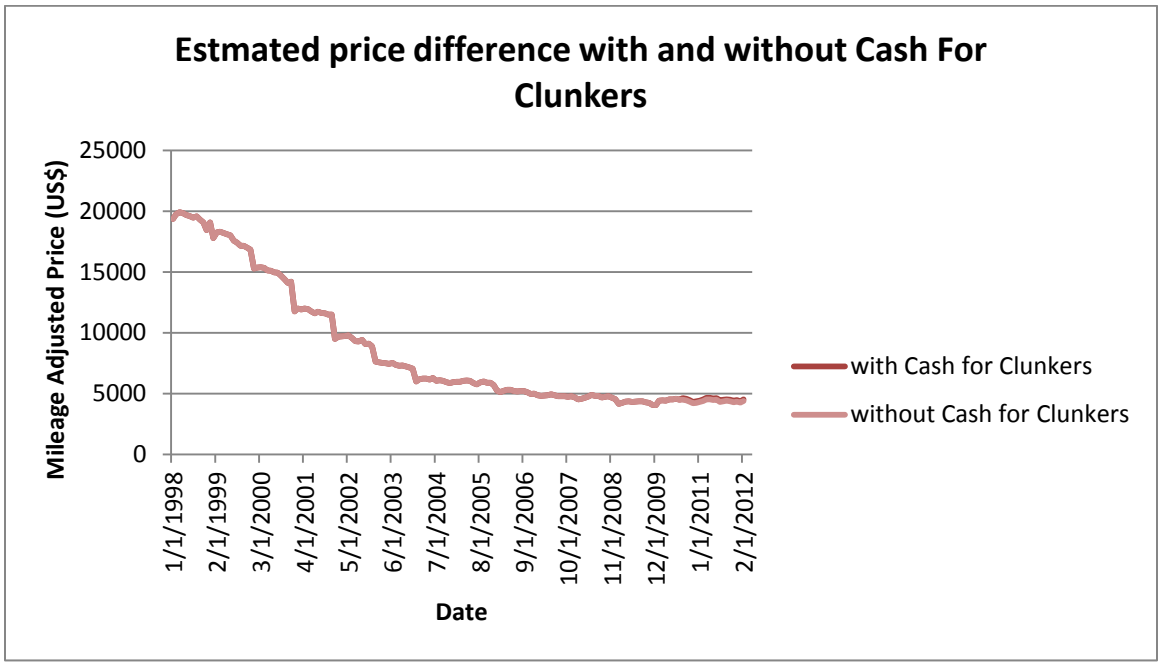

Figure 4: Estimated price difference with and without Cash for Clunkers

When one looks at the results closely in Table 4, one can see that there were several factors that had a much greater impact on the price of the vehicles in our sample than that of the Cash for Clunkers program. The age of the vehicle has a significant impact on the price of the automobile. A one year increase in age equates to a nine percent drop in vehicle price holding all other factors constant. (The fixed effects model does not include age as an explanatory variable because it does not vary with time but increases in a completely linear trend.)When we look at the year dummy variables we can see that in reference to the base year (1998) car prices tend to decrease with some fluctuation through 2006 and then gradually increase in price through the end of 2012. This variable not only picks up on the influence of inflation but the influence of economic fluctuations though time. The large coefficients for the year dummies in the fixed effects model are picking up on the effects of age of the automobile over time as

well as the effects across years. These coefficients should be read as a composite of both of these effects.

Some of the effects in the model are surprising in that they are the opposite of what was hypothesized. It is interesting to see that horsepower, a proxy for vehicle power, contributes negatively to vehicle price. One would think that vehicles with higher horsepower are valued more than those with lower horsepower. Additionally, the coefficients on the influence of SUV and CUV popularity in the industry are negative for all three models implying that the popularity of SUVs and CUVs actually make low-end used cars less desirable and lowers price. This is in contrast to the hypothesis that less expensive SUVs in our sample are substitutes for the more expensive crossover models and sport utility vehicles being introduced into the new car market.

Vehicle type and maker variables are also interesting in that they are very large. According to the OLS and random effects models, car type brings down the value of the automobile by more than twice its value while the influence of the car maker increases the price of the automobile by 88%. The large influences of these factors are most likely due to the limited variation across the sample. Descriptive statistics in Table 3 reveal that only 10% of the automobiles sampled were minivan in type and Dodge in maker.

Proxy variables for customer preference for size of an automobile, weight and length, together show a positive impact on price (the impact of weight was of negligible size) showing that customers prefer a larger vehicle and are willing to pay more for it. It is interesting to look at this statistic relative to the impact on MP$. All three models show that with an additional mile per dollar of gasoline (as the price of gasoline changes with

time) the price of the automobile increases showing a customer preference for more fuel efficient vehicles. These two results side by side show an interesting clash in consumer preferences as the larger the vehicle the less fuel efficient they become. The MP$ variable also allows for the influence of gas prices to be held constant within the model when looking at the effects of other factors separately.

Finally, the influence of mileage levels on the price of the used vehicles in the sample is indeed not a liner relationship as predicted. The coefficient on medium mileage shows that compared to low mileage vehicles medium level mileage decreases the price of the vehicle by nine percent. The effect of high mileage is over twice the effect of medium mileage on the price of vehicles (a 27% increase) when compared with low mileage vehicles.

Table 4: Regression results

	Pooled OLS	Random Effects	Fixed Effects		Pooled OLS	Random Effects	Fixed Effects
Intercept	8.89 (0.27)**	8.90 (0.45)**	9.61 (0.03)**	**Year 2009[¥]**	-0.32 (0.04)**	-0.32 (0.05)**	-1.28 (0.04)**
Age (years)	-0.09 (0.00)**	-0.09 (0.00)**		**Year 2010[¥]**	-0.16 (0.05)**	-0.16 (0.05)**	-1.20 (0.04)**
Cash for Clunkers[£]	0.03 (0.01)**	0.03 (0.01)**	0.03 (0.01)**	**Year 2011[¥]**	-0.06 (0.05)	-0.06 (0.05)	-1.18 (0.04)**
SUV (as % of Industry Sales)	-0.01 (0.00)**	-0.01 (0.00)**	-0.01 (0.00)**	**Year 2012[¥]**	-0.02 (0.05)	-0.02 (0.05)	-1.23 (0.04)**
CUV (as % of Industry Sales)	-0.02 (0.00)**	-0.02 (0.00)**	-0.02 (0.00)**	**Weight (lbs.)**	-0.00 (0.00)**	-0.00 (0.00)**	
Mile per dollar of fuel	0.01 (0.00)**	0.01 (0.00)**	0.01 (0.00)**	**Length (in.)**	0.03 (0.00) **	0.03 (0.00)**	
Year 1999[¥]	0.01 (0.01)	0.01 (0.01)	-0.08 (0.01)**	**Horsepower (hp.)**	-0.02 (0.00)**	-0.02 (0.00)**	
Year 2000[¥]	-0.03 (0.01)**	-0.03 (0.01)**	-0.20 (0.01)**	**Car type**	-2.20 (0.11)**	-2.20 (0.18)**	
Year 2001[¥]	-0.14 (0.01)**	-0.14 (0.01)**	-0.40 (0.01)**	**Car maker**	0.63 (0.04)**	0.63 (0.06)**	
Year 2002[¥]	-0.25 (0.01)**	-0.25 (0.02)**	-0.60 (0.01)**	**Medium mileage level**	-0.09 (0.00)**	-0.09 (0.00)**	
Year 2003[¥]	-0.37 (0.02)**	-0.37 (0.02)**	-0.80 (0.02)**	**High mileage level**	-0.24 (0.00)**	-0.24 (0.00)**	
Year 2004[¥]	-0.45 (0.02)**	-0.45 (0.02)**	-0.97 (0.02)**	**R-squared**	0.9728		
Year 2005[¥]	-0.39 (0.02)**	-0.39 (0.03)**	-1.00 (0.02)**	**Adjusted R-squared**	0.9727		
Year 2006[¥]	-0.43 (0.03)**	-0.42 (0.03)**	-1.12 (0.03)**	**Number of observations used**	4959	4959	4959
Year 2007[¥]	-0.38 (0.03)**	-0.38 (0.04)**	-1.15 (0.03)**				
Year 2008[¥]	-0.33 (0.04)**	-0.33 (0.04)**	-1.20 (0.03)**				

Standard errors are in parentheses.
**** significant at 1%, * significant at 5%**

[¥] variable is a dummy with base year 1998

[£]variable is a dummy representing start of Cash for Clunkers program and all dates after

[€]variable is a dummy representing mileage level compared to the lowest level

An area of concern as to the validity of the model becomes apparent when one looks at the correlation matrix of some of the variables in the model (see Appendix 2). Areas of high correlation between car type and length as well as SUV and CUV as a percent of industry sales may pose a threat to the reliability of the model as standard errors will increase as a result of the close linear relationships between these variables. These areas of high collinearity pose a threat to the multiple linear regression assumption that there is to be no perfect correlation among independent variables, and the level of correlation between some of the model's variables is very high (above 90% in some cases). The correlation between CUV and SUV sales are most likely a function of market shares. In this case, the large sample size reduces the influence of the high level of correlation and the standard errors in the model remain low. The relationship between length and car type can only be solved by generating a sample with greater variation within these variables.

7 Conclusions

Evidence presented by this model suggests that the influence of the Cash for Clunkers program on low-end used vehicle prices is not significant. With an increase on average of only $13 being contributed to the program, there is not enough evidence to suggest that the program has had enough influence on the price that it would cause a significant disadvantage to those low-income families and individuals looking for low-cost vehicles to help solve their transportation hardships. The increase in price of the vehicles in our sample reveal that it is not the influence of the Cash for Clunkers program alone that is contributing to the increase in price shown in Figures 2 and 3, but the influence of economic factors as well as consumer preference that has been driving up the price of these vehicles.

In light of this discovery it is important to understand the impact of car ownership and its effects on the livelihoods of individuals. In the future, it is hoped that there will be more federal programs that will address the need for reliable personal transportation, and that programs designed for such purposes like those of the CARS program will be designed carefully so as to not have a substantial impact on the ability of individuals to gain affordable private transportation. Further research into the effects of such programs is needed. In order to gain better results using similar model techniques, data available on single automobiles including their condition and odometer readings over time would be a valuable asset.

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Appendix 1

Table 5: Vehicle characteristics in data set

Vehicle Characteristics	Variable Type
Weight (lbs)	Numeric
Length (in)	Numeric
Horsepower (hp)	Numeric
Car Type	Categorical
Car Maker	Categorical
Captain's Chairs	Dummy
Center Console	Dummy
Bucket Seats	Dummy
Lighted Entry System	Dummy
Power Breaks	Dummy
Cloth Seating	Dummy
Vinyl Seating	Dummy
Power Steering	Dummy
Rear Defroster	Dummy
Alloy Wheels	Dummy
Driver and Passenger Side Airbags	Dummy
Am/FM Cassette System	Dummy
AM/FM No Cassette System	Dummy
14" Wheels	Dummy
15" Wheels	Dummy
Regular Fuel Engine	Dummy
Automatic Transmission Manual Transmission	Dummy
Manual Transmission	Dummy
Tachometer	Dummy
4-Wheel ABS	Dummy
Cruise Control	Dummy
Tilt Steering Wheel	Dummy

Appendix 2

Table 6: Correlation Matrix

	Car age	Weight	Length	Car type	Maker	Horse-power	Miles per $ of fuel	SUV as % of industry sales	CUV as % of industry sales
Car age	1.00	-0.03	-0.18	-0.14	-0.08	0.07	-0.83	-0.83	0.92
Weight	-0.03	1.00	-0.42	-0.45	-0.55	-0.25	-0.03	0	0
Length	-0.18	-0.42	1.00	0.97	0.69	-0.30	0.13	0	0
Car type	-0.14	-0.45	0.97	1.00	0.75	-0.29	0.14	0	0
Maker	-0.08	-0.55	0.69	0.75	1.00	0.42	0.06	0	0
Horse-power	0.07	-0.25	-0.30	-0.29	0.42	1.00	-0.11	0	0
Miles per $ of fuel	-0.83	-0.03	0.13	0.14	0.06	-0.12	1.00	0.74	-0.85
SUV as % of industry sales	-0.83	0	0	0	0	0	0.74	1.00	-0.88
CUV as % of industry sales	0.92	0	0	0	0	0	-0.85	-0.88	1.00