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Acclerated Vehicle Retirement: Toward a Conceptualized Framework for Design and Implementation

Nathan Woods
Clemson University, ntwoods@g.clemson.edu

ACCELERATED VEHICLE RETIREMENT: TOWARD A CONCEPTUALIZED FRAMEWORK FOR DESIGN AND IMPLEMENTATION

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Nathan Taylor Woods
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Dr. Anne Dunning, Committee Chair
Dr. Caitlin Dyckman
Dr. Mickey Lauria

ABSTRACT

In the past Accelerated Vehicle Retirement (AVR) programs have been implemented to combat the economic and environmental costs of automobile dependent societies. Seventy-five such programs have been implemented worldwide since 1990. This thesis examines correlations among factors affecting program performance, the relationship of articulated program objectives to program performance, and how factors affecting program performance influence environmental concerns. Employing a mixed methodology, this analysis answers how an accelerated vehicle retirement program can be designed to maximize desired outcomes and minimize undesirable outcomes. The results of this analysis demonstrate that the order and type of objective stipulated by a program will influence a program's performance, and that relationships among factors affecting program performance can dictate how well a program will function. The framework created from the literature review and from program analysis can apprise planners on how to most effectively design future AVR programs.

DEDICATION

This thesis is dedicated to my tolerant wife, Jennifer, who spent an inordinate amount of time alone while this work took shape.

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INTRODUCTION

Despite the economic and ecological costs of motoring, people in developed nations continue to hold private vehicles as their primary tool for mobility. Planners and policymakers alike must develop systems to cope with the peripheral consequences of an auto-dependent society. Consequences include national security concerns stemming from increased dependence on foreign oil suppliers, and detriments to air quality as a result of vehicle emissions. If people must commute via automobile, what policy implementations can reduce the economic and environmental costs of automobile operation?

One proposed solution for correcting ills generated from an auto-dependent society is accelerated vehicle retirement (AVR). In the past, AVR programs have been introduced as mechanisms to remedy a number of economic and environmental dilemmas instigated by a disproportionate amount of older vehicles utilized in a particular locale. AVR programs have been conducted both domestically and internationally at various scales. Set off in 1990, roughly fifty AVR programs have been introduced in the past twenty years. The U.S. federal government executed the most recent AVR program in July and August of 2009. The Consumer Assistance to Recycle and Save (CARS), or “Cash for Clunkers,” program offered consumers a monetary reward ($3,500 or $4,500) for trading in an older vehicle for a more fuel-efficient new vehicle. The CARS program dictated two broad objectives: to aid in an already expansive economic recovery effort by providing monetary stimulus through the increased sale of new automobiles, and to ameliorate past environmental harms caused by older gas-guzzling vehicles via the substitution of new fuel-efficient models. The debate concerning the degree to which either objective was accomplished persists.

While, vehicle retirement programs present an attractive method for expeditiously modifying entire vehicle fleets, objectives vary across various vehicle retirement programs, as do notions concerning the most optimal approach for execution. AVR implementation has occurred at various national and urban scales; the motivations behind such programs vary significantly. Design of AVR programs has not been methodical, and thus evaluation of such programs is neither objective nor able to account for diverse outcomes resulting from an AVR program's implementation. As evaluation is an essential part of government planning, given the lack of an accepted framework for designing an AVR program, this research has considered how various AVR objectives might be characterized to aid in the creation of a framework and performance-monitoring program for evaluating future AVR programs.

The objectives of this research are to create a framework for designing an advanced vehicle retirement program according to varying scales and objectives and to develop a performance-monitoring program that accounts for both intended and undesirable consequences of an AVR program. To realize the objectives, a literature review has been conducted that examines motivations behind the implementation of an AVR program.

REVIEW OF THE LITERATURE

A review of the literature was conducted on the motivations, theories, and structure of past Accelerated Vehicle Retirement (AVR) programs. The literature review examines acknowledged economic and environmental aspects of AVR programs, and details past occurrences of AVR. Scrutinizing past motivations and program structures allows for the formation of an AVR knowledge base and permits for more accurate analysis.

Motivations

Older vehicles are disproportionately responsible for the bulk of vehicle emissions, and contribute excessively to air pollution in urban areas (Dill 2004 22, EPA 1993 Section III, Hahn 1995 223, U.S. OTA 1992 1, Shaheen et. al. 1994 220). Natural vehicle attrition rates, coalesced with improved vehicle technology, regulatory standards for vehicle emissions, and increased vehicle replacement as a result of heightened sales during sustained periods of economic stability correct the emissions consequence for a great number of vehicles. The effects of these combined factors are not immediate; vehicle fleet turnover is a gradual progression (ECMT 1999 3) Accelerated Vehicle Retirement (AVR,) alternatively identified as vehicle scrappage, *cash-for-clunkers,* or fleet renewal can be a catalyst for hastening the total vehicle fleet turnover rate. A number of national and state governments, as well as private corporations, have implemented AVR programs throughout the past two decades.

Policymakers employ incentive-based AVR programs for the purpose of achieving various social, economic, and environmental targets, of which there are often multiple goals (Mapako, 2010, 1). AVR program objectives might include:

1. the stimulation of a national economy through new car sales
2. the reduction of vehicular emissions
3. the improvement of vehicle safety
4. the prevention of vehicle abandonment, or
5. the curtailing of consumer spending on gasoline (Allen et al. 2009 1, ECMT 1999 7, Mapako 2010 1).

A total vehicle fleet fuel consumption reduction might also result when an AVR program spawns the sale of new fuel-efficient vehicles (Evans 2008 66). Accordingly, rationale for AVR program implementation can be motivated by economic or environmental objectives – and, is regularly a combination of the two.

Environmental Motivations

The allure of AVR as a medium to achieve environmental resolutions has sustained as vehicle scrappage presents an economical strategy for the removal of older vehicles not outfitted to cope with pollutant control measures stipulated by increasingly stringent mobile emissions and Corporate Average Fuel Economy (CAFE) standards. As older vehicles often lack technologically advanced emissions control systems, or faulty emissions control systems due to mechanical failure, vehicle fleet renewal can decrease the amount of older vehicles in operation and “substantially curb atmospheric pollution” (ECMT 199 27). Mobile emissions standards strive to rein in pollution criterions that originate from a vehicle’s direct tailpipe emissions, as well as mechanical deterioration of vehicle components. Dominant vehicle emissions contain carbon monoxide, hydrocarbons, nitrogen oxides, lead and particulate matter (AMS 1999). A succession of United States federal policies has endeavored to regulate mobile emissions, and lead to a federal stance toward AVR in 1993.

California

Regulatory actions in the state of California have preceded federal policy on a number of occasions, and often-pilot federal behavior. In 1959, California’s State Department of Public Health was tasked state statute to establish air quality standards as well as motor vehicle emissions controls (Hanemann 2008 121). The air quality standards were the first of their kind enacted in the United States. Table 1 details California’s early regulatory action centered on emissions control:

Table 1: Early California Emissions Control Actions

Year	Action
1960	Motor Vehicle Pollution Control Board created to test, certify, distribute and install emissions control devices on vehicles sold in California.
1961	State Department of Public Health introduced the nation's first emissions controls, ordering positive crankcase ventilation on new vehicles sold in California beginning in 1963
1964	Motor Vehicle Control Board set tailpipe emissions standards for both hydrocarbons and carbon monoxide beginning in 1966
1966	California Highway Patrol began random inspections of vehicle smog control devices.
1967	California Air Resources Board (CARB) was created, to "To promote and protect public health, welfare and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state" (CARB 2009).

(Hanemann 2008 121)

Precedents set by early California regulatory actions have allowed the state to recurrently formulate emissions control legislation in advance of the federal government. Consequently, the nation's first AVR program, the Southern California Retired Automobile Program (SCRAP) was conducted by UNOCAL in the Los Angeles Air Basin in 1990 (Shaheen et. al. 1994 220).

The Air Pollution Control Act of 1955

Attempts to regulate air pollution by U.S. cities date back to the early 19th century. Air quality regulations were passed in 1815 by the city of Pittsburgh, and subsequently smoke control ordinances were ratified by both Cincinnati and Chicago (West 2005). Twenty-three U.S. cities approved air quality laws concerning smoke control by 1912 (West 2005). Following almost 150 years of allowing both state and local governments to enact often-divergent air quality regulations, the U.S. Congress passed the Air Pollution Control Act of 1955 to manage air pollution on a national scale (AMS 1999). The Air Pollution Control Act did little more than publicize the fact that air quality was a nationalized concern, and provided research funding to that end. Amended twice, in both 1960 and 1962, the 1962 amendments instructed the U.S. Surgeon General to "determine the health effects of various motor vehicle exhaust substances" (AMS 1999).

The Clean Air Act of 1963

The Clean Air Act (CAA) of 1963 substantially increased funding to state and local governments intended for air quality research and the formation of air pollution control measures. Centered on research of motor vehicle emissions instructed by the Air Pollution and Control Act Amendments of 1962, the CAA of 1963 advanced the idea that emissions standards could be advantageous for motor vehicles (AMS 1999). The Clean Air Act of 1963 was amended each year 1965-1967, as well as 1969. The 1965 amendments, dubbed the "Motor Vehicle Pollution Control Act," required the Department of Health, Education and Welfare to develop emissions standards for new vehicles – 6 years after California lawmakers had instructed the state's Department of Public Health to do the same (AMS 1999, Hanemann 2008 121). The 1965 amendments were created, in part, to prevent further action at the state level to control vehicle emissions. Following California's lead, several states had begun to propose vehicle emissions standards. Rather than face a system of multi-tiered distribution and a logistical nightmare, automakers rallied in support of a national emissions regulation (Gerard & Lave 2005 766). For that reason, the

1969 CAA broadened research funding for further research on automobile emissions as well as low emissions fuels (AMS 1999).

The Clean Air Act of 1970

Officially designated as an amendment, the CAA of 1970 was an entirely reshaped version of the 1963 CAA (AMS 1999). Coinciding with the creation of the Environmental Protection Agency (EPA) in 1970, the CAA of 1970 fashioned mobile source emission standards for automobiles and light trucks (Ruckelshaus 2009). Drafted by Maine democratic Senator Edmund Muskie, the amendments proposed more stringent vehicle emissions standards, “consistent with current technology and economic feasibility” (Gerard & Lave 2005 766). Measured against 1970 emission levels, the standards required a 90 percent reduction in carbon monoxide and emissions by 1975 and an additional 90 percent reduction in nitrogen oxide by 1976 (Rosenbaum 2010; Gerard & Lave 2005 766). The EPA was required to establish a Federal Testing Procedure (FTP) against which vehicle emissions would be estimated in order to obtain a federal certification, additionally the FTP provided a foundation on which the required 90 percent reductions would be based (Gerard & Lave 2005 767). Each vehicle sold that failed to obtain federal certification warranted a $10,000 penalty, to be paid by that vehicle’s manufacturer. The average new vehicle cost in 1975 was in the order of $5,000 (Gerard & Lave 2005 767). Following a series of delays and court battles surrounding EPA testing procedures and catalytic converters, the CAA amendments of 1977 extended the deadline to meet motor vehicle emissions standards. As the emissions standards outlined in the 1970 CAA were quite ambitious, the 1977 CAA amendments designated an additional period of time for compliance (AMS 1999).

Catalytic Converters

The catalytic converter accepts vehicle exhaust in advance of it leaving a vehicle's tailpipe. Structurally the most vital part of a vehicle's emissions control system, the catalytic converter aims to reduce harmful emissions released from a vehicle's engine (Sokol & Harmacy 14). Domestic auto manufacturers faced a host of tribulations in route to attaining the 90 percent emissions reduction required by the CAA of 1970, resulting in more than a few delays (Gerard & Lave 2005 768). Technology considered necessary to reach the CAA mandated reductions was not yet widely available in 1970, and significant costs faced auto manufacturers who were required to meet them. The EPA maintained that catalytic converters could be used to meet emissions standards, though they were not yet widely obtainable. As well, the U.S. fleet in the early 1970s was largely comprised of vehicles that operated on leaded gasoline. Leaded gasoline tended to ruin catalytic converters by depositing lead inside the converter housing (Gerard and Lave 2005 767). A sequence of court battles between the EPA and domestic auto manufacturers *(see Table 2)* resulted in the delay of the 90 percent emissions reduction date by one year (Gerard & Lave 767-768). In spite of this, domestic automobile manufacturers, without viable alternatives, began to employ catalytic converters in mass. Catalytic converter market dissemination, combined with the 1973-1974 oil embargo, resulted in leaded gasoline's virtual removal from the U.S. fuel supply in the late 1970s. After 1980, all vehicles produced for the U.S. market are required to be equipped with catalytic converter technology (Sokol & Harmacy 14). For the reason that a catalytic converters have a tendency to breakdown with age and use, the oldest vehicles in a vehicle fleet discharge more pollution into the atmosphere than do newer vehicles.

Table 2: Clean Air Act of 1970 Implementation Timeline

Date	*Action*
December 21, 1970	Clean Air Act Amendments direct EPA to set standards and federal Test procedure
June 23, 1971	EPA sets standards for 1975 model year
January 1, 1972	National Academy of Science issues report suggesting technology to meet standard is not yet available
March 13, 1972	Volvo requests delay of standards. Other automakers follow suit, including Ford, GM, and Dodge on April 5
March 12, 1972	EPA denies extension
December 18-19, 1972	D.C Court of Appeals hears automakers appeal and remands case back to EPA for further investigation (International Harvester V Ruckelshaus)
December 30, 1972	EPA issues supplement to Decision of the Administrator
February, 1973	D.C Court of Appeals again remands (International Harvester v. Ruckelshaus)
April, 1973	EPA delays HC, CO standards
June, 1973	EPA delays NOx standards
June, 1974	Congress extends interim HC, CO standards to 1977 and NOx to 1978
February, March 1975	EPA extends interim HC, CO standards to 1977 and NOx to 1978
August, 1977	Clean Air Act Amendments push interim HC to 1980 and CO, NOx standards to 1981

(Gerard & Lave 2005 769)

Clean Air Act Amendments of 1990

A decade after the CAA amendments of 1977, the California state legislature passed the California Clean Air Act (CCAA) of 1988. As air quality in California continued to deteriorate in the ten years since the federal CAA amendments of

1977 had passed, due to population growth that resulted in more vehicles on California roadways, legislators sought to cope with air quality problems through stricter air quality standards. The CCAA set forth numerous provisions including: the full elimination of leaded gasoline, enhanced catalytic converter requirements, gasoline-vapor recovery procedures, inspection and maintenance (I/M) programs for vehicles, advanced fuel-injection systems for passenger cars, mandated new emissions standards, and reformulated gasoline (Van Vorst & George 1997 34).

Heavily based on the CCAA of 1988, the CAA amendments of 1990 promulgated the use of gasoline-vapor recovery procedures, reformulated gasoline, and set more stringent emissions standards (McCarthy 2005 8-9). Passenger vehicles were required to meet a 40 percent emissions reduction in hydrocarbons, as well as a 50 percent emissions reduction in nitrogen oxide (McCarthy 2005 8). Provision was made for a second set of reductions beginning in year 2004, based on an evaluation of need. In 1998, the EPA reported to Congress that further emissions reductions were both desirable and attainable (McCarthy 2005 8). For the first time, Congress subjected minivans, SUVs, and light trucks to passenger car emissions standards in 2004 (EPA 2008, McCarthy 2005).

The CAA amendments of 1990 required the EPA to set National Ambient Air Quality Standards (NAAQS) to address pollutants harmful to both humans and the environment (Environmental Protection Agency, 2010). Areas that exceed the ambient air quality standard on four different dates over the duration of a three-year period are considered to be in “non-attainment” (Merrifield, 1998).

The EPA provides an updated list of non-attainment areas. Consequences for an area that falls into non-attainment include the loss of Federal transportation funds, the prohibition of major building projects, and general detrimental health effects for residents of that area (Environmental Protection Agency, 2008).

Additionally, the CAA amendments of 1990 mandated that metropolitan planning organizations (MPO) and air quality management districts (AQMD) secure consistency between air quality management plans and new transportation projects (Simon 1993 1). Titles I and IV of the CAA amendments of 1990 established a market-based emissions trading system for attaining NAAQS (Wooley and Morss 2000 13). Effectively launching the idea of cap and trade with regard to pollution control, polluters could purchase pollution credits from other entities, or reduce emissions in another area of their AQMD, if the total emissions reduction remedied their own emissions discharge (Washington 1993 1). The reductions could be attained from other CAA designated sectors. One tactic was to examine the more straightforward reductions available from mobile emissions standards (Washington 1993 1). Thus, AVR programs represented a cost-effective means for attaining mobile source emissions reduction credits (MSERC). UNOCAL's SCRAP program in 1990 provided the UNOCAL Corporation with emissions reduction credits as "the difference in emissions between retired and replacement vehicle" was claimed as an emissions reduction (Simon 1993 1). Table 3 provides a lineage of the Clean Air Act and its subsequent amendments:

Table 3: Clean Air Act Descriptions

Date	Name	Description
1955	Air Pollution and Control Act	An Act to provide research and technical assistance relating to air pollution control
1960	Air Pollution and Control Act amendment	Extended research funding for four more years
1962	Air Pollution and Control Act amendment	Instructed U.S. Surgeon General to determine the health effects of various motor vehicle exhaust
1963	Clean Air Act	An Act to improve, strengthen, and accelerate programs for the prevention and abatement of air pollution
1965	Clean Air Act amendment	Expanded local air pollution control programs
1966	Clean Air Act amendment	Divided the nation into Air Quality Control Regions (AQCRs) to monitoring ambient air quality and set a timetable for State Implementation Plans (SIPs)
1967	Clean Air Act amendment: Air Quality Act	Extended authorization for research on low emissions fuels and automobiles.
1970	Clean Air Act amendments	An Act to amend the Clean Air Act to provide for a more effective program to improve the quality of the Nation's air.
1977	Clean Air Act amendments	Extended deadline to meet Motor Vehicle Emission Standards
1990	Clean Air Act amendments	An Act to amend the Clean Air Act to provide for attainment and maintenance of health protective national ambient air quality standards, and for other purposes.

(AMS 1999)

CAFE Standards

Prior to an exploration of EPA vehicle retirement implementation documents, it is prudent to look at the convoluted ways in which Corporate Average Fuel Economy standards (CAFE) work in concert with the Clean Air Act. CAFE standards, which sought to reduce energy consumption by increasing the fuel economy of cars and light trucks (NHTSA, 2010) were endorsed in the Energy Policy Conservation Act (EPCA) of 1975 as a federal response to the 1973-1974 oil embargo (Morrow, et. a*l*, 2010, 1307; Goldberg, 1998, 1; NHTSA, 2010).

Novel at the time of enactment, the controversial CAFE standards required automobile manufacturers, who wished to market vehicles in the U.S., to attain a minimum sales weighted average fuel efficiency standard of 27.5 mpg by 1985, doubling new vehicle fuel economy (Goldberg, 1998, 1; NHTSA, 2010). Fears concerning both energy security and impending climate change have prompted a renewed focus on reduced fuel consumption and emissions in the U.S. over the last decade (Evans, 2008, 3). The Energy Independence and Security Act (EISA) of 2007 altered CAFE standards by establishing a target of 35 miles per gallon for both cars and light trucks by model year 2020 (Sissine, 2007, 1). EISA required a 92 percent compliance rate for all passenger cars and light trucks during a given model year, yet allows vehicle manufacturers to secure credits for vehicle classes that exceed the revised standards in order to make up for another vehicle class not in line with CAFE targets (Sissine, 2007, 4). In an effort to address CO2 emissions, the Obama administration set a goal of achieving a CAFE standard of 35.5 mpg by 2016 (Morrow et al., 2007, 1306). Canada's fuel consumption program established similar targets, however the program is voluntary (EIA, 2010, 112; Transport Canada, 2010). CAFE standards in conjunction with CAA amendments help regions thwart the possibility of falling into air quality non-attainment. Vehicles that consume less fuel have more efficient engines, and thus produce fewer emissions.

Massachusetts v. EPA

A point of contention surrounding the Air Quality Act of 1967 was whether states like California, who had previously imposed their own air quality emissions standards, would be allowed to continue to exceed government set emissions standards (Hanemann 2005 122). Auto manufacturers preferred a national emissions standards benchmark, rather than a variety of state formulated emissions yardsticks. As California's emissions standards were more stringent than national emissions standards, auto manufacturer arguments were particularly strident. In the end, California alone was granted federal exemption to continue to set its own emissions criterion (Hanemann 2005 122). A pioneer with respect to air quality standards, Congress was inclined to indulge California in its quest for emissions standards innovation, as advances in air quality improvement in California might reap benefits nationally (Hanemann 2005 122). Between 1967 and 2000, California has been granted federal exemption no less than sixteen separate occasions (Hanemann 205 122).

The Kyoto Protocol is an international treaty that created legally binding greenhouse gas (GHG) emissions targets for industrialized nations (Rosenbaum 2010 366). President Bill Clinton signed the treaty in 1998, but failed to consent the U.S. Senate and was soon involved in impeachment proceedings. Unsurprisingly, the Senate rejected the treaty (Rosenbaum 2010 375, Saundry 2005). President George W. Bush rejected the Kyoto Protocol in March 2001, opting instead to set domestic policy for voluntary GHG reductions (Saundry 2005).

In the absence of federal action, states began to adopt their own GHG emissions reduction targets (Rosenbaum 2010 376). The CAA of 1990 allows states the option to adhere to federal vehicle emissions standards or the more stringent California vehicle emissions standards (EDF 2008). Twelve states adopted California vehicle emissions standards after the CAA of 1990 including:

Arizona, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington (Pew Center on Global Climate Change). In 2006, the EPA contended that CO2 regulation was not warranted under the CAA, and resolved to deny California an exemption to enact more stringent vehicle emissions standards than the federal government on that basis (Rosenbaum 2010 377). California had historically been granted exemption, and as the CAA amendments allowed other states to adopt California vehicle emissions standards, the EPA opinion was challenged in federal court (Rosenbaum 2010 377). In *Massachusetts v. EPA*, the Supreme Court of the United States was petitioned by 29 entities to ascertain whether or not the CAA warranted the EPA to regulate CO2. Table 4 lists the entities involved in the case:

Table 4: Massachusetts v. Environmental Protection Agency participants

Petitioner	Challenger
California	EPA
Connecticut	Alliance of Automobile Manufacturers
Illinois	National Automobile Dealers Association
Maine	Engine Manufacturers Association
Massachusetts	Truck Manufacturers Association
New Jersey	CO2 Litigation Group
New Mexico	Utility Air Regulatory Group
New York	Michigan
Oregon	Alaska
Rhode Island	Idaho
Vermont	Kansas
Washington	Nebraska
New York City	North Dakota
Baltimore	Ohio
Washington D.C.	South Dakota
American Samoa	Texas
Center for Biological Diversity	Utah
Center for Food Safety	
Conservation Law Foundation	
Environmental Advocates	
Environmental Defense	
Friends of the Earth	
Greenpeace	
International Center for Technology Assessment	
Nation Environmental Trust	
Natural Resources Defense Council	
Sierra Club	
Union of Concerned Scientist	
U.S. Public Interest Group	

(Meltz 2007 2)

By a 5-4 margin the court held, in its first decision on climate change, that the CAA gave the EPA authority to regulate CO2 as its potential affect on climate change may harm human health and the environment (Rosenbaum, 2010 377, Meltz 2007 1).

The Supreme Court's decision to in *Massachusetts v. EPA* is the latest step in federal environmental policy that impacts the regulation of motor vehicle emissions. A litany of CAA amendments has resolved to police emissions from motor vehicles in an attempt to elevate U.S. air quality. When CAA regulation combined with CAFE standards do not produce expected motor vehicle emissions improvements, one alternative is AVR.

EPA Implementation

The CAA amendments of 1990 touted AVR as one practical method for reducing emissions in an inventory of potential transportation emissions source control measures (EPA 1993 Section II). To that end, a 1993 EPA implementation document entitled “Guidance for the Implementation of Accelerated Retirement of Vehicles Programs” reiterated the commonly held conviction that the oldest vehicles in a fleet are responsible for an inordinate amount of vehicle emissions in a particular locale (Section III). Citing AVR programs as a “cost–effective alternative to more expensive and difficult stations source emission control measures,” EPA’s vehicle scrappage implementation document promoted “the voluntary removal from use and the marketplace of pre-1980 model light duty vehicles and pre-1980 light duty trucks” (EPA 1993 Section II). The U.S. Office of Technology Assessment (OTA) encapsulates the ability of an AVR program to reduce vehicle emissions by affirming “retiring old vehicles will have a positive impact on vehicle emissions because the vehicles being retired were originally subject to emissions standards that were weaker than those required of new vehicles” (OTA 1992 3). Presupposing that natural attrition corrects the emissions consequence of a great number of vehicles, the EPA proposed vehicle scrappage programs as a way to cope with vehicles that continue to remain in operation for long periods of time (EPA, 1993, Section III). The eight requirements for an AVR program, as detailed by the EPA, are common to a number of domestic and foreign AVR programs. Table 5 details EPA designed requirements for AVR:

Table 5: Environmental Protection Agency Requirements for an AVR program

Requirement	Reason
Twelve month registration	To ensure that vehicles are not imported into an area for the sole purpose of being sold in the program, and that a vehicle owner did not purchase a vehicle for the sole purpose of selling that vehicle in an AVR program
Vehicle must be operable and driven to site	To target those vehicles most likely to continue to disperse harmful pollutants, and not those that have little remaining useful life
Owner must be present and possess valid title	To ensure that the legal owner of a vehicle intends to retire the vehicle, as accepted vehicles are dismantled and cannot be repaired
Owner must have valid inspection and maintenance (I/M) certificate (where applicable)	As a further assurance that in-use vehicles are retired
Environmentally safe disposal	To ensure that waste created during vehicle dismantling is handled properly, the EPA requires that vehicles be scrapped by licensed or approved facilities.
Emissions estimates	For the purposes of quantifying emissions reduction
Minimum data gathering for programs over 2500 vehicles	Rather than collect substantial data from each vehicle, large programs are allowed to select a random sample in order to provide the EPA a resource for evaluating a program
State responsibility	To ensure states are in accordance with EPA guidelines for the purposes of estimating a fleet emissions reduction

(EPA 1993 Section IV).

The eight requirements for conducting an AVR program, as detailed by the EPA, are concerned primarily with the beneficial environmental impacts an AVR program can produce, but allow for economic benefits by permitting states to award Mobile Source Emissions Reduction Credits (MSERCs) when clunkers are scrapped (Merrified 1998 2).

Environmental Accelerated Vehicle Retirement Theory

In response to the promulgation of Accelerated Vehicle Retirement programs as instruments for rectifying environmental harms as a result of continued older vehicle utilization, a plethora of literature on AVR focuses on both the potential environmental benefits and surmised environmental detriments of vehicle scrappage. The literature does not concentrate solely on the environmental implications of an AVR scheme. Rather, as vehicles represent a purchasable good, research with an environmental focus, at times, muddles through economic speculation. Still, as any environmental strategy will ultimately face a balance sheet, the research is worthy of examination.

The conclusion of several AVR programs led to an examination of the air quality impacts of vehicle scrappage in a 1994 issue of the *Transportation Research Record*. The analysis concluded air quality benefits attributable to AVR are, to a great extent, uncertain for reasons including:

1. Vehicles retired in scrappage programs are likely to have been junked in the near future without the existence of an AVR program, and
2. Retired vehicles may have sat idle, and thus produced no air quality impacts (Hsu et al., 1994, 90).

The review contended that in order to gauge accurate emissions reductions as a result of an AVR program, a number of questions must be answered. Thus, the following analytical framework was provided as a solution:

1. "How much earlier were the old automobiles retired than they otherwise would have been without the program?
2. How much would the automobiles have been driven if they had not been retired?
3. What were the emissions levels of the retired automobiles?
4. How were the VMT of the retired automobiles replaced?
5. How many VMT will occur on the replacement vehicle when there is one?
6. What will be the emissions levels of the replacement automobiles?" (Hsu et al., 90).

At the time the analytical framework was provided, scrappage programs were only recently beginning to become fervent policy topics. Consequently, cost-benefit and air quality impact analysis was not yet attainable for AVR programs. The framework suggested that despite the lack of available information from completed AVR programs, scrutiny of AVR implementation was necessary (Hsu et *al*., 1994, 98).

Examining proposed benefits and costs as a result of an AVR program, a 1995 analysis of AVR considered the implications of a scrappage program in Los Angeles County, and attempted to establish a model for gauging the emissions reductions for future AVR programs (Hahn, 1995, 222). The model determined that a vehicle's remaining lifetime was a crucial point of assessment in “determining whether retiring that vehicle was economical” (Hahn, 1995, 236). However, moving from a purely economical evaluation of vehicle scrappage, the model determined implications for location based vehicle scrappage. Hahn’s research suggested that an AVR scheme would be most effective in polluted urban areas “where there is a high fraction of older vehicles and the marginal benefits from reducing pollution are high” (1995 239). The model then anticipated that vehicle scrappage strategies would be implemented on a temporary basis. From an emissions reduction standpoint, the study questioned the effectiveness of vehicle scrappage programs over a long duration by suggesting, “once the relatively dirty vehicles are removed from the fleet, the gains from scrappage are significantly diminished” (Hahn, 1995, 239). Concerns arise from problems with fraud, estimating the remaining lifetime of a vehicle, and accurately testing harmful vehicle emissions. Despite these concerns, the model concluded, “it is, indeed, possible to design scrappage programs that will achieve some cost-effective emission reductions in selected urban areas” (Hahn, 1995, 239).

An AVR program that subsidizes vehicle scrappage in conjunction with an emissions tax that reflects deteriorating vehicle emissions systems over time was postulated in 1996 to be the most effectual strategy for designing an AVR scheme that would address the harmful environmental externalities created by personal vehicles (Innes, 1996, 236- 237). The proposed model was similar to current vehicle inspection and maintenance (I/M) programs, currently employed by numerous state governments. The model placed a higher tax on a vehicle’s emission system as the vehicle aged, and reversed the effect of the tax by offering higher scrappage subsidies for the newest vehicles in a fleet. As older vehicles that are retired sooner than later, reflect, “greater emission reduction benefits because the car is off the road an additional year,” the AVR model proposed a higher reward for vehicles retired earliest (Innes, 1996, 237). Unlike Hahn’s model, the Innes’ model conjectures an AVR program that is continuous “rather than a one shot” so that the temptation is removed for drivers who might purposefully retain their vehicles solely for the purpose of later qualifying for proposed AVR programs (Innes, 1996, 237).

A 1997 AVR analysis researched proposed AVR programs by employing the use of a new methodology entitled CALCARS, a vehicle choice-demand usage model for California used to simulate the response to large-scale AVR programs at the household level (Kavalec and Setiawan 1997 95). CALCARS introduced the ability to project the effect of an AVR on a host of new variables including:

1. Vehicle ownership,
2. Vehicle miles traveled (VMT,)
3. Fuel use,
4. Fuel efficiency, and
5. Consumer welfare, (Kavalec and Setiawan, 1997, 95).

With regard to vehicle emissions, the model conjectured that reducing the age of the vehicle fleet within a given area might benefit that area’s total average fuel economy. Conversely, they postulated that a “higher average miles per gallon (mpg) level and lower average vehicle age may mean more total VMT (Kavalec and Setiawan, 1997, 95).

Kavalec and Setiawan examined the impacts of AVR programs that targeted vehicles both ten-plus and twenty-plus-years-old, and determined that an AVR program that concentrated on acquiring vehicles twenty years and older might "be a more cost effective way of reducing" pollution than a program that targets vehicles ten-years and older (Kavalec and Setiawan, 1997, 106). Various AVR programs commonly have requirements that vehicles be older than ten to twenty-five years of age, but not older than twenty-five years. The 2009 U.S. CARS program stipulated that vehicles must have been "manufactured less than 25 years before the date of trade-in" (NHTSA, 2009, 6). Initially hypothesizing that an AVR program may adversely affect "low income households by significantly affecting the price of the lowest cost vehicles," the research concluded that a 20-year-plus program might retard the effect of an AVR on used vehicles because the supply of low cost vehicles aged 10-plus-years would remain robust (Kavalec and Setiawan, 1997, 106). An extension of this research in 2004 found that vehicle subsidies during an AVR program increased the probability that owners of vehicles aged 10-plus-years would elect to scrap their vehicles by 20 percent (Yamamoto *et al.*, 2004, 924).

The prospective negative consequence of Accelerated Vehicle Retirement has led to four objections against the supposition that AVR programs are beneficial to the environment including:

1. The focus of previous research on AVR programs has been concerned exclusively with vehicle use, and neglected other phases in a vehicle life-cycle that require energy including production and demolition that stimulate emissions,
2. AVR shortens in-use vehicle lifetimes and accelerates new vehicle production, thus escalating emissions,

3. Due to increased energy-efficiency replacement cars are likely to be driven more, "which leads to an increase in petrol consumption," and
4. The proclamation that a retrofitting strategy may be favorable to an AVR scheme, as vehicles that produce the highest amounts of pollution may be dealt with more cost-effectively. (Van Wee et al., 2000, 138-141).

Analysis has concluded that AVR as an emissions reduction strategy is flawed because the actual result is an increase in "life-cycle energy use" and emissions, a trend that will continue unless yearly fuel efficiency improvements are greatly augmented (Van Wee *et al.*, 2000, 143). Kim et *al.* determined that scrapping vehicles less than 20 years of age resulted in a small increase in of CO2 emissions, when accounting for vehicle production (Kim *et al.*, 2004, 246). Spitzley et *al.* revealed that an optimal vehicle scrappage age of 10-14 years reduced the overall cost of pollutants, ownership costs notwithstanding (Spitzley *et al.*, 2005, 173).

The idea that a vehicle scrappage program will produce environmental benefits appears intuitive. Removing older vehicles with feeble emissions systems and replacing them with vehicles that house robust emission control systems inevitably decreases harmful tailpipe emissions, at face value. Various foreign and domestic AVR programs ostensibly interpret such ideas at face value, without accounting for increases in VMT or full life-cycle emissions. As well, many domestic programs have made no conjectures as to what, if any, impact the programs would have in areas in danger of being in air quality non-attainment. Even more curiously, some years after hybrid vehicles have become a rational and cost-effective choice for many consumers; many programs have not placed an overt emphasis on the utilization of hybrid vehicles. Assumedly, had these vehicles been utilized, a greater share of vehicle emissions could have been reduced.

Synopsis of Environmental Motivations for AVR

Disproportionately responsible for the bulk of vehicle emissions, older vehicles contribute unjustifiably to air pollution in urban areas (Dill 2004 22, EPA 1993 Section III, Hahn 1995 223, U.S. OTA 1992 1, Shaheen et. al. 1994 220). A reduction in older vehicles will reduce emissions, "since older cars not only produce higher emissions, but also fail to use new and environmentally friendlier technologies" (Baltas and Xepapadeas, 1999, 329). In order to rectify harms caused by vehicle emissions, progressively more stringent emissions controls have been enacted by the United States Congress and enforced by the U.S. EPA and NHTSA. As such emissions control measures are innately incapable of resolving emissions harms generated by older vehicles on international roadways, a "blunt instrument" is required to remedy the emissions damages generated by the oldest vehicles in a vehicle fleet (Hahn 1995 239). AVR can hasten the amount of time with which the oldest vehicles in a fleet are replaced, thus diminishing the emissions impact of a great number of older vehicles.

Theories concerning the likelihood that an AVR program is capable of reducing greenhouse gas emissions abound. It has been speculated that AVR can have an impact on air pollution in urban areas by removing the oldest vehicles in the operational vehicle fleet. Doubt concerning an AVR program's ability to reduce vehicle emissions conjectures that, once an older vehicle has been replaced with a new vehicle, the new vehicle will be driven more often. In lieu of such supposition, many foreign and domestic AVR programs continue to implement AVR with environmental motivations.

Economic Motivations

The attraction of Accelerated Vehicle Retirement as a medium to achieve economic stimulus is tied directly to environmental motivations for vehicle scrappage. When older vehicles are removed from the vehicle fleet for the purpose of reducing pollutant emissions, replacement vehicles are an anticipated acquisition. Historically, the economic benefits of vehicle scrappage were merely consequential. In recent years, AVR strategies have been imposed with the primary objective of reviving slumping automobile sales. Both foreign and domestic countries have instituted AVR programs to resuscitate distressed automobile manufacturers, which represent a sizeable portion of worldwide economies. The largest of such programs, the 2009 U.S. cars program, ensued a national economic recession. AVR programs can be implemented to stimulate vehicle sales by offering a cash incentive to participants. The magnitude of purchase incentives has varied according to location, and is often based on the discretion of national leadership.

Economic Accelerated Vehicle Retirement Theory

Much of the existing economic literature concerning vehicle scrappage explores the makeup of private economic evaluations regarding whether or not to scrap an older vehicle (Hahn, 1995, 223). Deriving primarily from the field of economics, a preponderance of the literature attempts to model determinants of participation in an AVR program, and the resulting impact on the economy as a whole (Dill, 2001, 17; Chen and Lin, 2006, 733). Economic Theory of AVR centers on several criteria including: age, cost of repair, incentive amount.

Age

A vehicle's utility inherently declines with age. As well, the notion that the decision to scrap a vehicle, once the cost to repair that vehicle is more than the vehicle's market value is relatively straightforward. Accordingly, initial economic models of vehicle scrappage are consistently traced to an analysis that scrutinized vehicle scrappage rates in the U.S. from 1949 through 1967 (Hahn, 1995, 223; Walker 1968, 503). The analysis yielded that vehicle scrappage would occur when an owner has concluded he/she cannot "profitably repair, recondition and resell" a vehicle (Walker, 1968, 503). Thus, the decision to scrap a vehicle was stated to be contingent upon four identifiable characteristics including:

1. Age
2. Condition
3. Cost of repair or reconditioning, and
4. Expected resale value (Walker 1968 503.)

The likelihood that a vehicle will be scrapped was established to ascend with the age of that vehicle and level off at the most advanced vehicle ages. The oldest vehicles in a fleet face an exceedingly decreased amount of operation. The stabilization of vehicle scrappage rates at advanced vehicle ages was due in large part to a decrease in the odds that the oldest vehicles in a fleet were being intentionally preserved by their owners as classics (Walker, 1968, 505).

The decision to scrap a vehicle was aligned to an additional set of cost criteria in 1977 that integrated:

1. Vehicle purchase cost
2. Maintenance and repair costs, and
3. Cost of vehicle replacement (Parks, 1977, 1099).

By means of regression analysis, the model demonstrated that vehicle repair costs implicitly rise with the age of a vehicle. As a result, older vehicles were concluded to comprise those vehicles most probably scrapped (Chen and Lin, 2006, 734.) Individual vehicle owners would opt to repair their vehicles if the costs of doing so did “not exceed the difference between the value of a working vehicle and its scrap value” (Parks, 1977, 1100). Greenspan and Cohen later corroborated this notion in a 1996 analysis of vehicle scrappage (Greenspan and Cohen, 1996, 375). The decision to scrap a vehicle was analyzed in 2006 by modeling vehicle survival rates at a government agency, the Dupage County, Illinois County Forest Preserve District (Chen & Lin, 2006, 732). It was determined that while vehicle age alone appears to increase the probability that a vehicle will be scrapped, other variables also contribute to the decision. Variables include vehicle make, vehicle type, and the number of repairs performed on a particular vehicle.

An examination of data derived from the Israeli vehicle market in 1983 took the work of Parks (1977,) and applied it in a location-based context (Manski and

Goldin, 1983, 365 – 366). In the vein of the 1977 model, the new model assumed that a vehicle would be scrapped if that vehicle's scrap value exceeded the current market value of the vehicle, minus any needed repair costs (Dill, 2001, 18). All other variables equal (mileage, condition, current market value,) the model determined that a vehicle's scrappage probability would decrease as its price increased (Manski and Goldin, 1983, 372). Plainly, as older vehicles are often those least valued, they are most commonly those vehicles most likely to be scrapped. The examination determined that increases in the scrappage rates of vehicles aged between 3 and 14 years was "due much more to the depreciation of vehicle prices as vehicles age than to increases in failure-proneness" (Manski and Goldin, 1983, 375).

Subsequent economic inquiry built on the assumptions of past models, specifically that vehicles will be repaired only if the cost to do so was less than the value of that vehicle in working condition (Berkovec, 1985, 198). Applying these models in the context of the automobile market as a whole, a 1985 analysis determined that a progressively greater amount of owners will select to scrap their vehicles as compounded mechanical failures within a particular vehicle render the overall value of the vehicle near that of the vehicle's scrapped value (Berkovec, 1985, 199). The inquiry went on to argue that the total U.S. vehicle fleet would grow throughout the 1980's, not directly related to the sale of new vehicles, but owing to the combined effects of an increase in new vehicle price points and a decrease in the number of scrapped vehicles. The analysis predicted that despite the fact that outputs by vehicle manufacturers would decrease throughout the 1980s, additional numbers of aging vehicles would be utilized as a cost saving remedy (Berkovec, 1985, 213). The inquiry concluded with the idea that a rise in the number of older vehicles within the U.S. vehicle fleet would have repercussions for both "automobile safety and the environment" (Berkovec, 1985, 213).

The age of a vehicle and that age correlation with maintenance costs are embedded within an individual's decision of whether or not to scrap a particular vehicle. Vehicle age is directly coupled with a vehicle's emissions. As such, the age of a vehicle is significant for both environmental and economic motivational determinants.

Incentive Amount

The determined incentive amount for a particular AVR program can influence the decision to participate. Survey data collected during a 1992 Delaware accelerated vehicle retirement program was scrutinized to develop a theoretical model of vehicle ownership in which it was assumed a vehicle owner will maximize the utility available from a single vehicle over the duration of that vehicle's lifetime (Alberini *et al*, 1995, 94). The analysis sought to model participation in a vehicle scrappage program where monetary incentives were offered. It was found that a potential vehicle scrappage program participant's "decision to scrap at any point in time depends on the difference between the offer price and the owner's reservation price – the minimum he is willing to accept for the vehicle" (Alberini *et al.*, 1995, 94). Predictably, a participant's reservation price would be higher under the influence of several factors including:

1. When a vehicle warranted a high blue book value

2. When a vehicle was in better condition,
3. When a vehicle had a longer expected remaining life,
4. When a vehicle owner anticipated low vehicle expenditures in the year to come, and
5. When a vehicle owner had fewer additional vehicles as a means of alternative transportation (Alberini et al., 1995, 111).

Equally, reservation prices were found to be lowest for vehicles “in the poorest condition, with relatively short remaining life,” which concurred with previous scrappage theories (Alberini *et al.*, 1995, 111).

Examination of a 1999 AVR program in Greece conjectured that subsidy increases in an AVR program would reduce the replacement time of an old car and “accelerate the purchase of a new clean car” (Baltas and Xepapadeas, 1999, 333). An increase in the purchase subsidy offered during an AVR program will reduce the number of old vehicles on the road. With respect to the effect of subsidies in the automobile sector as a whole that the ability of an incentive policy to induce vehicle scrappage is clear; however, the long-term effects of an AVR scheme are uncertain (Adda & Cooper, 2000, 778-781). An analysis of two AVR schemes in France surmised vehicle scrappage policies stimulate individual vehicle sales during the duration of an AVR program, but produce a subsequent reduction in vehicle sales - a major argument against the 2009 U.S. CARS program (Adda & Cooper, 2000, 778, 780-781). The study projected that a decrease in vehicle sales will last approximately 15 years, or till vehicles sold under the scrappage policy are deemed inoperable (Adda & Cooper, 2000, 801).

Research in 2007 attempted to characterize the effects of a vehicle scrappage subsidy on both new and used car markets as a whole (Esteban, 2007, 4). The research maintained that though AVR programs may have environmental implications, because they upset the conventional framework of both new and used car markets, their repercussions expand beyond their environmental benefit (Esteban, 2007, 1). Basing examinations on a Danish AVR program, where a bulk of participants used their scrappage subsidy to purchase used vehicles, the analysis made a critical contribution to the economic literature on vehicle scrappage in determining that "accounting for an active secondary market might be critical" in the study of vehicle scrappage subsidies (Esteban, 2007, 1-2). The used car market has not been considered in many recent AVR programs intent on providing economic stimulus including the 2009 U.S. CARS program, as the programs have sought to stimulate the economy through the sale of new vehicles. As scrapped vehicles are inherently used vehicles, and would otherwise be sold in the used car market, AVR scrappage subsidies symbolize a "price floor in the used car market" (Esteban, 2007, 2). Two significant contributions emerged from the model: AVR subsidies that offer less for a used vehicle than the price of that vehicle in the free market may still induce scrappage *and* in order for an AVR subsidy to proficiently induce scrappage, at minimum the subsidy must also maximize a participant's welfare (Esteban, 2007, 26).

Intuitively, the amount of obtainable incentive can influence a person's decision to participate in an AVR program. Varying incentive amounts have been used in both foreign and domestic AVR programs. As such, incentive amount can a strong motivational tool in persuading a person to participate in an AVR program.

Odometer Reading, Vehicle Make, and Vehicle Type

Several additional determinants influence the decision to scrap a vehicle, including a vehicle's odometer reading, the make of a vehicle, and vehicle type. Odometers continually calculate the number of miles a vehicle has been driven throughout its lifetime. The number of miles a car has been driven significantly impacts the likelihood that car will be scrapped, and, "heavily used cars will be replaced sooner" (Chen and Lin, 2006, 734; De Jong, 1996, 268).

Vehicle make may also influence the scrappage decision. Concerning domestic vehicle makes, a 2006 analysis found that for Ford and Chevy vehicles, the probability of scrappage increases drastically between 5 and 15 years in use, reaching a 20 percent chance of survival after 20 years in use. The probability that a Dodge vehicle would be scrapped increased the instant that vehicle entered the fleet (Chen and Lin, 2006, 741-742). A previous model determined that both German and Swiss vehicles tend to have a decreased probability of vehicle scrappage, and remain in operation longer than similar makes from various countries of origin (De Jong, 1996, 268).

A final determinant of vehicle scrappage is vehicle type. Cynthia Chen has argued the idea that vehicle type is one way to forecast whether or not a vehicle will be scrapped at length. Her 2005 model determined that minivans were expected to be scrapped later than other vehicle types (Chen and Lin, 746). As well, De Jong discovered that vehicles with diesel engines are expected to remain in the vehicle fleet for extended lengths of time over vehicles with gasoline engines (De Jong, 1996, 268).

Odometer reading, vehicle make, and vehicle type all have significant economic effects on the overall value of a particular vehicle. Persons holding vehicles with the lowest value are often more inclined to participate in an AVR program, should the available incentive supplant the additional financial burden of owning a new vehicle. Owners of certain vehicle makes are less likely to participate in a vehicle scrappage program. As such, odometer reading, vehicle make, and vehicle type are essential aspects to consider in both the design of an AVR program, as well as the decision to participate in that program.

Impact of Fuel Costs

Vehicle acquisitions embody fixed costs for a consumer, but consumers must also account for ongoing variable costs when purchasing a vehicle. The bulk of variable costs pertaining to car ownership are a result of the cost of fuel (Busse *et al.*, 2009, 2). An inquiry as to how gasoline prices affect both new and used vehicle markets estimated that the market share of the least fuel-efficient new vehicles would decrease by 17.7 percent when gasoline prices increased by a mere $1. Conversely, the same inquiry estimated that the most fuel-efficient new vehicles would increase market share by 17.5 percent (Busse *et al.*, 2009, 34). Concerning used vehicles, the inquiry estimated the total transaction price of fuel-inefficient vehicles would fall by more than $1000 when gas prices increased by a mere $1, and that the total transaction price of the most fuel-efficient vehicles would rise by more than $1500 (Busse *et al*., 2009, 35). With reference to the U.S. CARS program, consumers faced with the possibility of a substantial loss in vehicle worth due to fuel price increases found a strong motivation to participate in the program as doing so would subsidize their vehicle value loss with government funding. Concerning this trend, Li *et al*. found that fuel price increases would encourage vehicle owners to hold their fuel-efficient vehicles longer, while owners of the most fuel-inefficient vehicles would be prompted to scrap their vehicles (Li *et al*., 2009, 116).

Goldberg investigated the effect of fuel prices on VMT in 1998. Her model found that in the short-term fuel cost increases narrowly bring about a reduction in VMT, but that over periods of sustained high fuel costs VMT would decrease dramatically (Goldberg, 1998, 19). Additionally, the model determined that an increase in the purchase price of a vehicle was more likely to affect consumer vehicle choice than a "proportional increase in fuel costs (Goldberg, 1998, 20). For the reason that AVR programs provide a decrease in the purchase price of a vehicle, especially in times of sustained high gas prices, programs should effectively sway more consumers to buy the most fuel-efficient vehicles. Huang determined that only 7.2 percent of consumers opted for the most fuel-efficient vehicles available during the 2009 U.S. CARS program (Huang, 2010, 3). Still evaluations of singular vehicle scrappage programs are not complete without examining factors that may have resulted in the need for such a strategy in the first place. Throughout the past decade, fuel prices have varied drastically, providing a strong motivator for consumer participation.

Synopsis of Economic Motivations for AVR

In elementary terms, economic inquiry of vehicle scrappage dictates that a vehicle's marginal utility decreases with that vehicle's age combined with a number of other factors. As both the likelihood of mechanical breakdown and probability of more frequent repair costs increase with age, older vehicles are more apt to be scrapped. Furthermore, vehicle values decrease proportionately to that vehicle's age (unless at some occasion in the lifetime of a vehicle, that vehicle is deemed to be a "classic.") Consequently, the decision to scrap a vehicle is based upon that vehicle's current value, alongside the repair costs for making the vehicle fully operational and the sustained impact of fuel prices. As such, AVR programs most effectively motivate vehicle owners with the most inexpensive vehicles. Likewise, rates of participation should increase when scrappage incentives are largest (Allen *et al.*, 2009, 9).

Urban Planning Motivations

Accelerated Vehicle Retirement can aid in eradicating a number of environmental, social, and spatial ills in urban areas caused by motor vehicle transportation. Namely, AVR can help retaliate against global warming, aid in the relief of congestion in increasingly urbanized locations, increase vehicle and road safety, and diminish air pollution. Vehicles emissions are responsible for prodigious amounts of CO2 and greenhouse gas emissions, which contribute to global warming. Global warming may produce a host of negative externalities including: population displacement brought about by rising sea levels, the extinction of climate sensitive species, and more frequent hurricane and drought periods (Markham, 2009). Entwined with global climate change is a global increase in air pollution. Air pollution poses significant respiratory health threats to citizens in urban areas. Removing older vehicles from roadways in both urban and rural areas is an inherent goal of an AVR program, and one practical method urban planners might employ to combat climate change. Whether an AVR program focuses specifically on an environmental or economic goal is irrelevant; a reduction in vehicle emissions will transpire.

AVR programs may aid in the removal of a great number of vehicles in urban areas, which may reduce vehicle congestion and increase air quality. As urbanization of the world's population continues at a frenzied pace, space restrictions in urban areas prevent residents from efficiently owning and operating an automobile. Complications resulting from automobile congestion in urban areas can harm residents' productivity and health. Planners must seek methods to properly increase traffic flow without jeopardizing air quality. While public mass transit is the most efficient method for moving people throughout urban areas, it can be expensive to implement. AVR can help reduce the number of vehicles in an area, when the program is designed to offer a cash incentive toward something other than the purchase of a new vehicle.

A myriad of people worldwide are injured or die in traffic accidents each year. Urban planners face concerns regarding expected service levels for emergency services in particular areas, issues with roadway design, as well as the general health, safety, and welfare of residents. In instances where AVR programs offer incentives toward the purchase of a new vehicle, a reduction in older vehicles will result in overall increase in vehicles equipped with modern safety features. Advances in vehicle headlights, airbags, and other standard safety features occur each model year. Replacing older vehicles with new vehicles may help prevent a number of traffic related deaths, and offer planners a viable tactic for improving the overall safety of roadways in a given community.

Urban planners are instinctively concerned with the health, safety, and welfare of residents in a particular area. Therefore, global warming concerns along with more general air quality concerns and traffic safety involvements are inherently urban planning matters. AVR is one method urban planners might consider when attempting to alleviate the harms of an auto dependent society. AVR can be instituted by urban planners to efficiently lighten the burdens caused by motor vehicles.

Past AVR Programs

For as long as motor vehicles have been an integral part of personal mobility, Accelerated Vehicle Retirement (AVR,) alternatively identified as vehicle scrappage, *cash-for-clunkers,* or fleet renewal, has been proposed as a catalyst for hastening the vehicle fleet turnover rate. In the 1920s, General Motors Corporation (GM) concocted a method for accelerating new car sales by requiring dealers to pay $5 into a general fund for each new vehicle they ordered. Dealers then received $50 from the fund for older vehicles taken in trade and subsequently scrapped (Nieuwenhuis and Wells, 2003, 146). The scheme was designed to remove older vehicles from the national fleet for the purpose of invigorating new car sales.

Whereas the 2009 *cash-for-clunkers* program symbolized the first federal program of its kind in the U.S., the notion that such a strategy could be effective was not a contemporary one. The George H. W. Bush administration proposed a *cash-for-clunkers* program in 1992, “under which states and companies [could have met] Federal clean-air requirements by buying and scrapping the old vehicles that generate the most pollution” (Hershey, 1992). The nation’s first AVR program took place in 1990 in Los Angeles (Hsu and Sperling, 1994, 1444). Entitled the “Unocal South Coast Recycled Auto Project (SCRAP)” the program scrapped 8,376 pre-1971 vehicles over a four-month period for a bounty of $700 cash (Hsu and Sperling, 1994, 1444; Dill, 2001, 7). Table 6 lists 75 known past AVR programs:

Table 6: Past Accelerated Vehicle Retirement Programs

	Program	*Dates*
1	Unocal South Coast Recycled Auto Program (SCRAP)	6/1/1990 - 11/18/1990
2	Greece	1/1/1991 - 3/31/1993
3	San Joaquin Valley REMOVE Program Phase I	1992-1993
4	France	10/1/1992 -12/31/92
5	Delaware Vehicle Buyback Program	1992-1993
6	Illinois EPA (Chicago)	1993
7	Unocal South Coast Recycled Auto Program (SCRAP II)	5/26/93
8	Hungary	9/1/1993 - 2/1994
9	Santa Barbara Old Car buyback program	1993 - 1996
10	San Joaquin Valley REMOVE Program Phase II	1993-1994
11	Denver Total Clean Cars Program	12/1993 - 04/1994
12	Denmark	1/1/1994 - 6/30/1995
13	Spain	4/1/1994 - 10/1/1994
14	Unocal South Coast Recycled Auto Program (SCRAP III)	1994
15	San Joaquin Valley REMOVE Program Phase III	1994-1995
16	France	2/1994 - 06/1995
17	Spain	11/1994 - 6/1/1995
18	Unocal South Coast Recycled Auto Program (SCRAP IV)	1995
19	San Joaquin Valley Vehicle Buy-Back Program	1995-1996
20	Ireland	1/6/1995 -12/31/1997
21	San Joaquin Valley REMOVE Program Phase IV	1995-1996
22	France	09/1995 - 09/30/1996
23	Norway	1996
24	British Columbia Scrap-It Pilot Program	4/1996 - 12/1998
25	San Joaquin Valley REMOVE Program Phase V	1996-1998
26	Bay Area Air Quality Management District vehicle buyback program	1996 - 2005

27	Italy	1/1/1997 - 9/30/1997
28	San Joaquin Valley Vehicle Buy-Back Program	1997-1998
29	Italy	2/1/1998 - 9/30/1998
30	California Air Resources Board Pilot Program	11/1998 - 11/1999
31	San Joaquin Valley REMOVE Program Phase VI	1998-1999
32	California Consumer Assistance Program	1998 - 6/30/2001
33	Old Car Buyback and Scrap Program	12/1/2009 - present
34	British Columbia Scrap-It	1/1/1999 - present
35	Argentina	3/22/1999 - 11/14/2000
36	San Joaquin Valley REMOVE Program Phase VII	1999-2000
37	Santa Barbara Old Car buyback program	5/1999 - 8/2001
38	Maine High Pollution Vehicle Retirement Pilot Program	11/1/2000 - 10/8/2002
39	California Air Resources Board Pilot Program	7/1/2001 - 12/31/2001
40	Alberta Clean Air Scrappage Pilot Project	3/21/2001 - 3/31/2002
41	California Air Resources Board Pilot Program	1/1/2002 - 12/31/2005
42	San Joaquin Valley REMOVE Program Phase VIII	2002 -2003
43	California Air Resources Board Pilot Program	FY 06/07
44	Bay Area Air Quality Management District vehicle buyback program	2006 - 2008
45	Santa Barbara Old Car buyback program	2006 - 12/31/2010
46	California Air Resources Board Pilot Program	FY 07/08
47	High Emitter or Scrap I (HEROS)	06/2007 - 04/2009
48	Texas Drive a Clean Machine	12/2007 - 11/30/2010
49	California Air Resources Board Pilot Program	FY 08 - 2/8/2009
50	Spain Plan VIVE	12/1/2008–10/1/2010
51	France Prime a la casse	12/4/2008–12/31/2009
52	Portugal Plan I	1/1/2009–8/7/2009
53	Germany	1/14/2009–12/31/2009

54	Cyprus	1/16/2009 - 9/16/2009
55	Luxembourg	1/22/2009–10/1/2010
56	Canada (Retire Your Ride)	2/1/2009 - 3/31/2011
57	California Air Resources Board Pilot Program	2/9/2009 - 12/31/2010
58	Italy	2/7/2009–12/31/2009
59	Slovakia Plan I	3/9/2009–3/25/2009
60	Austria (Verschrottungsprämie)	4/1/2009–12/12/2009
61	Slovakia Plan II	4/6/2009–12/31/2009
62	United Kingdom	5/1/2009–3/31/2010
63	Spain Plan 2000E	5/22/2009–5/18/2010
64	The Netherlands	5/29/2009 - 12/31/2010
65	Japan	6/19/2009 - 3/31/2010
66	United States	7/1/2009 - 8/24//2009
67	Portugal Plan II	8/8/2009–12/31/2009
68	Greece	9/30/2009–11/2/2009
69	Bay Area Air Quality Management District vehicle buyback program	2009-2010
70	France Prime a la casse 2	1/1/2010 - 6/30/2010
71	Ireland	1/1/2010 - 12/30/2010
72	Romania	2/15/2010 - 11/23/2010
73	Russia	3/8/2010 - 12/31/2010
74	France Prime a la casse 3	7/1/2010 - 12/31/2010
75	Cyprus	10/11/2010 - 12/13/2010

(*See Appendix A. for Citations)*

Varying Objectives

Past Accelerated Vehicle Retirement programs list various primary objectives. Several of the first AVR programs sought vehicle scrappage as a way to earn MSERCs in heavily polluted areas. Other programs have pursued broad based emissions pollution reduction as a primary objective. More recent programs have employed AVR for the primary purpose of stimulating new car sales. Still other programs pursued primary objectives specific to an issue found only in their respective location. (*See Tables 52 – 61)*

Varying Scales

Past Accelerated Vehicle Retirement programs have occurred in areas with divergent populations. The total population of an area where an AVR program is conducted can have ramifications on the number of vehicles retired and number of participants throughout an AVR program's tenure. All other factors being equal (incentive amount, eligible vehicle criteria, and government investment) one would assume that AVR programs carried out in areas with larger populations would generate greater total program effectiveness. *(See Tables 16 – 20)*

2009 Economic Climate

Faced with escalating fuel prices, a slowing global economy, and rising unemployment, automobile purchases were a distant consideration for much of the American citizenry in 2009 (Canis and Yacobucci, 2010, 1-2). The accumulated economic misfortunes of 2009 exposed weaknesses in both foreign and domestic automotive industry business models. However, obstacles for automakers were present long before President Obama announced the enactment of the first federal AVR program.

The U.S. automotive industry had encountered a sustained reduction in vehicle sales over the last three decades, attributed to reductions in quality and the emergence of viable foreign vehicle alternatives (Clark et. al., 2009, 1). In the summer of 2008, with heightened fear of global terrorism and wars in both Afghanistan and Iraq, the price of oil reached a record $147 a barrel (Leech, 2010). Subsequently, gas prices climbed in many parts of the country from prices just over $2 per gallon to an average of over $4 per gallon, more than $5 in some parts, resulting in a national average of $4.11 in the U.S. (Leech, 2010; Canis and Yacobucci, 2010, 2). New motor vehicle sales annually account for around 10 percent of total consumer merchandise spending in the leading industrial economies (Stanford, 2010, 2). Faced with a sinking economy and high fuel prices, scores of Americans restricted spending on both major and trivial purchases. At the same time, owners of the most fuel-inefficient vehicles began to reconsider their means of transportation. Yet, faced with a reduced availability of credit, many consumers opted to suffer financially, via increased expenditures on fuel, rather than suffer the loss of resale values in the vehicle market (Canis and Yacobucci, 2010, 1-2).

The result of combined economic hardships was a population largely apathetic to the U.S. automobile market. Nationwide, 2008 vehicle sales endured a 2.9 million unit sales decrease in cars and light trucks from the previous year and a 4.6 million unit decrease from the vehicle sales zenith observed at the turn of the century (Canis and Yacobucci, 2010, 1-2). 2009 vehicle sales were down 35 percent in the U.S., 11 percent in Canada, and 41 percent in Russia (AECA, 2010).

The year 2009 saw trials affecting the automotive industry including:

1. a global recession
2. a crisis in global credit markets
3. bankruptcy of both General Motors Corporation (GM) and Chrysler LLC
4. financial bailout packages provided by the federal government for both GM and Chrysler that included provisions for governmental ownership
5. automobile plant closings
6. automotive worker buyouts, and
7. the cash-for-clunkers program at summers end (Canis and Yacobucci, 2010, 1).

Financial bailouts were allocated to support domestic automakers in the fall of 2008 by then President George W. Bush. North American automotive industry bailouts were unique to international approaches in two respects:

1. Government assistance was requisite to ensure the automakers survival, and
2. The rescue of the U.S. automotive manufacturers “occurred within the context of a continental market that has come to be dominated by offshore-based producers” (Stanford, 2010, 2).

Automotive industry bailouts met varying degrees of public support and suspicion. Many argued the dilemma of the domestic automotive industry was the result of several decades’ worth of declining quality. Others believed the automotive industry should be left to meet its own demise. Still, others reasoned that should the automotive industry fail, the nation's entire economy would implode. The devastating economic consequences of 2008 and 2009 amalgamated so that by mid-2009, theories began to advance concerning the improbability of the U.S. auto sector's ability to survive. A new mechanism was required to ensure the automotive industry would endure.

Timeline

A host of hurdles stood between the idea of a national vehicle scrappage program and the eventual execution of the *Cash-for-clunkers* program of 2009. A chain of events that began a year prior to the program's completion are important to note in order to describe the method by which the NHTSA elected to conduct the federal AVR program. The timeline in table 7 details the events that impacted the U.S. CARS program:

Table 7: U.S. Cash-For-Clunkers Timeline of Events

September 29, 2008	The U.S. House of Representatives reject a $700 billion Troubled Asset Relief Program (TARP) rescue bill by a vote of 228-205, subsequently the Dow fell 777.68 points, the largest one-day loss in history.
October 1, 2008	The U.S. Senate passes an amended TARP bill
October 3, 2008	The U.S. House of Representatives votes in favor of TARP funds for the banking industry.
November 14, 2008	President George W. Bush implores Congress to release $25 billion in loans to U.S. automakers. Controversy erupts, as loans were not originally intended to relieve automakers.
December 19, 2008	$17.4 billion in TARP funds are distributed to GM and Chrysler
January 2009	A Cash for Clunkers bill is proposed in Congress
February 17, 2009	Both GM and Chrysler ask for additional funds totaling $5 billion.
March 30, 2009	President Barack Obama asks GM CEO, Rick Wagoner to resign as part of a total restructuring plan
April 30, 2009	Chrysler announces that it will file for bankruptcy
June 1, 2009	GM enters bankruptcy. The U.S. government provides the company $30.1 billion in additional TARP funds in exchange for 60% ownership in the company once it emerges from bankruptcy.
June 9, 2009	The Consumer Assistance to Recycle and Save Act (CARS) of 2009 is passed by the U.S. House of Representatives
June 18, 2009	CARS is passed by the U.S. Senate
July 10, 2009	GM emerges from bankruptcy
July 24, 2009	President Barack Obama signs the Consumer Assistance to Recycle and Save Act of 2009
July 27, 2009	The CARS program begins at U.S. dealerships
August 7, 2009	Congress appropriates an additional $2 billion for the CARS program
August 25, 2009	The CARS program ends

(Clark et. al, 2009, 2-3; Canis and Yacobucci, 2010, NHTSA, 2009, Li et al., 2010, 7).

Though it lasted a mere 55 days, the U.S. *Cash-for-clunkers* program of 2009 stimulated the U.S. economy through an increase of vehicle sales, and altered the age makeup of the national vehicle fleet (Huang, 2010, 2).

2009 U.S. Cash for Clunkers

The Consumer Assistance to Recycle and Save Act of 2009 (CARS) (U.S.C. 49, § 32901) enacted by Congress was signed into law by President Barack Obama on June 24, 2009 and required the National Highway Traffic Safety Administration (NHTSA) to administer an AVR program (NHTSA, 2009, 3). NHTSA was mandated to formulate a strategy for the CARS program within 30 days of the law's ratification. NHTSA was not instructed to submit the proposed strategy back to Congress prior to the strategy's implementation (NHTSA, 2009, 5,) a controversial aspect for people concerned with fiscal responsibility. The Act initially appropriated $1 billion for the CARS program, for which $50 million was to be towards administrative expenses; 12 days into the program Congress provided an additional $2 billion was provided (Pub. L. 111-47) owing to the program's early success (NHTSA, 2009 3-4).

Originally deemed the Consumer Assistance to Recycle and Save Act of 2009, the designation was later only used with reference to the act signed by the President in June. The Acronym CARS denoted "Car Allowance Rebate System" throughout the program's tenure. Responsible for the first federal AVR program in the United States, NHTSA worked in conjunction with the EPA to determine fuel economy ratings for both clunker and new-vehicle eligibility throughout the program (NHTSA, 2009, 5-6). The CARS program officially launched July 27th, 2009 and was terminated prematurely on August 25, 2009, as funds allocated by Congress for the program had been exhausted (Li et al., 2009).

The U.S. CARS program combined two goals: promoting auto sales to benefit a lackluster economy that had been especially hard on U.S. automotive manufacturers, and to improve the environment by replacing old vehicles with vehicles that provided an increase in fuel economy (Yacobucci and Canis, 2009, 2; Li et al., 2010, 4, U.S. GAO, 2010). CARS offered consumers a financial incentive towards the purchase or lease of a new vehicle, if that vehicle represented an increase in fuel economy when compared to a consumer's old vehicle (Yacobucci and Canis, 2009, 1; U.S. GAO, 2010, 4). The financial incentive provided to consumers was a rebate of up to $4,500 based on the set of criteria in table 8 formulated by NHTSA (Yacobucci and Canis, 2009, 1; NHTSA, 2009, 6) including:

Table 8: CARS Rebate Value Criteria

	New Vehicle Category			
Rebate Value	Passenger Automobile	Category 1 Truck	Category 2 Truck	Category 3 Truck
$4,500	At least 10 mpg higher fuel economy than trade-in	At least 5 mpg higher than trade-in	At least 2 mpg higher than trade-in	None
	22 mpg minimum	18 mpg minimum	15 mpg minimum	
$3,500	At least 4 mpg higher than trade-in	At least 2 mpg higher than trade-in	At least 1 mpg higher than trade-in OR trade-in is a MY2001 or newer category 3 truck	Trade-in is MY2001 or newer category 3 truck
	22 mpg minimum	18 mpg minimum	15 mpg minimum	Trade-in is of similar size or larger than new truck

(Yacobucci and Canis, 2009, 4).

Rebate values wholly depended on increase in fuel economy (Huang, 2010, 4).

Four criteria were also established regarding trade-in vehicle eligibility. The criteria were designed to ensure that vehicles received throughout the program would not otherwise continue to be utilized as mode of transportation. Table 9 details eligibility criteria established for the U.S. CARS program:

Table 9: CARS Vehicle Eligibility Criteria

Trade in Vehicle	• Is in drivable condition • Has been both continuously insured, consistent with the laws of your States, and continuously registered to the same owner for at least one year immediately prior to the trading-in your vehicle under the CARS program • Manufactured less than 25 years before the date of trade (i.e., before mid- to late- 1984) and, in the case of category 3 trucks, not later than model year 2001 • Has combined MPG of 18 or less (this does not apply to category 3 trucks, i.e., very large pickup trucks or cargo vans)
New Vehicle (Purchased or Leased)	• Is new (i.e., legal title has not been transferred by anyone) • Has manufacturer's suggested retail price of $45,000 or less

(Li et al., 2010; U.S. GAO, 2010, 5)

Vehicles traded-in during the program were dismantled to ensure they did not reappear in the vehicle fleet and continue polluting (Li et al., 2010, 7).

Motivation

The idea that federal programs can be used to stimulate national spending can be traced to British economist John Maynard Keynes. Keynesian economics espouses the view that governments should stabilize consumer demand through deficit spending to prevent economic recessions (Smiley, 2008). Where classical economics maintains that macroeconomic business cycles are efficient, Keynesian economics argues that government intervention may be necessary to stabilize national economies during times of economic hardship

(McKeehan 2008 4). Keynesian economics considers unemployment to be a "more serious problem than inflation," and advocates the "multiplier effect" where expenditures resonate throughout an economy (McKeehan 2008 4).

President George W. Bush signed H.R. 5140 – The Economic Growth Act of 2008 on February 1, 2008. The first of what would be a litany of Keynesian economic stimulus spending, offered a tax rebate for working families, provisions for capital expenditures made by small business, and increased government housing loan limits (Hutchison and Hughes 2008). President Obama signed the American Recovery and Investments Act H.R. 1 of 2009 on February 17, 2009. The act intended to save existing jobs and create new ones, spur economic activity through government infrastructure spending, and provide tax cuts and benefits for working families (recovery.gov 2010). Both acts evoked the Keynesian principle that a government could generate economic activity through deficit spending. The supplemental Consumer Assistance to Recycle and Save Act of 2009 (CARS) (U.S.C. 49, § 32901) signed by President Obama on June 24, 2009, built directly on the assumption that governments could spend their way out of a recession. As motor vehicles exhibit a substantial purchase price, should enough consumers opt to partake of government offered incentives, reverberations would be felt throughout the U.S. economy. Such motivations led President Obama and both houses of Congress to ratify the Consumer Assistance to Recycle and Save Act of 2009. The motivations were not exclusively intended to relieve ailing automakers, but rather, the U.S. economy as a whole.

Results

In an internal memorandum dated April 22, 2010 NHTSA Administrator David L. Strickland described the CARS program as a “remarkable success story and an example of exemplary service provided by the Federal Government to the American people in times of crisis” (2010, 1). Strickland went on to remark that the “program was highly successful in accomplishing its primary goals of stimulating the economy and aiding the environment (Strickland, 2010, 1). Table 10 details the numerical extent of the program:

Table 10: Results of the U.S. Cars Program

Component	Total
Number of participating dealerships	18,908
Number of participating states	50*
Voucher applications	690,114
Paid vouchers	677,842
Cancelled transactions	12,272
Average voucher amount	4,209
Total voucher amount	$2.85 billion
Total new vehicles sold or leased (passenger cars)	401,274
Total new vehicles sold or leased (light trucks)	274,602
Total new vehicles sold or leased (heavy trucks)	1,966
Average combined EPA fuel rating	24.9
Replaced vehicle average combined EPA fuel rating	15.8
Average difference in fuel economy	9.2
Percent of vehicles manufactured domestically	49%
Estimated increase in GDP	$3.8 to $6.8 billion
Jobs created or saved	over 60,000
Estimated reduction in fuel consumption over 25 years	824 million gallons
Estimated reduction in fuel consumption annually	33 million gallons
Estimated reduction in carbon dioxide over 25 years	9 million metric tone
Estimated social benefit of carbon dioxide reduction	$278 million

* as well as the District of Columbia, Guam, the Northern Mariana and Virgin Islands, and Puerto Rico (NHTSA, 2009, 2).

Throughout the CARS program, trade-in vehicles were primarily domestically manufactured. The majority of decommissioned vehicles came from Ford, Chevrolet, and Dodge. 46.6% percent of the new purchases came from Asian manufacturers Toyota, Honda, Nissan, and Hyundai. The discrepancy raises doubt about how fully the stimulus money went to the American economy.

Public Reception

The national news media squandered little time in touting opinions about the proposed success or failure of the CARS program. The Berkeley Electronic Press ballyhooed early estimates that the CARS program represented a "net drain on society of roughly $2,000 per vehicle" and claimed the "total welfare loss to be $1.4 billion." The same article acknowledged "the popularity of CARS should be no surprise: it gives participants a substantial gift… meanwhile the burden of the program is dispersed over a large group of taxpayers" (Abram and Parsons, 2009, 3). Others conjectured that program was designed to divert attention from the already deep intervention of the government into the U.S. automotive industry (Graham, 2009). An article entitled "Cash for Clunkers: A Retrospective" appeared in *The American* in June of 2010, and put forward the idea of a CARS type AVR program during the OPEC fuel crisis under President Carter. The article surmised the implications that such a program would have had on modern classic vehicle markets, as well as the idea that the CARS program obliterated the concept that "one man's trash is another's treasure." In the rather scathing article the author challenged that CARS "broken policy" was "an old-fashioned wealth transfer" and that "the policy allowed politicians to claim success despite failure" (Borders, 2010).

Jeffrey D. Sachs in an article for the *Scientific American* put forth “billions of dollars were spent quickly without clear answers on what we were getting for our money.” Sachs also alleged there were “countless ways to reduce CO2 emissions” that “are less expensive than smashing up autos five years before their natural demise” (Sachs, 2009). *The New American went* on to propose “consumers participate, of course, because they are able to get more money for their old cars than the old cars are worth – in many cases thousands of dollars more” (Benoit, 2009).

Albeit the 2009 U.S. CARS program had disproportionate media attention and a colossal economic cost, the brief duration of the program alongside vast government expenditures across a host other economic sectors has afforded the program little academic evaluation to date. In spite of this, a small number of assessments have been conducted. Three comprehensive examinations of the U.S. CARS program have ensued since the program’s termination that account for auto sales and jobs (economic factors,) as well as the program’s effects on the environment. A CARS synopsis reported to the House Committee on Energy and Commerce, the Senate Committee on Commerce, Science, and Transportation, as well as the House and Senate Committees on Appropriations in December of 2009 by the National Highway Traffic Safety Administration. April 2010 provided an additional CARS assessment by the U.S. Government Accountability Office. A subsequent CARS evaluation by a private government think-tank transpired in August 2010. Studies vary in degrees of agreement with NHTSA Administrator David L. Strickland’s summation that the “CARS program achieved the objectives set out by Congress to increase automotive sales and aid the environment” (Strickland, 2010, 6).

Economic Evaluation

Of the first environmental evaluations to surface regarding the CARS program was a lengthy August 13, 2009 report entitled *The Implied Cost of Carbon Dioxide under the Cash for Clunkers Program.* The analysis suggested, through slack calculation, that the program was, at best, a highly expensive way to reduce vehicle pollution (Knittel, 2009, 1). A scenario which used a computation of the highest rebate offered for a trade-in vehicle under the CARS program, $4,500, estimated that the per ton cost of saved carbon dioxide under the program was on average over $400 per ton. The average cost was reached using the following parameters:

1. $4500 rebate
2. Average VMT of 12,000 miles
3. Clunker fuel economy of 16 mpg
4. New vehicle fuel economy of 25 mpg
5. Per year savings of 270 gallons of gasoline by switching vehicles
6. Carbon Dioxide creation of 20 pounds for a burned gallon of gasoline

In determining price estimates for greenhouse gas (GHG) allowances under the Clean Energy Jobs and American Power Act, the Congressional Budget Office (CBO) estimates that the price for GHG emission allowances over the period 2011 – 2019 will cost on average $23 (CBO, 2009, 11). At a cost of $23, the analysis' preliminary projections are that the U.S. CARS program exceeded this average by approximately $375 per ton (Knittel, 2009, 3). A similar valuation of CO2 emissions reduction by Li et al., estimated the cost ranged from $91 to $295 per ton (Li et al., 2010, 6).

A more recent evaluation of the CARS program attempted to address effects on employment using a geometric decay function. Between both vehicle assembly and parts industry employment, the model found that one job-year was created for every 67 vehicles sold under the program, or 3,676 job-years total (Li et al., 2010, 28). The same study determined that CARS induced approximately .39 million-vehicle sales throughout the program's duration (Li et al., 2010, 20).

The Government Accountability Office (GAO) maintained, "the extent to which the program stimulated vehicle sales, as measured by the number of vehicle sales attributable to the CARS program, is unclear" (GAO, 2010, 13). The reason for the ambiguous nature of their analysis concerns "incremental vehicle sales," or vehicles that were sold as a direct result of the program that would not have otherwise occurred. They determine incremental vehicle sales cannot be accurately calculated (GAO, 2010, 13). Equally, the GAO maintains that the program's effect on gross domestic product is uncertain; this, too as a result of incremental vehicle sales remaining undefined (GAO, 2020, 16). The GAO speculates the lack of consensus of the CARS program's impact on employment can be attributed to incremental vehicle sales as well (GAO, 2010, 17).

Despite the near constant advertising of the CARS program's effects on the economy by President Obama and the democrat-led Congress that helped to pass the legislation, to a great extent evaluations of the program's effect on the economy remain inconclusive. Opponents argue that the program, in effect, subsidized a large number of vehicle consumers. Proponents maintain that the program preserved auto-manufacturing jobs by delaying plant closures due to an increased need for production. Despite both accusations, the central question remains – would vehicles sold throughout the duration of the CARS program have been sold without the program? Thus far, results are inconclusive.

Environmental Evaluation

Opponents of CARS argue that environmental impact of the program was abysmal. One point of contention maintains that in the absence of the program, fleet fuel economy would have improved due to previously imposed more stringent CAFE standards under the Bush administration (Huang, 2010, 2). In spite of this, Huang (2010) found that for the reason that an extra $1,000 was awarded to consumers who gained the most extreme improvements in fuel-efficiency, 7.2 percent of consumers elected to purchase vehicles with the highest fuel-efficiency ratings (Huang, 2010, 3). Such behavior produced an environmental benefit by reducing emissions (as vehicles with aged emissions were traded-in and scrapped) and a decrease in fuel consumption (Huang, 2010, 3).

Researchers at the University of Michigan's Transportation Research Institute later conducted an analysis of the effect of the CARS program on vehicle fuel economy. The study examined the average fuel economy of vehicles purchased in both July and August 2009, and found that average fuel economy improved a mere 0.6 in July 2009 and 0.7 in August 2009 (Sivak and Schottle, 2009, 4). An additional estimation determined the CARS program reduced the total gasoline consumption of trade-in vehicles by approximately 2,915 gallons – "8 days' worth of current U.S. gasoline consumption (Li et al., 2010, 23). The GAO maintains that while the CARS program succeeded in placing more fuel-efficient vehicles on the Road, the extent to which the program reduced fuel consumption is uncertain (GAO, 2010, 18).

Comparable to economic evaluations of the CARS program, estimations concerning the environmental impacts are largely inconclusive to date. We know that the CARS program eradicated nearly 700,000 vehicles from America's roadways and replaced them with vehicles that, at the very least, represented increases in fuel economy. By itself, this accomplishment should have significant impacts on environmental quality. When fuel life-cycle CO2 emissions and alleged increases in VMT are taken into consideration, supposed environmental improvements under the program may be canceled out.

Alternatives to Accelerated Vehicle Retirement

Few programs exist comparable in both scale and scope to AVR. As AVR can be implemented at various civic scales, alternatives must account for dilemmas that can arise at more than a few dimensions. To date, only two alternatives appear qualified to work in tandem or supplant AVR programs.

Inspection and Maintenance Programs

When considering the impacts of an AVR program it is common sense to ascertain how programs might work in conjunction with a vehicle inspection and maintenance (I/M) strategy. I/M programs require motorists to periodically subject their vehicles to emissions testing at a local inspection facility (Harrington et *al*., 154). Vehicle I/M strategies effectively identify the highest polluters in a vehicle fleet and enforce procedures for their repair (Yamamoto *et* *al*., 2004, 906). Whereas AVR programs induce vehicle replacement more often than not at the end of a vehicle's lifetime, I/M programs ascertain whether or not a vehicle is operating efficiently, in terms of emissions controls systems, throughout the lifetime of a vehicle. Few other mechanisms exist to ensure vehicles emissions systems are up to standard after purchase (Moghadam, 2010, 285).

The EPA has suggested that vehicle scrappage in conjunction with an I/M program can "improve program benefit and/or reduce costs" (EPA, 1993, Section VIII). Stringent I/M programs can increase vehicle scrappage (Hahn, 1995, 240). Recent evaluations of I/M programs in France dictate that vehicle owners have a propensity to keep their vehicles 20% longer on average in an area with an I/M policy, as vehicles are apt to be maintained more effectively over the course of their operable lifetime (Yamamoto *et al*., 2004, 923-924).

Apprehensions concerning the costs of conducting a vehicle I/M program, and a program's forced cost upon a local citizenry, often prevent this strategy from emerging as a convincing approach towards emissions reduction. In an examination of an Arizona I/M program, Harrington et *al*. found that owners of the oldest vehicles will suffer the most substantial repair costs under an I/M program, as older vehicles failed I/M tests most often (Harrington *et al*., 2000, 162). Such a situation generates uncertainties pertaining to fairness. Still, the same analysis found that the oldest vehicles cede the highest emissions reductions (Harrington *et al*., 2000, 162). For that reason, researchers have found that minute reductions in pollution abatement targets for I/M programs, yield substantial cost reductions (Moghadam & Livernois, 2010, 297).

Additionally, decreasing the inspection testing intervals from an annual requirement to one that takes place biannually could significantly reduce costs as well as aid in a more effective strategy for targeting high polluting vehicles (Moghadam & Livernois, 2010, 296).

As national I/M programs do not exist, and states vary greatly on the level of scrutiny applied during vehicle inspection, I/M programs cannot be viewed as a national alternative to vehicle scrappage. Rather, a continual I/M program that enforced vehicle scrappage after a certain point in an emissions control system's degradation would be preferable. As such the most effective scenario would be a vehicle scrappage program performed in union with an I/M program.

Hybrid Vehicle Purchase Tax Credit

Hybrid vehicle income tax credits were provided by the Energy Policy Act of 2005 between December 31, 2005 and December 31, 2010 (IRS, 2007). Income tax credits were provided to consumers that purchased a number of hybrid cars and several hybrid sport utility vehicles and trucks. Foreseen as an approach to effectively alter consumer purchase behavior, hybrid vehicle tax credits were available in amounts ranging from $3,100.00 to $250.00 depending on the type of vehicle purchased and that vehicle's fuel economy (IRS, 2007.) Despite the fact that a number of consumers took advantage of the tax credit, hybrid vehicle market share was a mere 3% in 2010 (Miravete and Moral, 2010, 4). Hybrid vehicles remain an anomaly in the U.S. alongside a new vehicle fleet largely dependent on gasoline propulsion. As such, consumers remain wary of new hybrid vehicle technology. Hybrid vehicle income tax credits are the closest current alternative to a vehicle scrappage program in the U.S. because they effectively disperse a cash incentive to consumers who opt to trade-in their old vehicle for a new hybrid vehicle. The difference between hybrid vehicle income tax credits and a vehicle scrappage program is that consumers claim the incentive at some point in the future (on their income tax statement) rather than at the point of sale. This delayed satisfaction may explain why more of the credits have not been utilized, and why hybrid vehicle market share remains low.

Government Performance Results Act of 1993

The Government Performance Results Act of 1993 (GPRA) required federal government agencies to formulate goals and performance monitoring plans for proposed programs within an agency's budget (Heen 2000 1). GPRA correspondingly required agencies to measure and report program outcomes to the Office of Management and Budget (OMB) and to Congress (Heen 2000 1). Congress enacted GPRA after finding:

- "waste and inefficiency in Federal programs undermine the confidence of the American people in the Government and reduces the Federal Government's ability to address adequately vital public needs;
- Federal managers are seriously disadvantaged in their efforts to improve program efficiency and effectiveness, because of insufficient articulation of program goals and inadequate information on program performance; and

- Congressional policymaking, spending decisions and program oversight are seriously handicapped by insufficient attention to program performance and results (U.S. Congress 103-62).

The Government Performance Results Act had a number of purposes including:

- to “improve the confidence of the American people in the capability of the Federal Government, by systematically holding Federal agencies accountable for achieving program results;”
- to “initiate program performance reform with a series of pilot projects in setting program goals, measuring program performance against those goals, and reporting publicly on their progress;”
- to “improve Federal program effectiveness and public accountability by promoting a new focus on results, service quality, and customer satisfaction;”
- to “help Federal managers improve service delivery, by requiring that they plan for meeting program objectives and by providing them with information about program results and service quality;”
- to “improve congressional decision making by providing more objective information on achieving statutory objectives, and on the relative effectiveness and efficiency of Federal programs and spending; and”
- to “improve internal management of the Federal Government” (U.S. Congress 103-62).

All agencies of the federal government, including independent agencies and agencies classified as government corporations, are bound by GPRA. The

Legislative Branch, Judicial Branch, Central Intelligence Agency, Panama Canal Commission, and the Postal Rate Commission are not required to follow GPRA guidelines. As well, the Postal Service has separate GPRA requirements (OMB Watch 2002).

GPRA requires government agencies to formulate three plans including:

- a strategic plan
- a performance plan, and
- performance results (OMB Watch 2002).

Strategic Plan

GPRA requires agencies to develop a strategic plan. The strategic plan must include the following:

- a comprehensive mission statement covering the major functions and operations of the agency;
- general goals and objectives, including outcome-related goals and objectives, for the major functions and operations of the agency;
- a description of how the goals and objectives are to be achieved, including a description of the operational processes, skills and technology, and the human, capital, information, and other resources required to meet those goals and objectives;
- a description of how the performance goals included in the plan shall be related to the general goals and objectives in the strategic plan;

- an identification of those key factors external to the agency and beyond its control that could significantly affect the achievement of the general goals and objectives; and
- a description of the program evaluations used in establishing or revising general goals and objectives, with a schedule for future program evaluations" (US Congress 103-62)

The formulation of a strategic plan, as outlined by GPRA, could have positive effects on implementation of AVR programs at various scales. The clear wording and precise requirements outlined by the GPRA strategic plan are in place to ensure both a minimal margin of error and program transparency. Both elements are essential to an AVR program's success. As well, GPRA requires that in developing a strategic plan, government agencies consult with Congress and solicit input from outside stakeholders who might be affected by the plan (OMB Watch 2002).

Performance Plan

GPRA also requires agencies to develop an annual performance plan. The performance plan requires agencies to do the following:

- "establish performance goals to define the level of performance to be achieved by a program activity;
- express such goals in an objective, quantifiable, and measurable form
- briefly describe the operational processes, skills and technology, and the human, capital, information, or other resources required to meet the performance goals;

- establish performance indicators to be used in measuring or assessing the relevant outputs, service levels, and outcomes of each program activity;
- provide a basis for comparing actual program results with the established performance goals; and
- describe the means to be used to verify and validate measured values" (U.S. Congress 103-62).

Performance plans, as required by GPRA, can aid AVR programs in attaining established objectives. In setting numerical goals, the performance plan, can help an agency or program ascertain whether or not a program has been successful and provide opportunity to modify a program while the program is in action. The requirement of performance plans to "establish performance indicators to be used in measuring… outcomes" of a program can help AVR programs to correctly define attainable objectives.

Performance Reports

To ascertain the execution of both strategic and performance plans, required by GPRA, performance reports are to be published. The performance report is required to accomplish the following:

- "review the success of achieving the performance goals of the fiscal year;
- evaluate the performance plan for the current fiscal year relative to the performance achieved toward the performance goals in the fiscal year covered by the report;

- explain and describe, where a performance goal has not been met (including when a program activity's performance is determined not to have met the criteria of a successful program activity or a corresponding level of achievement if another alternative form is used)
  - why the goal was not met;
  - those plans and schedules for achieving the established performance goal; and
  - if the performance goal is impractical or infeasible, why that is the case and what action is recommended;
- describe the use and assess the effectiveness in achieving performance goals of any waiver
- include the summary findings of those program evaluations completed during the fiscal year covered by the report" (U.S. Congress 103-62)

Performance reports can be instrumental in evaluating the success of an AVR program. An AVR performance plan would detail those actions applied correctly by an AVR and determine why any actions failed.

The Government Performance Results Act of 1993 can be an essential evaluation tool when applied to an AVR program. GPRA requires that an agency clearly define strategic goals and objectives prior to a plan's implementation. Clearly defined objectives are elusive in some AVR programs. As well, GPRA was not applied to the 2009 U.S. CARS program for reasons unknown. Though, not all AVR programs transpire domestically, the U.S. GPRA provides a template for determining an efficient course of action that accounts for varying outcomes, and evaluating unintended consequences.

SYNTHESIS OF LITERATURE

Planners and policymakers are tasked with reducing environmental and economic consequences that stem from a society travel-dependent on motor vehicles. An often-implemented solution to correct ills generated by older vehicles still in operation is Accelerated Vehicle Retirement (AVR). Over fifty domestic and international AVR programs have been executed since 1990, including the 2009 U.S. CARS program, the largest such program to date.

Economic and environmental theories abound concerning how to most effectively conduct an AVR program. The advantages and detriments of an AVR scheme have direct effects on consumers as well as the economy and environment as a whole. A sizeable catalogue of past AVR programs exists as an instrument for framing an effective AVR policy. As well the Government Performance Act of 1993 provides a template for monitoring a program's efficacy prior to and throughout AVR implementation.

Vehicle retirement programs can expeditiously modify entire vehicle fleets for both environmental and economic purposes. However, objectives vary across vehicle retirement programs. AVR implementation has occurred on diverse national and urban scales, backed with various motivations. Design of AVR programs has not been methodical. As evaluation is an essential part of government planning, given the lack of an accepted framework for AVR program design, this research has considered how various AVR objectives might be characterized to aid in developing a framework for future AVR programs. This research will attempt to answer the following research questions:

- What categorizations can be made concerning articulated objectives of past accelerated vehicle retirement programs
- How can characterizations of the objectives and outcomes of past Accelerated Vehicle Retirements programs be use to formulate an implementation criteria that addresses both economic expectations and also environmental regulation at varying civic scales?
- What performance measures would ensure that an Accelerated Vehicle Retirement program attained defined objectives while minimizing causal burdens?

METHODOLOGY

Accelerated Vehicle Retirement (AVR) programs have been implemented as a means to removing a large number of older vehicles, which produce an excessive amount of vehicle emissions, from the vehicle fleet. Over fifty AVR programs have taken place since 1990. Vehicle scrappage programs place varying levels of emphasis on factors affecting program performance and articulated objectives, which results in varying outcomes. While design of an AVR program is a product of intended objective, commonalities exist between programs. In order to create a framework for designing an accelerated vehicle retirement program multiple methods are required.

Content Analysis

To determine what categorizations can be made concerning articulated objectives of past accelerated vehicle retirement programs, data was obtained from a number of resources. Content analysis was utilized to mine the data for the following:

- Order and type of articulated objective
- Program performance
- Scale of program, and
- Factors affecting program performance

The data was compiled in an Excel document. Content analysis was then performed on the collected data to identify patterns in programs' specified objectives. The analysis provided a way to characterize specified objectives, determine scale, and enumerate program outcomes. Furthermore, content analysis afforded a method to categorize stated program goals for various programs as a means of characterizing major themes across programs. While each program exhibited a primary goal, many programs presented secondary goals. Several programs revealed tertiary goals. From this analysis a framework was constructed for AVR based on categorizations of articulated objectives.

Population

Seventy-five past AVR programs were identified through the literature review. This comprehensive population is warranted to ascertain impacts of scale, as the programs took place in varying localities. To capture a wide range of program structures, initially the population was not further narrowed. Due to time constraints and issues with data availability, once a more general analysis of all 75 programs was complete a smaller group samples were utilized to provide a more in-depth analysis of AVR.

Statistical Analysis

Once characterizations of past AVR programs were made, statistical analysis was performed on the data to determine correlations and dependencies among program variables. Statistical analysis was performed using the following variables:

- Monetary (interval-ratio)
- Minimum and Maximum Participant Incentive (interval-ratio)
- Total Program Investment (interval-ratio)

- Number of Vehicles Retired (interval-ratio)
- Program Duration (interval-ratio)
- Minimum Vehicle Age Requirement (interval-ratio)
- Spatial Scale of Implementation (ordinal,) and
- Order and Type of Objective (nominal)

Hypothesis testing techniques applied to the identified variables included t-testing, Pearson's *R* correlation tests, and chi-squared tests related to program objectives. Once t-test and chi-squared tests were preformed across all 75 programs, a framework was devised based on the analysis.

Environmental Scrutiny

As there remains discrepancy over the cost of a carbon per ton across various nations, scientific communities, and research, a more general approach was taken to examine the environmental benefit/detriment of AVR programs. This examination involved taking various factors affecting program performance and testing those against program's that provided data for the total emissions (tons) reduction. Though air quality is impacted by a number of other factors including both stationary sources and also climate, the examination allowed for a general picture of what affects an AVR program might have on reducing vehicle emissions.

Framework Design

Once content analysis, statistical analysis, and environmental inquiries were complete, a framework for AVR was constructed utilizing the Government Performance and Results Act. Utilizing GPRA criteria as a template for an AVR framework helped to determine how it might endure under performance monitoring stipulations. In developing the framework, selected objectives were looked at in conjunction with accompanying factors affecting program performance.

A mixed methodology of content and statistical analysis served to yield the most in-depth analysis possible, within time and economic constraints, for a large population of identified programs. The methodology also allowed programs that lacked data for a given variable used in one analysis, to be included in an analysis for which data was available.

ANALYSIS

Data analysis reveals much about the structure of past Accelerated Vehicle Retirement (AVR) programs. By means of two distinct methods of research (content analysis and statistical analysis,) the data was combined to formulate a framework for future AVR programs. A number of tables are used at the outset of the analysis as a means of grouping components of past programs, and to provide a previously unavailable conglomeration of past program data.

Programs

AVR programs have been utilized in various locations for the purpose of attaining a number of goals since the early 1990s. At least seven such programs were introduced in California beginning in 1990, along with others in Delaware, Colorado, Illinois, Texas, and Maine. European Union (EU) countries made use of AVR programs throughout the mid-1990s. Deluges of new programs were employed globally in years 2009 and 2010, coinciding with the global economic recession.

Seventy-five past AVR programs were identified by means of content analysis of past program implementation document, legal statutes, and past reviews and research of completed AVR programs. As there is no current clearinghouse for information on past AVR programs, this research will serve as a database for future research. Throughout the data collection and content analysis process, Google translator was employed in order to appraise documents that were in languages other than English. As well, currency converters were employed to convert foreign currencies to U.S. dollars in order to aid the evaluation process.

Program Subgroups

Attributable to inconsistencies in the way data was recorded throughout assorted waves of AVR implementations, it was prudent to categorize AVR programs into several subgroups including:

- Group 1: National Programs (2009 – 2010)
- Group 2: California Programs (1990 – 2010)
- Group 3: U.S. State-Based Programs (1992 – 2010)
- Group 4: Canadian Programs (1996 – 2002), and
- Group 5: National Programs (1992 – 2000)

Tables 11 thru 15 depict programs assigned to each subgroup through content analysis:

Table 11: Group 1 National Programs (2009 – 2010)

	Country
1	Austria
2	Canada
3	Cyprus
4	Cyprus
5	France
6	France
7	France
8	Germany
9	Greece
10	Italy
11	Ireland
12	Japan
13	Luxembourg
14	The Netherlands
15	Portugal
16	Portugal
17	Romania
18	Russia
19	Slovakia
20	Slovakia
21	Spain
22	Spain
23	United Kingdom
24	United States

Table 12: Group 2 California Programs (1990 – 2010)

	Program
1	Unocal South Coast Recycled Auto Program (SCRAP)
2	Unocal South Coast Recycled Auto Program (SCRAP II)
3	Unocal South Coast Recycled Auto Program (SCRAP III)
4	Unocal South Coast Recycled Auto Program (SCRAP IV)
5	Old Car buyback program
6	Old Car buyback program
7	Old Car buyback program
8	California Air Resources Board Pilot Program
9	Consumer Assistance Program
10	Consumer Assistance Program
11	Consumer Assistance Program
12	Consumer Assistance Program
13	Consumer Assistance Program
14	Consumer Assistance Program
15	Consumer Assistance Program
16	REMOVE Program Phase I
17	REMOVE Program Phase II
18	REMOVE Program Phase III
19	REMOVE Program Phase IV
20	REMOVE Program Phase V
21	REMOVE Program Phase VI
22	REMOVE Program Phase VII
23	REMOVE Program Phase VIII
24	Vehicle Buy-Back Program
25	Vehicle Buy-Back Program
26	Bay Area Air Quality Management District vehicle buyback
27	Bay Area Air Quality Management District vehicle buyback
28	Bay Area Air Quality Management District vehicle buyback
29	High Emitter or Scrap I (HEROS)
30	Old Car Buyback and Scrap Program

Table 13: Group 3 U.S. State-Based Programs (1992 – 2010)

	Program	Location
1	Delaware Vehicle Retirement Program	Delaware
2	Total Clean Cars Program	Denver, CO
3	Illinois EPA	Chicago, IL
4	Drive a Clean Machine	Texas*
5	High Pollution Vehicle Retirement Pilot Program	Maine

Table 14: Group 4 Canadian Programs (1996 – 2002)

	Program	Location
1	Scrap-It Pilot Program	British Columbia
2	Scrap-It Program	British Columbia
3	Alberta Clean Air Scrappage Pilot Project	Calgary

Table 15: Group 5 National Programs (1992 – 2000)

	Country
1	Denmark
2	France
3	France
4	France
5	Greece
6	Hungary
7	Spain
8	Spain
9	Ireland
10	Norway
11	Italy
12	Italy
13	Argentina

Scale of Implementation

The scale of past AVR programs can be categorized by means of three distinct measures: spatial, monetary, and outcome. The only ordinal variable in the group, spatial scale, applies to the level of population where a given AVR program was executed. Monetary scale yields three interval-ratio categories: amount of investment, low incentive amount, and high incentive amount. Incentive amount produced two categorizations, as often there were ranges of incentive amounts to be earned (i.e. the U.S. CARS program offered incentives between $3,500 and $4,500 U.S. dollars.) Finally, scale of program outcome related to the total number of vehicles retired in a given program.

Spatial Scale

Table 16: Spatial Scale Group 1

	Country	*Population*		*Country*	*Population*
1	Austria	8214160	13	Luxembourg	497538
2	Canada	33759742	14	The Netherlands	16783092
3	Cyprus	1102677	15	Portugal	10735765
4	Cyprus	1102677	16	Portugal	10735765
5	France	64768389	17	Romania	21959278
6	France	64768389	18	Russia	139390205
7	France	64768389	19	Slovakia	5470306
8	Germany	82282988	20	Slovakia	5470306
9	Greece	10749943	21	Spain	46505963
10	Italy	58090681	22	Spain	46505963
11	Ireland	4622917	23	United Kingdom	62348447
12	Japan	126804433	24	United States	310232863

(*See Appendix A for citations*)

Table 17: Spatial Scale Group 2

	Program	*Population*
1	Unocal South Coast Recycled Auto Program (SCRAP)	8,863,000
2	Unocal South Coast Recycled Auto Program (SCRAP II)	9,208,100
3	Unocal South Coast Recycled Auto Program (SCRAP III)	9,280,600
4	Unocal South Coast Recycled Auto Program (SCRAP IV)	9,327,300
5	Old Car buyback program	386,108 (1996)
6	Old Car buyback program	401,690 (2001)
7	Old Car buyback program	402,025 (2009)
8	California Air Resources Board Pilot Program	9,437,290 (1999)
9	Consumer Assistance Program	34,507,030 (2001)
10	Consumer Assistance Program	34,507,030 (2001)
11	Consumer Assistance Program	35,885,415 (2005)
12	Consumer Assistance Program	36,377,534 (2007)
13	Consumer Assistance Program	36,756,666 (2008)
14	Consumer Assistance Program	36,961,664 (2009)
15	Consumer Assistance Program	36,961,664 (2009)
16	REMOVE Program Phase I	3,326,552 (2000)
17	REMOVE Program Phase II	3,326,552 (2000)
18	REMOVE Program Phase III	3,326,552 (2000)
19	REMOVE Program Phase IV	3,326,552 (2000)
20	REMOVE Program Phase V	3,326,552 (2000)
21	REMOVE Program Phase VI	3,326,552 (2000)
22	REMOVE Program Phase VII	3,326,552 (2000)
23	REMOVE Program Phase VIII	3,326,552 (2000)
24	Vehicle Buy-Back Program	3,326,552 (2000)
25	Vehicle Buy-Back Program	3,326,552 (2000)
26	Bay Area Air Quality Management District vehicle buyback program	7,014,896 (2005)
27	Bay Area Air Quality Management District vehicle buyback program	7,427,757 (2009)
28	Bay Area Air Quality Management District vehicle buyback program	7,427,757 (2009)
29	High Emitter or Scrap I (HEROS)	16,800,000
30	Old Car Buyback and Scrap Program	265, 297(July 2008)

(*See Appendix A for citations*)

Table 18: Spatial Scale Group 3

	Program	Population (2009)
1	Delaware Vehicle Retirement Program	863,832
2	Total Clean Cars Program	582,447
3	Illinois EPA	2,824,064
4	Drive a Clean Machine	6,002,550*
5	High Pollution Vehicle Retirement Pilot Program	1,274,923

*Dallas-Ft. Worth, Austin-Round Rock, and Houston-Galveston-Brazoria Metropolitan Statistical Areas

(*See Appendix A for citations*)

Table 19: Spatial Scale Group 4

	Program	Population
1	Scrap-It Pilot Program	4011375 (1999)
2	Scrap-It	4530960 (2010)
3	Alberta Clean Air Scrappage Pilot Project	1022000 (2000)

(*See Appendix A for citations*)

Table 20: Spatial Scale Group 5

	Country	Population (July 2010 est.)
1	Denmark	5,515,575
2	France	64,768,389
3	France	64,768,389
4	France	64,768,389
5	Greece	10,749,943
6	Hungary	9,992,339
7	Spain	46,505,963
8	Spain	46,505,963
9	Ireland	4,622,917
10	Norway	4,676,305
11	Italy	58,090,681
12	Italy	58,090,681
13	Argentina	41,343,201

(*See Appendix A for citations*)

Monetary Scale

A program's monetary scale can be itemized as one of 3 distinct classifications. Classifications include: the total dollar amount invested in a program, a program's minimum incentive offered to participants, and the maximum incentive offered to program participants. Design of past AVR programs often dictated a range of incentive amounts available to participants. For categorization purposes the amounts were grouped as minimum and maximum. When only one incentive amount was known, the figure was labeled as the "maximum" incentive available. Throughout tables 21- 25, blank shaded boxes denote unknown investment and incentive amounts. For group 5, only one program, Hungary, had a known investment amount. All values have been converted from local currency to U.S. dollars.

Table 21: Monetary Scale Group 1

	Program	*Investment*	*Minimum Incentive*	*Maximum Incentive*
1	Austria	61,130,257.0		2037.00
2	Canada	93,216,474.9		303.90
3	Cyprus	11,546,826.0	349.00	2322.00
4	Cyprus	2,716,900.30		2400.00
5	France	795,340,274.2		1358.00
6	France	428,792,147.8*		950.00
7	France	428,792,147.8*		679.00
8	Germany	6,792,250,856.8		3396.00
9	Greece	No budget	679.00	2988.00
10	Italy	1,600,000,000.00	2037.00	9509.00
11	Ireland	2590800 **		2037.00
12	Japan	4,500,942,655.00		3041.00
13	Luxembourg	13,584,501.00	2037.00	2377.00
14	The Netherlands	169,806,271.40	1000.00	2330.00
15	Portugal	30,565,128.85***	1698.00	2037.00
16	Portugal	30,565,128.85***	1358.00	1698.00
17	Romania	229,578,078.90		1212.00
18	Russia	713,875,333.00		1699.00
19	Slovakia	45,100,545.60	1358.00	2037.00
20	Slovakia	30,021,748.70	1358.00	2716.00
21	Spain	1,358,450,171.30		2,716****
22	Spain	328,344,000.00	679.00	2716.00
23	United Kingdom	644,379,720.00		3221.00
24	United States	3,200,000,000.00	3500.00	4500.00

* France = 857,584,295.7 ÷ 2 (857584295.7 total dollars were allocated for both programs)
** Ireland = 1,500 × the number of vehicles scrapped (however, program was largely revenue neutral as incentive amount was tied to a taxation decrease)
*** Portugal = 61,130,257.70 ÷ 2 (61,130,257.70 total dollars were allocated for both programs.
**** Interest free loan up to $13,300
(*See Appendix A for citations*)

Table 22: Monetary Scale Group 2

	Program	Investment	Minimum	Maximum
1	Unocal South Coast Recycled Auto Program (SCRAP)	5,000,000		700
2	Unocal South Coast Recycled Auto Program (SCRAP II)	775,000		700
3	Unocal South Coast Recycled Auto Program (SCRAP III)			700
4	Unocal South Coast Recycled Auto Program (SCRAP IV)			600
5	Old Car buyback program	930,000		500
6	Old Car buyback program	250,000		500
7	Old Car buyback program	~1,000,000	800	1000
8	California Air Resources Board Pilot Program	1,000,000		500
9	Consumer Assistance Program			450
10	Consumer Assistance Program	38,000,000		1000
11	Consumer Assistance Program			1000
12	Consumer Assistance Program	21,000,000		1000
13	Consumer Assistance Program	30,000,000		1000
14	Consumer Assistance Program	41,000,000		1000
15	Consumer Assistance Program	46,139,000		1000
16	REMOVE Program Phase I	3,665,200	400	600
17	REMOVE Program Phase II	4,773,814	400	600
18	REMOVE Program Phase III	3,594,486	400	600
19	REMOVE Program Phase IV	2,688,311	400	600
20	REMOVE Program Phase V	5,309,952	400	600
21	REMOVE Program Phase VI	2,556,403	400	600
22	REMOVE Program Phase VII	2,422,741	400	600
23	REMOVE Program Phase VIII	1,210,648	400	600
24	Vehicle Buy-Back Program	1,000,000		500
25	Vehicle Buy-Back Program	1,000,000		500
26	Bay Area Air Quality Management District vehicle buyback program	~58,500,000*		500
27	Bay Area Air Quality Management District vehicle buyback program	~13,000,000*		650
28	Bay Area Air Quality Management District vehicle buyback program	6,800,000		1000
29	High Emitter or Scrap I (HEROS)	4,000,000		1000
30	Old Car Buyback and Scrap Program	200,000		800

* 6.5 million per year (*See Appendix A for citations)*

Table 23: Monetary Scale Group 3

	Program	Investment	Minimum	Maximum
1	Delaware Vehicle Retirement Program			500
2	Total Clean Cars Program	500,000.0		1,000
3	Illinois EPA		647	902
4	Drive a Clean Machine	133,753,331.2	3,000	3,500
5	High Pollution Vehicle Retirement Pilot Program	178,517.0	1,000	2,000

(*See Appendix A for citations)*

Table 24: Monetary Scale Group 4

	Program	Investment	Minimum	Maximum
1	Scrap-It Pilot Program		504	757
2	Scrap-It		504*	1009*
3	Alberta Clean Air Scrappage Pilot Project			500**

* $504 toward the purchase of a bicycle (50% of purchase price to maximum)
$504 toward a 1988 or newer vehicle
$756 toward 14 months of a 1-zone transit pass
$757 toward a new vehicle
$757 toward vanpooling
$780 toward 10 months of a 2-zone transit pass
$824 toward 8 months of a 3-zone transit pass
$1009 toward a new natural gas vehicle
**12 free consecutive monthly transit passes ($504 value)

(*See Appendix A for citations)*

Table 25: Monetary Scale Group 5

	Country	Investment	Minimum	Maximum
1	Denmark			1184.12
2	France			413
3	France			1033
4	France		1033	1446
5	Greece			
6	Hungary	454,000		506.56
7	Spain		692.97	814.55
8	Spain		692.97	814.55
9	Ireland			1610.40
10	Norway			864
11	Italy		1049	1399
12	Italy		874	1049
13	Argentina	520,946,723.97	996	4,482

(See Appendix A for citations)

Scale of Outcome

The number of vehicles retired in each program varied considerably. A number of variables that may have influenced fluctuations of a program's direct outcome will be discussed throughout the analysis. Tables 26 thru 31 detail the scale of results for each program:

Table 26: Scale of Outcome Group 1

	Country	*Number of Vehicles Retired*
1	Austria	30,000
2	Canada	118,980
3	Cyprus	10,039
4	Cyprus	1,100
5	France	600,000
6	France	200,000
7	France	300,000
8	Germany	2,000,000
9	Greece	70,000
10	Italy	856,000
11	Ireland	17,272
12	Japan	748,000
13	Luxembourg	52000
14	The Netherlands	56,900
15	Portugal	32,500
16	Portugal	8,875
17	Romania	190,000
18	Russia	230,000
19	Slovakia	22,100
20	Slovakia	22,100
21	Spain	260,000
22	Spain	70,000
23	United Kingdom	400,000
24	United States	677, 842

(*See Appendix A for citations*)

Table 27: Scale of Outcome Group 2

	Program	*Number of Vehicles Retired*
1	Unocal South Coast Recycled Auto Program (SCRAP)	8367
2	Unocal South Coast Recycled Auto Program (SCRAP II)	502
3	Unocal South Coast Recycled Auto Program (SCRAP III)	335
4	Unocal South Coast Recycled Auto Program (SCRAP IV)	11167
5	Old Car buyback program 1	1,200
6	Old Car buyback program 2	350
7	Old Car buyback program 3	1,400
8	California Air Resources Board Pilot Program	1,001
9	Consumer Assistance Program 1	7,000
10	Consumer Assistance Program 2	34,003
11	Consumer Assistance Program 3	~4000
12	Consumer Assistance Program 4	16,900
13	Consumer Assistance Program 5	21,909
14	Consumer Assistance Program 6	22,331
15	Consumer Assistance Program 7	45,000
16	REMOVE Program Phase I	
17	REMOVE Program Phase II	
18	REMOVE Program Phase III	
19	REMOVE Program Phase IV	
20	REMOVE Program Phase V	
21	REMOVE Program Phase VI	
22	REMOVE Program Phase VII	
23	REMOVE Program Phase VIII	
24	Vehicle Buy-Back Program	~2,100
25	Vehicle Buy-Back Program	~2,100
26	BAAQMD vehicle buyback	24,300
27	BAAQMD vehicle buyback	5,400
28	BAAQMD vehicle buyback	15,600
29	High Emitter or Scrap I (HEROS)	370
30	Old Car Buyback and Scrap Program	200

(*See Appendix A for citations*)

Table 28: Scale of Outcome Group 3

	Program	*Number of Vehicles Retired*
1	Delaware Vehicle Retirement Program	125
2	Total Clean Cars Program	271
3	Illinois EPA	207
4	Drive a Clean Machine	41,671
5	High Pollution Vehicle Retirement Pilot Program	62

(*See Appendix A for citations)*

Table 29: Scale of Outcome Group 4

	Program	*Number of Vehicles Retired*
1	Scrap-It Pilot Program	1,000
2	Scrap-It	25000 *
3	Alberta Clean Air Scrappage Pilot Project	600

* As of 7/1/2010
(*See Appendix A for citations*)

Table 30: Scale of Outcome Group 5

	Program	*Number of Vehicles Retired*
1	Denmark	Unknown*
2	France	
3	France	750,000**
4	France	750,000**
5	Greece	59,540
6	Hungary	~150,000
7	Spain	211,000
8	Spain	146,000
9	Ireland	59540
10	Norway	150,000
11	Italy	1,148,000
12	Italy	
13	Argentina	103,532

*100,000 in first 6 months, though program lasted nearly a year and a half.
**1,500,000 for both programs
(*See Appendix A for citations*)

Program Duration

Program duration was calculated by first finding the number of days between a program's start and end date. The number of days between a program's start and end date was then divided by 30.5 - the approximate average number of days in a given month. Duration values represent the approximate number of months of a program's tenure. Several programs are ongoing and were analyzed based on program performance thus far. When a program was ongoing an end date of 3/1/2011 was used. For an exact list of program dates, see Table 6.

Table 31: Program Duration Group 1

	Country	*Duration (Months)*
1	Austria	8.23
2	Canada	25.42
3	Cyprus	7.84
4	Cyprus	2.03
5	France	12.65
6	France	5.81
7	France	5.90
8	Germany	11.32
9	Greece	1.06
10	Italy	10.55
11	Ireland	11.71
12	Japan	9.19
13	Luxembourg	8.13
14	The Netherlands	18.74
15	Portugal	7.00
16	Portugal	4.70
17	Romania	9.10
18	Russia	9.60
19	Slovakia	0.50
20	Slovakia	8.70
21	Spain	21.60
22	Spain	11.60
23	United Kingdom	10.80
24	United States	1.70

(*See Appendix A for citations)*

Table 32: Program Duration Group 2

	Program	Duration
1	Unocal South Coast Recycled Auto Program (SCRAP)	4.48
2	Unocal South Coast Recycled Auto Program (SCRAP II)	
3	Unocal South Coast Recycled Auto Program (SCRAP III)	
4	Unocal South Coast Recycled Auto Program (SCRAP IV)	
5	Old Car buyback program	35.32
6	Old Car buyback program	39.26
7	Old Car buyback program	58.87
8	California Air Resources Board Pilot Program	12.71
9	Consumer Assistance Program	41.16
10	Consumer Assistance Program	5.90
11	Consumer Assistance Program	47.10
12	Consumer Assistance Program	11.74
13	Consumer Assistance Program	11.74
14	Consumer Assistance Program	7.16
15	Consumer Assistance Program	22.26
16	REMOVE Program Phase I	11.77
17	REMOVE Program Phase II	11.77
18	REMOVE Program Phase III	11.77
19	REMOVE Program Phase IV	11.77
20	REMOVE Program Phase V	11.77
21	REMOVE Program Phase VI	11.77
22	REMOVE Program Phase VII	11.77
23	REMOVE Program Phase VIII	11.77
24	Vehicle Buy-Back Program	11.77
25	Vehicle Buy-Back Program	11.77
26	Bay Area Air Quality Management District vehicle buyback	171.81
27	Bay Area Air Quality Management District vehicle buyback	116.94
28	Bay Area Air Quality Management District vehicle buyback	35.32
29	High Emitter or Scrap I (HEROS)	23.52
30	Old Car Buyback and Scrap Program	22.55

(*See Appendix A for citations*)

Table 33: Program Duration Group 3

	Program	Duration
1	Delaware Vehicle Retirement Program	12
2	Total Clean Cars Program	0.5
3	Illinois EPA	12
4	Drive a Clean Machine	35.3
5	High Pollution Vehicle Retirement Pilot Program	11.1

(*See Appendix A for citations*)

Table 34: Program Duration Group 4

	Program	Duration
1	Scrap-It Pilot Program	332.38
2	Scrap-It	142.58
3	Alberta Clean Air Scrappage Pilot Project	12.09

(*See Appendix A for citations*)

Table 35: Program Duration Group 5

	Program	Duration
1	Denmark	17.58
2	France	
3	France	16.58
4	France	12.74
5	Greece	26.45
6	Hungary	4.94
7	Spain	5.90
8	Spain	6.84
9	Ireland	35.16
10	Norway	11.77
11	Italy	8.77
12	Italy	7.77
13	Argentina	19.45

(*See Appendix A for citations)*

Minimum Vehicle Age Requirement

Past AVR programs stipulate that age of a vehicle must be at least a certain specified age in order to be eligible to participate in a given program. Minimum vehicle age values represent the minimum allowable age a of a vehicle to participate.

Table 36: Minimum Vehicle Age Group 1

	Country	*Minimum Vehicle Age*
1	Austria	13.0
2	Canada	15.0
3	Cyprus	15.0
4	Cyprus	15.0
5	France	10.0
6	France	10.0
7	France	10.0
8	Germany	9.0
9	Greece	9.0
10	Italy	9.0
11	Ireland	10.0
12	Japan	13.0
13	Luxembourg	10.0
14	The Netherlands	9.0
15	Portugal	10.0
16	Portugal	8.0
17	Romania	13.0
18	Russia	10.0
19	Slovakia	10.0
20	Slovakia	10.0
21	Spain	10.0
22	Spain	10.0
23	United Kingdom	10.0
24	United States	8

(*See Appendix A for citations*

Table 37: Minimum Vehicle Age Group 2

	Program	Min. Vehicle Age
1	Unocal South Coast Recycled Auto Program (SCRAP)	18.0
2	Unocal South Coast Recycled Auto Program (SCRAP II)	21.0
3	Unocal South Coast Recycled Auto Program (SCRAP III)	22.0
4	Unocal South Coast Recycled Auto Program (SCRAP IV)	21.0
5	Old Car buyback program	21.0
6	Old Car buyback program	26.0
7	Old Car buyback program	14.0
8	California Air Resources Board Pilot Program	18.0
9	Consumer Assistance Program	Not Applicable*
10	Consumer Assistance Program	Not Applicable*
11	Consumer Assistance Program	Not Applicable*
12	Consumer Assistance Program	Not Applicable*
13	Consumer Assistance Program	Not Applicable*
14	Consumer Assistance Program	Not Applicable*
15	Consumer Assistance Program	Not Applicable*
16	REMOVE Program Phase I	11.0
17	REMOVE Program Phase II	12.0
18	REMOVE Program Phase III	13.0
19	REMOVE Program Phase IV	14.0
20	REMOVE Program Phase V	15.0
21	REMOVE Program Phase VI	16.0
22	REMOVE Program Phase VII	17.0
23	REMOVE Program Phase VIII	18.0
24	Vehicle Buy-Back Program	19.0
25	Vehicle Buy-Back Program	20.0
26	Bay Area Air Quality Management District vehicle buyback	12.0
27	Bay Area Air Quality Management District vehicle buyback	22.0
28	Bay Area Air Quality Management District vehicle buyback	20.0
29	High Emitter or Scrap I (HEROS)	Not Applicable*
30	Old Car Buyback and Scrap Program	19.0

*Not a requirement, instead must fail smog check
(*See Appendix A for citations*)

Table 38: Minimum Vehicle Age Group 3

	Program	Minimum Vehicle Age
1	Delaware Vehicle Retirement Program	12.0
2	Total Clean Cars Program	12.0
3	Illinois EPA	13.0
4	Drive a Clean Machine	10.0
5	High Pollution Vehicle Retirement Pilot Program	13.0

(*See Appendix A for citations*)

Table 39: Minimum Vehicle Age Group 4

	Program	Minimum Vehicle Age
1	Scrap-It Pilot Program	9.0
2	Scrap-It	4.0
3	Alberta Clean Air Scrappage Pilot Project	13.0

(*See Appendix A for citations*)

Table 40: Minimum Vehicle Age Group 5

	Program	Minimum Vehicle Age
1	Denmark	
2	France	
3	France	10.0
4	France	8.0
5	Greece	10.0
6	Hungary	Not applicable
7	Spain	10.0
8	Spain	7.0
9	Ireland	10.0
10	Norway	10.0
11	Italy	Not applicable
12	Italy	Not applicable
13	Argentina	10.0

(*See Appendix A for citations*)

Factors Affecting Program Performance

Five factors affecting program performance are detailed in tables 6 - 20 including:

- Total Monetary Investment
- Minimum Participant Incentive Amount
- Maximum Participant Incentive Amount
- Program Duration, and
- Minimum Vehicle Age Requirement.

As each factor can be measured at the interval-ratio level, statistical techniques were employed to determine correlations between variables. By means of calculating Pearson's r, the coefficient of determination (r^2,) and the slope between different variables, the analysis sought to answer three questions: Is there a relationship between the variables? How strong is the relationship? What is the direction of the relationship? Calculations are summarized for each variable across all groups in Tables 41-51 and by program subgroup in Appendix *B.*

Pearson's *r*, or the correlation coefficient, is a measure of the association between to interval-ratio variables and varies from 0.00 to ±1.00. A value of 0.00 indicates no association. A value of ±1.00 would indicate a perfect positive or negative relationship. How closely a measure approaches the extremes can be described as "weak" or "strong." The coefficient of determination can be interpreted as how much our *x* variable increases our facility to predict or explain *y.* Finally, our calculated slope (*b*) indicates that for each unit change in *x* there is an increase or decrease of *b* units in *y* (Healey 2005 402-409).

Because data available on factors affecting program performance is based on data from a random sample from all AVR programs, it is necessary to test our calculated *r* values for significance. For all inspections we assume: random sampling, an interval-ratio level of measurement, bivariate normal distributions, a linear relationship, homoscedasticity, and that our sampling distribution is normal. Our null hypothesis is that there is no linear association between the two variables in the population from which the sample was drawn. Our sampling distribution is a *t* distribution, with an Alpha of 0.05. After measures of association were calculated, each measure was then tested for significance.

Interrogating the relationship between monetary factors can help determine whether or not the benefit of conducting a program was commensurate with the cost of a given program, in terms of the total cost and participant incentive amounts. Investigating the relationship between minimum vehicle age requirement and other factors can help to determine the appropriate vehicle age stipulation for future programs. Finally, exploring the relationship between program duration and other factors can help to determine the appropriate length of an AVR program. The following analysis scrutinizes each factor across all programs in order to gauge a program's effectiveness. The relationship between two given variables will be analyzed one time. As our investigations progress, each new table will fail to repeat an analysis explained in a previous section.

Number of Vehicles Retired

Intuitively, all AVR programs endeavor to retire the maximum number of vehicles possible in a given location. The number of vehicles retired by a given program provides a window as to how various program variables effect program participation. The following analysis examines *how the number of vehicles retired by a program is affected by that program's total monetary investment, minimum and maximum participant incentive, length of duration, and minimum vehicle age requirement?*

Note that throughout the analysis our sample size *N* fluctuates as assorted factors affecting program performance are measured for association. Lack of data and inconsistencies in the way various programs recorded information are to be blamed for the fluctuation. Ideally, known past AVR programs would have provided consistent data in order to afford a must accurate analysis. In spite of this, analysis was consistent and sample sizes are annotated in each variable row

Table 41: Correlation Summary - Number of Vehicles Retired

Factor	Correlation	Correlation Coefficient	Coefficient of Determination	% of variance explained by factor	N	Slope
Total Monetary Investment	Strong, Positively linear	0.9320	0.868635787	86.8	53	0.000255
Minimum Incentive	Weak, Positively linear	0.3008	0.090540273	9.1	22	124.32
Maximum Incentive	Moderately strong, Positively linear	0.6126	0.37532284	37.5	63	88.02
Program Duration	Weak, Negatively linear	-0.1356	0.01839520	0.1	61	-1008.05
Minimum Vehicle Age	Weak, Negatively linear	-0.2372	0.05628964	5.6	54	-47904.70

(*See Appendix A for included & excluded programs)*

Table 42: Significance Summary – Factors Affecting the Total Number of Vehicles Retired

N =	53 Total Monetary Investment	22 Minimum Incentive	63 Maximum Incentive	61 Program Duration	54 Minimum Vehicle Age Requirement
t (critical)	2.015	2.086	1.996	2.001	2.006
t (obtained)	17.051	1.411	6.053	-1.051	-1.761
Statistical Significance to Total AVR Population	✓	✓	✓	×	×

(See Appendix *A* for included and excluded programs)

Summary

The number of vehicles retired by a given program can be affected by factors including: the total monetary investment in a program, the minimum and maximum participant incentive amount offered by a program, a program's duration, and the minimum vehicle age eligibility requirement stipulated by a program. While all factors were proven to affect program performance, even though program duration and minimum vehicle age requirement were related in the sample there is not enough evidence to conclude the variables are also related in the population, and may have occurred by chance alone.

Total Monetary Investment

The total amount of monetary investment in a program can affect a program's performance. Greater investment should effect greater participation. The following analysis examines *what impact a program's total monetary investment has on the number of vehicles retired, the individual incentive amount offered, the length of a program, and a program's minimum vehicle age requirement?*

Table 43: Correlation Summary - Total Monetary Investment

Factor	Correlation	Correlation Coefficient	Coefficient of Determination	% of variance explained by factor	N	Slope
Minimum Incentive	weak, positively linear	0.6687	0.4471	44.7	22	559245.8
Maximum Incentive	moderately strong, positively linear	0.4581	0.209881	20.9	54	354519.5
Program Duration	weak, negatively linear	-0.1258	0.0158	1.5	61	-8337283.6
Minimum Vehicle Age	weak, negatively linear	-0.3125	0.0977	9.7	47	-89868429.5

(*See Appendix A for included and excluded programs)*

Table 44: Significance Summary – Factors Affecting the Total Monetary Investment

N =	22 Minimum Incentive	54 Maximum Incentive	45 Program Duration	47 Minimum Vehicle Age Requirement
t (critical)	2.086	2.066	2.0167	2.0141
t (obtained)	4.021	3.716	-.0831	-2.206
Statistical Significance to Total AVR Population	✓	✓	×	✓

(*See Appendix A for included and excluded programs)*

Summary

The total monetary investment in a given AVR program can be affected by factors including: the minimum and maximum participant incentive amount offered by a program, a program's duration, and the minimum vehicle age eligibility requirement stipulated by a program. The total monetary investment in a given AVR program can affect the number of vehicles retired by program. Though program duration and total monetary investment were related in our sample, there is not sufficient evidence to conclude that the variables are also related in the population, and that our sample value may have occurred by chance alone.

Minimum Incentive Amount

The minimum incentive amount offered by a program can affect a program's performance. Greater incentives, for minimum participation requirements, should effect greater participation. The following analysis examines *what relationship exists between the minimum incentive amount offered by a program, the number of vehicles retired in a program, a program's total monetary investment, the maximum incentive amount offered, the length of a program, and a program's minimum vehicle age requirement?*

Table 45: Correlation Summary - Minimum Incentive Amount

Variable	Correlation	Correlation Coefficient	Coefficient of Determination	%	N	Slope
Maximum Incentive	moderately strong, positively linear	0.6176	0.392792	39.3	31	.265898
Program Duration	weak, negatively linear	-0.1524	0.02325	.02	31	-1.87742
Minimum Vehicle Age	weak, negatively linear	-0.3562	.126898	12.6	29	-81.8553

(*See Appendix A for included and excluded programs)*

Table 46: Significance Summary – Factors Affecting the Minimum Incentive Amount

N =	31 Maximum Incentive	31 Program Duration	29 Minimum Vehicle Age Requirement
t (critical)	2.0452	2.0452	2.0518
t (obtained)	3.352	-.8308	-1.980
Statistical Significance to Total AVR Population	✓	×	×

(*See Appendix A for included and excluded programs)*

Summary

The minimum incentive amount offered by an AVR program can be affected by factors including: the total monetary investment in a program, the maximum participant incentive amount offered by a program, a program's duration, and the minimum vehicle age eligibility requirement stipulated by a program. The minimum incentive amount offered can affect the number of vehicles retired by program. While program duration and minimum vehicle age requirement were related to a program's minimum incentive amount in the sample there is not sufficient evidence to believe that the variable are also related in the population, and our sample *r* value may have occurred by chance.

Maximum Incentive Amount

The maximum incentive amount offered by a program can affect program performance. Greater incentives, for fulfilling maximum participation requirements, should effect greater participation. The following analysis examines *what relationship exists between the maximum incentive amount offered by a program, the number of vehicles retired in a program, a program's total monetary investment, the minimum incentive amount offered, the length of a program, and a program's minimum vehicle age requirement?*

Table 47: Correlation Summary - Maximum Incentive Amount

Variable	Correlation	Correlation Coefficient	Coefficient of Determination	%	N	Slope
Program Duration	weak, negatively linear	-0.1524	0.02325	.02	31	1.8485
Minimum Vehicle Age	weak, negatively linear	-0.3562	.126898	12.6	29	-101.51

(*See Appendix A for included & excluded programs)*

Table 48: Significance Summary – Factors Affecting the Maximum Incentive Amount

N =	70 Program Duration	65 Minimum Vehicle Age Requirement
t (critical)	1.9955	1.9983
t (obtained)	-.0538	-2.86902
Statistical Significance to Total AVR Population	×	✓

(See Appendix *A* for included & excluded programs)

Summary

The maximum incentive amount offered by an AVR program can be affected by factors including: the total monetary investment in a program, the minimum participant incentive amount offered by a program, a program's duration, and the minimum vehicle age eligibility requirement stipulated by a program. The maximum incentive amount offered can affect the number of vehicles retired by program. While program duration and the maximum incentive amount offered by a program were related in our sample, there is not sufficient evidence to conclude that the variables are also related in the population, and may have occurred by chance.

Program Duration

A program's duration can affect program performance. The following analysis examines *how the duration of a given program affects the number of vehicles retired, the total monetary investment, the individual incentive amount offered, and a program's minimum vehicle age requirement?*

Table 1: Correlation Summary - Program Duration

Variable	Correlation	Correlation Coefficient	Coefficient of Determination	%	N	Slope
Minimum Vehicle Age	weak, negatively linear	-0.3562	.126898	12.6	29	-81.8553

(*See Appendix A for excluded programs)*

Table 50: Significance Summary – Factors Affecting Program Duration

N =	65 Minimum Vehicle Age Requirement
t (critical)	1.9983
t (obtained)	-.4666
Statistical Significance to Total AVR Population (*See Appendix A for excluded programs)*	×

Summary

A programs duration can be affected by factors including: the total monetary investment offered by a program, the minimum and maximum participant incentive amount offered by a program, and the minimum vehicle age eligibility requirement stipulated by a program. Program duration can affect the number of vehicles retired by a program. While program duration and minimum vehicle age requirement were related in our sample, there is not sufficient evidence to conclude that the variables are also related in the population, and may have occurred by chance.

Minimum Vehicle Age Requirement

A program's minimum vehicle age requirement can affect program performance. The following analysis examines *how the minimum vehicle age requirement stipulated by a given program affects the number of vehicles retired, the total monetary investment, the individual incentive amount offered, and the duration of a given program?*

The relationship, and the significance of the relationship, between a programs minimum vehicle age requirement and its relationship to a programs performance and between other factors affecting program performance has been explained in the previous sections. The following section summarizes the relationships for six factors effecting program performance.

Summary

Correlations exist between the number of vehicles retied by an AVR program, an AVR program's total monetary investment, the minimum and maximum incentive amount offered by a program, a program's duration, and the minimum vehicle age requirement stipulated by a program. Our analysis details the strength and direction of the relationship of factors affecting program performance to the number of vehicles retired, and relationships among individual factors. We note that the monetary scale of a program is positively related to a program's outcome. With greater investment and offered incentives, a greater number of vehicles will be retired.

Both program duration and minimum vehicle age are negatively associated with program performance. While the two negatively associated factors appear to be not statistically relevant to the total population through our analysis, both factors represent a large portion of the total population. Qualitatively, we might explain the negative association between the length of a program's duration and the number of vehicles retired by reflecting on the initial excitement surrounding the 2009 U.S. CARS program. Though the program was extended once to accommodate willing participants, it retired almost 700,000 vehicles in a mere two months. We can conjecture that the sense of urgency present during the program's short duration might not have sustained for a much longer period of time. We also see that as the minimum vehicle age requirement set by a program increases, the number of vehicles retired decreases. We Innately understand that vehicles wear with age, and thus a smaller amount of older vehicles than newer vehicles will always be present. Extending the minimum vehicle age requirement ensures that there are less cars available to participate.

Table 51 relates interrelationships across AVR programs for six factors affecting program performance:

Table 51: Correlation Matrix – Interrelationships for factors affecting program performance

		1	2	3	4	5	6
		Number of Vehicles Retired	Investment	Minimum Incentive	Maximum Incentive	Program Duration	Minimum Vehicle Age
1	Number of Vehicles Retired	1.00	0.93	0.30	0.61	-0.03	-0.24
2	Investment	0.93	1.00	0.67	0.46	-0.13	-0.31
3	Minimum Incentive	0.30	0.67	1.00	0.63	-0.15	-0.36
4	Maximum Incentive	0.61	0.46	0.63	1.00	-0.06	-0.34
5	Program Duration	-0.03	-0.13	-0.15	-0.06	1.00	-0.06
6	Minimum Vehicle Age	-0.24	-0.31	-0.36	-0.34	-0.06	1.00

Other factors affecting program performance

While various insights can be taken from correlations derived from data collected for this analysis, other outstanding factors can affect program performance. In light of the current global economic crisis, a trigger for the commencement of several programs included in this analysis, it is apparent that economic cycles may play a roll in how well a program performs. How much of a role an economic cycle might play in an AVR program's performance is outside the realm of this analysis. However, we can conclude that many of the program's included in Group 1 would not have occurred were it not for an economic downswing.

Existing auto ownership might also factor in whether or not an AVR program performs effectively. Consider a population where a majority of the residents utilize public transit or areas where strict emissions regulations dictate that residents will not keep vehicles past prime running condition, to understand this occurrence. Simply put, if great numbers of vehicles do not exist in an area where a program is conducted, program performance will suffer.

Hand in hand with existing auto ownership are cultural factors. Again, these factors are outside the realm of this analysis, but we know that different cultures place different values on personal vehicles. Many cultures are auto averse, and seek other means of travel whenever possible. Other cultures view personal vehicles as a mark of prestige. Still others view the very cars likely eligible for an AVR program as "classics," and decline participation in an AVR program, whereas other "green" cultures might readily participate. In personal conversations throughout this analysis, several people offered reservations about the ecological ramifications of retiring a "clunker" for a new vehicle. Mentioned in the literature review of this analysis, emissions are expended during automobile production. Reservations stem from the likelihood that an older, well-running vehicle might still produce fewer emissions than those incurred during vehicle production.

Finally, the availability of information about a program may also affect program performance. While the 2009 U.S. *Cash-for-clunkers* program received extensive initial coverage by the national news media, program details were opaque well after the program's commencement. How a program markets itself to the general public may play a major role in choice of scores of participants, qualified or not, to travel to dealerships or other program locations. As well, we must assume that a sector of would-be program participants do not have internet access. Websites such as www.cars.gov and www.retireyourride.ca provide a wealth of information, but are useless to participants without computers and/or internet access. Programs might alleviate this issue by capitalizing on traditional media sources. A final note about the availability of information deals with those participants with internet access. Through data collection, several websites were discovered to be user-unfriendly. Information about a program housed in a hard to navigate website is of little value to participants.

Articulated objectives

Identified past AVR programs proposed articulated objectives, toward which, a program's implementation was intended to execute. Each of the seventy-five programs had at least one articulated objective. A number of the identified programs proposed a secondary objective in addition to the primary articulated objective. A handful of identified programs had tertiary objectives in addition to the primary and secondary objectives.

Articulated objectives were categorized first by the order of objective (assuming emphasis) and again by objective type. Objective types can be broadly defined as those having to do with vehicle sales (economic,) those concerned with reducing air pollution (environmental,) and those interested in road safety (safety.) By and large the most recent (2009-2010) AVR programs have been primarily concerned with economic benefits that may occur as a result of an AVR program's implementation. However, the primary objective of many state based programs, especially those in California, have historically centered on environmental concerns.

Order of Objectives

The order in which objectives were identified for a particular program assumes emphasis. Even though objectives were sometimes stated in ways that insinuate equality between objectives, our analysis assumes a ranking. (See NHTSA 2009 p 2.: "The CARS program achieved the objectives set out by Congress to increase automotive sales and aid the environment.") Ranking the objectives provided a way to delineate primary, secondary, and tertiary objectives. A breakdown of ranked identifiable objectives includes:

- Sixty-eight of the seventy-five programs listed at least one objective
- Only six of the seventy-five programs had no identifiable objective
- Fifty-one programs listed a single "primary objective
- Twenty-four programs listed a "secondary" objective in addition to the "primary" objective
- Seven programs listed a "tertiary" objective

Tables 52-56 detail the order of objectives from past AVR programs

Table 52: Order of Objectives – Group 1

	Country	Primary Objective	Secondary Objective	Tertiary Objective
1	Austria	Stimulate Auto Industry	Reduce Pollutant Emissions	
2	Canada	Reduce Pollutant Emissions		
3	Cyprus	Road Safety	Reduce Pollutant Emissions	Stimulate Auto Industry
4	Cyprus	Road Safety	Reduce Pollutant Emissions	Stimulate Auto Industry
5	France	Stimulate Auto Industry	Reduce Pollutant Emissions	
6	France	Stimulate Auto Industry	Reduce Pollutant Emissions	
7	France	Stimulate Auto Industry	Reduce Pollutant Emissions	
8	Germany	Stimulate Auto Industry		
9	Greece	Stimulate Auto Industry	Reduce Pollutant Emissions	
10	Italy	Stimulate Auto Industry	Reduce Pollutant Emissions	
11	Ireland	Stimulate Auto Industry	Reduce Pollutant Emissions	Road Safety
12	Japan	Stimulate Auto Industry	Reduce Pollutant Emissions	
13	Luxembourg	Reduce CO2 emissions	Stimulate Auto Industry	
14	The Netherlands	Reduce CO2 emissions	Stimulate Auto Industry	
15	Portugal	Reduce CO2 emissions	Road Safety	
16	Portugal	Reduce CO2 emissions	Road Safety	
17	Romania	Stimulate Auto Industry	Reduce Pollutant Emissions	
18	Russia	Stimulate Auto Industry		
19	Slovakia	Stimulate Auto Industry	Reduce Pollutant Emissions	Road Safety
20	Slovakia	Stimulate Auto Industry	Reduce Pollutant Emissions	Road Safety
21	Spain	Stimulate Auto Industry	Reduce CO2 Emissions	Road Safety
22	Spain	Stimulate Auto Industry	Reduce CO2 Emissions	Road Safety
23	United Kingdom	Stimulate Auto Industry	Road Safety	
24	United States	Stimulate Auto Industry	Reduce CO2 Emissions	

(See Appendix A for Citations)

Table 53: Order of Objectives - Group 2

	Program	Primary Objective
1	Unocal South Coast Recycled Auto Program (SCRAP)	Generate MERC's*
2	Unocal South Coast Recycled Auto Program (SCRAP II)	Generate MERC's
3	Unocal South Coast Recycled Auto Program (SCRAP III)	Generate MERC's
4	Unocal South Coast Recycled Auto Program (SCRAP IV)	Generate MERC's
5	Old Car buyback program	Reduce Pollutant Emissions
6	Old Car buyback program	Reduce Pollutant Emissions
7	Old Car buyback program	Reduce Pollutant Emissions
8	California Air Resources Board Pilot Program	Reduce Pollutant Emissions
9	Consumer Assistance Program	Reduce Pollutant Emissions
10	Consumer Assistance Program	Reduce Pollutant Emissions
11	Consumer Assistance Program	Reduce Pollutant Emissions
12	Consumer Assistance Program	Reduce Pollutant Emissions
13	Consumer Assistance Program	Reduce Pollutant Emissions
14	Consumer Assistance Program	Reduce Pollutant Emissions
15	Consumer Assistance Program	Reduce Pollutant Emissions

	Program	Primary Objective
16	REMOVE Program Phase I	Reduce Pollutant Emissions
17	REMOVE Program Phase II	Reduce Pollutant Emissions
18	REMOVE Program Phase III	Reduce Pollutant Emissions
19	REMOVE Program Phase IV	Reduce Pollutant Emissions
20	REMOVE Program Phase V	Reduce Pollutant Emissions
21	REMOVE Program Phase VI	Reduce Pollutant Emissions
22	REMOVE Program Phase VII	Reduce Pollutant Emissions
23	REMOVE Program Phase VIII	Reduce Pollutant Emissions
24	Vehicle Buy-Back Program	Reduce Pollutant Emissions
25	Vehicle Buy-Back Program	Reduce Pollutant Emissions
26	Bay Area Air Quality Management District vehicle buyback	Reduce Pollutant Emissions
27	Bay Area Air Quality Management District vehicle buyback	Reduce Pollutant Emissions
28	Bay Area Air Quality Management District vehicle buyback	Reduce Pollutant Emissions
29	High Emitter or Scrap I (HEROS)	Reduce Pollutant Emissions
30	Old Car Buyback and Scrap Program	Reduce Pollutant Emissions

(See Appendix A for Citations)

Table 54: Order of Objectives - Group 3

	Program	Primary Objective
1	Delaware Vehicle Retirement Program	Offset increased HC Emissions
2	Total Clean Cars Program	Reduce Pollutant Emissions
3	Illinois EPA	Reduce Criteria Pollutant Emissions
4	Drive a Clean Machine	Reduce Pollutant Emissions in Counties with Ground Level O-Zone
5	High Pollution Vehicle Retirement Pilot Program	Reduce Pollutant Emissions

(See Appendix A for Citations)

Table 55: Order of Objectives - Group 4

	Program	Primary Objective	Secondary Objective
1	Scrap-It Pilot Program	Reduce greenhouse gas emissions	
2	Scrap-It	Reduce greenhouse gas emissions	
3	Alberta Clean Air Scrappage Pilot Project	Reduce criteria air contaminants	Reduce greenhouse gas emissions

(See Appendix A for Citations)

Table 56: Order of Objectives - Group 5

	Country	Primary Objective	Secondary Objective
1	Country	Primary Objective	Secondary Objective
2	Denmark	Reduce HC and NO x emissions	
3	France	Reduce Pollutant Emissions	
4	France	Reduce Pollutant Emissions	
5	France	Reduce Pollutant Emissions	
6	Greece	Reduce Average Vehicle Age	Improve Emission Technology embodied in Vehicle Fleet
7	Hungary	Eliminate old two-stroke engine vehicles	Reduce criteria pollutant emissions
8	Spain		
9	Spain		
10	Ireland		
11	Norway		
12	Italy		
13	Italy		
14	Argentina	Stimulate Vehicle Sales	

(See Appendix A for citations)

Type of Objective

Objectives listed by individual programs can be further broken down by objective type. Recent programs have focused primarily upon stimulating auto sales, with a secondary focus on reducing air pollution. Programs held at the state-level throughout the 1990's concentrated primarily on environmental issues in accordance with an idea proposed in the 1990 Clean Air Act Amendments that stated entities could reduce emissions in one area of an AQMD, if the total emissions reduction remedied high pollution in another area (Washington 1993 1). A handful of European programs have centered on country specific tribulations such as road safety (Cyprus) and the elimination of two-stroke engines (Hungary.)

Objectives were categorized first by order of objective, and secondly by objective type. Tables 57-61detail type of objective by program:

Table 57: Objective Type - Group 1

	Country	Primary Objective Type	Secondary Objective Type	Tertiary Objective Type
1	Austria	Economic	Environmental	
2	Canada	Environmental		
3	Cyprus	Other	Environmental	Economic
4	Cyprus	Other	Environmental	Economic
5	France	Economic	Environmental	
6	France	Economic	Environmental	
7	France	Economic	Environmental	
8	Germany	Economic		
9	Greece	Economic	Environmental	
10	Italy	Economic	Environmental	
11	Ireland	Economic	Environmental	Other
12	Japan	Economic	Environmental	
13	Luxembourg	Environmental	Economic	
14	The Netherlands	Environmental	Economic	
15	Portugal	Environmental	Other	
16	Portugal	Environmental	Other	
17	Romania	Economic	Environmental	
18	Russia	Economic		
19	Slovakia	Economic	Environmental	Other
20	Slovakia	Economic	Environmental	Other
21	Spain	Economic	Environmental	Other
22	Spain	Economic	Environmental	Other
23	United Kingdom	Economic	Other	
24	United States	Economic	Environmental	

(See Appendix A for Citations)

Table 58: Objective Type - Group 2

	Program	Primary Objective Type
1	Unocal South Coast Recycled Auto Program (SCRAP)	Environmental
2	Unocal South Coast Recycled Auto Program (SCRAP II)	Environmental
3	Unocal South Coast Recycled Auto Program (SCRAP III)	Environmental
4	Unocal South Coast Recycled Auto Program (SCRAP IV)	Environmental
5	Old Car buyback program	Environmental
6	Old Car buyback program	Environmental
7	Old Car buyback program	Environmental
8	California Air Resources Board Pilot Program	Environmental
9	Consumer Assistance Program	Environmental
10	Consumer Assistance Program	Environmental
11	Consumer Assistance Program	Environmental
12	Consumer Assistance Program	Environmental
13	Consumer Assistance Program	Environmental
14	Consumer Assistance Program	Environmental
15	Consumer Assistance Program	Environmental
16	REMOVE Program Phase I	Environmental
17	REMOVE Program Phase II	Environmental
18	REMOVE Program Phase III	Environmental
19	REMOVE Program Phase IV	Environmental
20	REMOVE Program Phase V	Environmental
21	REMOVE Program Phase VI	Environmental
22	REMOVE Program Phase VII	Environmental
23	REMOVE Program Phase VIII	Environmental
24	Vehicle Buy-Back Program	Environmental
25	Vehicle Buy-Back Program	Environmental
26	Bay Area Air Quality Management District vehicle buyback	Environmental
27	Bay Area Air Quality Management District vehicle buyback	Environmental
28	Bay Area Air Quality Management District vehicle buyback	Environmental
29	High Emitter or Scrap I (HEROS)	Environmental
30	Old Car Buyback and Scrap Program	Environmental

(See Appendix A for Citations)

For all programs in Group 2 no secondary or tertiary objectives were identified.

Table 59: Objective Type Group 3

	Program	Primary Objective
1	Delaware Vehicle Retirement Program	Environmental
2	Total Clean Cars Program	Environmental
3	Illinois EPA	Environmental
4	Drive a Clean Machine	Environmental
5	High Pollution Vehicle Retirement Pilot Program	Environmental

(See Appendix B for Citations)

For all programs in Group 3 and no secondary or tertiary objectives were identified.

Table 60: Objective Type Group 4

	Program	Primary Objective	Secondary Objective
1	Scrap-It Pilot Program	Environmental	
2	Scrap-It	Environmental	
3	Alberta Clean Air Scrappage Pilot Project	Environmental	Environmental

(See Appendix A for Citations)

No tertiary objectives were identified for programs in Group 4.

Table 61: Objective Type Group 5

	Country	Primary Objective	Secondary Objective
1	Denmark	Environmental	
2	France	Environmental	
3	France	Environmental	
4	France	Environmental	
5	Greece	Other	Environmental
6	Hungary	Other	Environmental
7	Spain		
8	Spain		
9	Ireland		
10	Norway		
11	Italy		
13	Italy		
14	Argentina	Economic	

(See Appendix A for Citations)

Tests

Using Chi Square, objectives were assessed for independence against several program variables. For each model we assume independent random samples, a nominal level of measurement, and a null hypothesis that the two variables are independent. Appendix B. dictates those programs excluded from each test.

Test 1: Type of Objective and Order of Objective

Our first test was to determine if the order in which a program articulates its objectives is dependent on the type of objective. Objectives were categorized by type and by the order in which they were stated.

Table 62: Type of Objective by Order of Objective of all AVR Programs

	Order of Objective			
Type of Objective	Primary	Secondary	Tertiary	Totals
Economic	18	2	2	22
Environmental	47	18	4	69
Safety	2	2	5	9
Other	2	1	0	3
Totals	69	23	11	103

Expected frequencies were then obtained for both variables:

Table 63: Expected Frequencies for Table 62

	Order of Objective			
Type of Objective	Primary	Secondary	Tertiary	Totals
Economic	14.74	4.91	2.35	22
Environmental	46.22	15.41	7.37	69
Safety	6.03	2.01	0.96	9
Other	2.01	0.67	0.32	3
Totals	69	23	11	103

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 6
x^2(critical) = 12.592
x^2(obtained) =24.63

Our test statistic of 24.63 falls into the critical region and thus we reject the null hypothesis that the two variables are independent. The pattern of cell frequencies in Table 62 is unlikely to have occurred by chance alone. The variables are dependent. Based on the data, the probability that the order in which an AVR program articulates its objectives is dependent on the type of objective articulated. Table 64 helps to make this relationship more obvious.

Table 64: Percentages for Table 62

	Order of Objective			
Type of Objective	Primary	Secondary	Tertiary	Totals
Economic	26.08%	8.69%	18.18%	21.35%
Environmental	68.11%	78.26%	36.36%	66.90%
Safety	2.89%	8.69%	45.45%	8.73%
Other	2.89%	4.34%	0.00%	2.91%
Totals	100%	100%	100%	100%

The primary objective listed by a program is approximately 42% more likely to be an environmental objective rather than an economic objective. Whereas an economic objective is approximately 17% more likely to be the primary objective articulated by program rather than a secondary objective. According to these results, environmental objectives are more apt to be articulated as both primary and secondary objectives, while safety objectives are most likely to be a program's articulated tertiary objective.

Test 2: Program Performance by Order and Type of Objective

The second test was to determine whether or not a program's performance was dependent on the order and type of articulated objective. Program performance was ranked as low, average, and high based on the number of vehicles retired. Primary objectives were first tested against 59 programs that listed a primary objective.

Table 65: AVR Program Performance by Primary Objective

	Primary Objective			
Program Performance	Economic	Environmental	Other	Totals
High	12	3	1	16
Average	5	10	1	16
Low	1	24	2	27
Totals	18	37	4	59

Expected frequencies were then obtained for both variables

Table 66: Expected Frequencies for Table 65

	Primary Objective			
Program Performance	Economic	Environmental	Other	Totals
High	4.88	10.03	1.08	16
Average	4.88	10.03	1.08	16
Low	8.23	16.93	1.83	27
Totals	18	37	4	59

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) =24.65

Our test statistic of 24.65 falls into the critical region and thus we reject the null hypothesis that the two variables are independent. The pattern of cell frequencies in Table 65 is unlikely to have occurred by chance alone. The variables are dependent. Based on the data, an AVR program's performance is dependent on its stated primary objective. Table 67 helps to make this relationship more obvious.

Table 67: Percentages for Table 65

	Primary Objective			
Program Performance	Economic	Environmental	Other	Totals
High	66.66	8.10	25	27.11
Average	27.77	27.02	25	27.11
Low	5.55	64.86	50	45.76
Totals	100	100	100	100

Approximately 67% of high performing programs articulate economic primary objectives vs. 8% of programs with environmental primary objectives. For average performing programs the type of primary objective does not seem to bear much concern. However, programs with the lowest performance only state an economic primary objective 5% of the time, insinuating that programs with economic primary objectives perform better than those with other primary objectives.

Secondary objectives were then tested against 27 programs with an articulated secondary objective.

Table 68: AVR Program Performance by Secondary Objective

	Secondary Objective			
Program Performance	Economic	Environmental	Other	Totals
High	0	9	1	10
Average	2	5	2	9
Low	2	4	2	8
Totals	4	18	5	27

Expected frequencies were derived for both variables:

Table 69: Expected Frequencies for Table 68

Program Performance	Secondary Objective			Totals
	Economic	Environmental	Other	
High	1.48	6.66	1.85	10
Average	1.33	6	1.66	9
Low	1.18	5.33	1.48	8
Totals	4	18	5	27

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) = 4.331666667

Our test statistic of 4.331666667 falls out of the critical region and thus we fail to reject the null hypothesis that the two variables are independent. The observed frequencies are not significantly different from the frequencies we would expect to find if the variables were independent and only random chance were operating. Based on the results, an AVR program's performance is not dependent on its stated secondary objective.

Tertiary objectives were then tested against 7 programs with tertiary objectives.

Table 70: Program Performance by Tertiary Objective

Program Performance	Tertiary Objective			Totals
	Economic	Environmental	Other	
High	0	0	1	1
Average	0	0	3	3
Low	2	0	1	3
Totals	2	0	5	7

Expected frequencies were calculated for both variables

Table 71: Expected Frequencies for Table 70

	Tertiary Objective			
Program Performance	Economic	Environmental	Other	Totals
High	0.28571428	0	0.714285714	1
Average	0.85714285	0	2.142857143	3
Low	0.85714285	0	2.142857143	3
Totals	2	0	5	7

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) = 3.733333333

Our test statistic of 3.733333333 falls out of the critical region and thus we fail to reject the null hypothesis that the two variables are independent. The observed frequencies are not significantly different from the frequencies we would expect to find if the variables were independent and only random chance were operating. Based on the results, an AVR program's performance is not dependent on its stated tertiary objective.

Test 3: Total Program Investment and Objective Order and Type

The third test was to determine whether or not the order and type of a program's articulated objective was dependent on a program's level of investment. Program investment was ranked as low, medium, and high based on the total investment. Primary objectives were first tested against 54 programs that listed a primary objective.

Table 72: Level of Program Investment by Primary Objective

	Primary Objective			
Investment	Economic	Environmental	Other	Totals
Low	1	15	2	18
Medium	2	15	1	18
High	14	4	0	18
Totals	17	34	3	54

Expected frequencies were calculated for both tables:

Table 73: Expected Frequencies for Table 72

	Primary objective			
Investment	Economic	Environmental	Other	Totals
Low	5.666666667	11.33333333	1	18
Medium	5.666666667	11.33333333	1	18
High	5.666666667	11.33333333	1	18
Totals	17	34	3	54

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) = 30.58823529

Our test statistic of 30.58 falls into the critical region and thus we reject the null hypothesis that the two variables are independent. The pattern of cell frequencies in Table 72 is unlikely to have occurred by chance alone. The variables are dependent. Based on the data, an AVR program's level of investment is dependent on its stated primary objective. Table 74 helps to make this relationship more obvious.

Table 74: Percentages for Table 72

	Primary objective			
Investment	Economic	Environmental	Other	Totals
Low	5.882352941	44.11764706	66.66666667	33.33333333
Medium	11.76470588	44.11764706	33.33333333	33.33333333
High	82.35294118	11.76470588	0	33.33333333
Totals	100	100	100	100

Approximately 82% of programs with a high level of investment articulate economic primary objectives vs. 11% of programs with environmental primary objectives. Conversely, programs with the lowest level of investment only state an economic primary objective approximately 6% of the time, insinuating that programs with economic primary objectives are more highly funded than those with other primary objectives.

Secondary objectives were then tested against 21 programs with an articulated secondary objective.

Table 75: Level of Program Investment by Secondary Objective

	Secondary objective			
Investment	Economic	Environmental	Other	Totals
Low	0	3	0	3
Medium	1	3	2	6
High	1	10	1	12
Totals	2	16	3	21

Expected frequencies were calculated for both tables:

Table 76: Expected Frequencies for Table 75

	Secondary objective			
Investment	Economic	Environmental	Other	Totals
Low	0.285714286	2.285714286	0.428571429	3
Medium	0.571428571	4.571428571	0.857142857	6
High	1.142857143	9.142857143	1.714285714	12
Totals	2	16	3	21

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) = 3.71875

Our test statistic of 3.71875 falls out of the critical region and thus we fail to reject the null hypothesis that the two variables are independent. The observed frequencies are not significantly different from the frequencies we would expect to find if the variables were independent and only random chance were operating. Based on the results, an AVR program's level of investment is not dependent on its stated secondary objective.

Tertiary objectives were then tested against 7 programs with tertiary objectives. As only 7 programs had data for both level of investment and tertiary objective, we can suspect from the outset that we will fail to reject our null hypothesis that the two variables are independent.

Table 77: Level of Program Investment by Tertiary Objective

	Tertiary Objective			
Investment	Economic	Environmental	Other	Totals
Low	1	0	1	2
Medium	1	0	2	3
High	0	0	2	2
Totals	2	0	5	7

Expected frequencies were calculated for both tables:

Table 78: Expected Frequencies for Table 77

	Tertiary Objective			
Investment	Economic	Environmental	Other	Totals
Low	0.571428571	0	1.428571429	2
Medium	0.857142857	0	2.142857143	3
High	0.571428571	0	1.428571429	2
Totals	2	0	5	7

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) = 1.283333333

Our test statistic of 1.283333333 falls out of the critical region and thus we fail to reject the null hypothesis that the two variables are independent. The observed frequencies are not significantly different from the frequencies we would expect to find if the variables were independent and only random chance were operating. Based on the results, an AVR program's level of investment is not dependent on its stated tertiary objective.

Test 4: Region and Primary Program Objective

The fourth test was to determine whether or not the primary articulated objective of a particular program was dependent on the region in which a program was conducted. Primary objectives were tested for 69 programs that listed a primary objective.

Table 79: Region by Primary Objective

	Primary Objective			
Location	Economic	Environmental	Other	Totals
European	15	8	4	27
North American	1	39	0	40
Other	2	0	0	2
Totals	18	47	4	69

Expected frequencies were then calculated for both variables:

Table 80: Expected Frequencies for Table 79

	Primary Objective			
Location	Economic	Environmental	Other	Totals
European	7.043478261	18.39130435	1.565217391	27
North American	10.43478261	27.24637681	2.31884058	40
Other	0.52173913	1.362318841	0.115942029	2
Totals	18	47	4	69

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) = 45.6230792

Our test statistic of 45.63 falls into the critical region and thus we reject the null hypothesis that the two variables are independent. The pattern of cell frequencies in Table 79 is unlikely to have occurred by chance alone. The variables are dependent. Based on the data, an AVR program's stated primary objective is dependent on its location. Table 81 helps to make this relationship more obvious.

Table 81: Percentages for Table 79

	Primary Objective			
Location	Economic	Environmental	Other	Totals
European	83.33333333	17.0212766	100	39.13043478
North American	5.555555556	82.9787234	0	57.97101449
Other	11.11111111	0	0	2.898550725
Totals	100	100	100	100

Approximately 83% of European programs articulate economic primary objectives vs. 17% of programs with environmental primary objectives. Conversely, North American programs state environmental primary objectives approximately 83% of the time vs. economic objectives stated as primary only about 5% of the time. Programs outside of Europe and North America are primarily concerned with economic objectives, while Europe houses the only countries concerned primarily with other objectives.

Test 5: Level of Development and Primary Objective

The fifth test was to determine whether or not a program's primary articulated objective was dependent on a program's level of development (population.) Primary objectives were tested for 69 programs that listed a primary objective.

Table 82: Level of Development by Primary Objective

	Primary Objective			
Population	Economic	Environmental	Other	Totals
Low	0	21	2	23
Medium	6	15	2	23
High	12	11	0	23
Totals	18	47	4	69

Expected frequencies were then calculated for both variables:

Table 83: Expected Frequencies for Table 82

	Primary Objective			
Population	Economic	Environmental	Other	Totals
Low	6	15.66666667	1.333333333	23
Medium	6	15.66666667	1.333333333	23
High	6	15.66666667	1.333333333	23
Totals	18	47	4	69

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 4
x^2(critical) = 9.488
x^2(obtained) = 17.23404255

Our test statistic of 17.23 falls into the critical region and thus we reject the null hypothesis that the two variables are independent. The pattern of cell frequencies in Table 82 is unlikely to have occurred by chance alone. The variables are dependent. Based on the data, an AVR program's stated primary objective is dependent on the level of development of the area in which it is conducted. Table 79 helps to make this relationship more obvious.

Table 84: Percentages for Table 82

	Primary Objective			
Population	Economic	Environmental	Other	Totals
Low	0	44.68085106	50	33.33333333
Medium	33.33333333	31.91489362	50	33.33333333
High	66.66666667	23.40425532	0	33.33333333
Totals	100	100	100	100

Approximately 66% of programs with a high level of development articulate economic primary objectives vs. 33% of programs with a medium level of development. Conversely, programs with a low level of development focus primarily on environmental objectives. While areas with low and medium levels of development seem concerned primarily with other objectives, the percentage is misleading as only 4 programs fell into this group.

Test 6: Spatial Scale and Primary Objective

The sixth and final chi square test was to determine whether or not a program's primary articulated objective was dependent on a program's spatial scale (country, county, city). Primary objectives were tested for 69 programs that listed a primary objective.

Table 85: Spatial Scale by Primary Objective

	Primary Objective			
Spatial Scale	Economic	Environmental	Other	Totals
Nation	18	9	4	31
Region	0	14	0	14
State	0	12	0	12
County	0	5	0	5
City	0	7	0	7
Totals	18	47	4	69

Expected frequencies were then calculated for both variables:

Table 86: Expected Frequencies for Table 85

Spatial Scale	Primary Objective: Economic	Environmental	Other	Totals
Nation	8.086956522	21.11594203	1.797101449	31
Region	3.652173913	9.536231884	0.811594203	14
State	3.130434783	8.173913043	0.695652174	12
County	1.304347826	3.405797101	0.289855072	5
City	1.826086957	4.768115942	0.405797101	7
Totals	18	47	4	69

Sampling distribution = x^2 distribution
Alpha = 0.05
Degrees of freedom = 10
x^2(critical) = 18.307
x^2(obtained) = 39.59094029

Our test statistic of 39.59 falls into the critical region and thus we reject the null hypothesis that the two variables are independent. The pattern of cell frequencies in Table 85 is unlikely to have occurred by chance alone. The variables are dependent. Based on the data, an AVR program's stated primary objective is dependent on the spatial scale in which it is conducted. Table 82 helps to make this relationship more obvious.

Table 87: Percentages for Table 85

Spatial Scale	Primary Objective: Economic	Environmental	Other	Totals
Nation	100	19.14893617	100	44.92753623
Region	0	29.78723404	0	20.28985507
State	0	25.53191489	0	17.39130435
County	0	10.63829787	0	7.246376812
City	0	14.89361702	0	10.14492754
Totals	100	100	100	100

For this test we can see that only nations are apt to have economic and other primary objectives. The remaining five spatial scales only have primary environmental objectives. Regional scales account for 29% of those programs with primary environmental objectives, while less than 20% of national programs have a primary objective classified as “environmental.”

Descriptive Statistics

Thirty-Eight programs with primary environmental objectives and 18 programs with primary economic objectives were looked at as part of this analysis. Each program varied in size and outcome. Simply, by observing the range for both programs we can see that programs with an economic primary objective are much larger than those with environmental primary objectives. Correspondingly, the standard deviation for programs with an economic primary objective is nearly three times that of programs with an environmental primary objective, even though there were approximately twice as many programs with an environmental primary objective.

Table 88: Descriptive Table for Primary Objectives

	Economic Primary Objective	Environmental Primary Objective
Mean	377,602.56	55,875.42
Median	215,000	7,683.50
Standard Deviation	472,258.01	165,361.2123
Range	1,982,728.00	749,938.00

Summary

Chi square tests were utilized to assess objectives for statistical significance against a host of variables including: type of objective by order of objective; program performance by primary, secondary, and tertiary objective; level of investment by primary, secondary, and tertiary objective; program region by primary objective; level of development (population) by primary objective; and spatial scale (nation, state, region, county, city) by primary objective. The tests confirmed whether or not the null hypothesis, that the variables are independent in the population, was true. In instances when the null hypothesis was rejected, we can conclude that the variables are dependent on one another. Calculated percentages allow us to see how independent variables affect dependent variables. Looking at program means and standard deviations, we can see clearly that programs with an economic focus were much larger than programs with an environmental focus. From our tests we learned that:

- The order of an objective is dependent on the type of objective.
- Program performance is dependent on the type of primary objective, but not the type of secondary or tertiary objective.
- The level of investment in a program is dependent on the type of primary objective, but not the type of secondary or tertiary objective.
- The type of primary objective articulated by a program is dependent on the region in which an AVR program is held.
- The type of primary objective articulated by a program is dependent on the level of development (population) where a program is held, and
- the type of primary objective articulated by a program is dependent on the scale (nation, region, state, county, city) where a program is held.

Importance of Stakeholders

Though dependencies among objectives to various program variables have been uncovered in our analysis, it is important to note the importance of stakeholders and the role they might play in establishing program objectives. While it may now be obvious that program performance is dependent on the type of primary objective articulated by a program, it may not be obvious that a number of forces might influence the type of primary objective. As shown by the most recent wave of AVR programs aimed at generating economic stimulation, a host of political stakeholders may have a say in the type of objective articulated by a program. In the last wave of programs (2009-2010) we can assume that labor unions, automobile manufacturers, and political parties each had a hand in ensuring a program was aimed at an economic objective rather than an environmental. Additionally, we can assume that environmentalists and air quality management districts faced with poor air quality throughout California, had a hand in influencing a majority of California programs would be focused on the environment.

Descriptive statistics show us that economic programs are much larger in scale and performance than environmental programs, a phenomenon that may deal with the speed in which a program's reward is realized. The impact of a program aimed at stimulating the economy will be felt much sooner than that of a program focused on the environment. Environmental programs strive to realize results immediately, but also far in the future. Economic programs may have a more immediate effect on an economy. This short-term vs. long-term perspective comes back to how willing stakeholders are to wait to see the objectives of an AVR program, designed under their reign, met.

Ecological Impact

Proponents and opponents alike cite the ecological impact of an AVR program as cause for conducting such a program. While the extent to which an AVR program harms or helps the environment could potentially, by itself, dictate how future programs are directed, available data on environmental impacts is scant. Nine programs provided data for both tons of emissions reduced and the number of vehicles retired. Another ten programs provided data for tons of emissions reduced, but not the number of vehicles retired. Based on the limited amount of records concerning AVR environmental aspects, the data was analyzed to determine the strength of relationship between ecological impacts and other variables.

As each factor can be measured at the interval-ratio level, statistical techniques were employed to determine correlations between between the total emissions (tons) and other program variables. By means of calculating Pearson's r, the coefficient of determination (r^2,) and the slope between different variables, the analysis sought to answer three questions: Is there a relationship between the variables? How strong is the relationship? What is the direction of the relationship?

Because data available on factors affecting program performance is based on data from a random sample from all AVR programs, it is necessary to test our calculated *r* values for significance. For all inspections we assume: random sampling, an interval-ratio level of measurement, bivariate normal distributions, a linear relationship, homoscedasticity, and that our sampling distribution is normal. Our null hypothesis is that there is no linear association between the two variables in the population from which the sample was drawn. Our sampling distribution is a *t* distribution, with an Alpha of 0.05. After measures of association were calculated, each measure was then tested for significance.

Caveats and Summary

Calculations concerning correlations between different program variables and the ecological impact of a program were first conducted using all available data related to the total emissions (tons) reduced by a program. This was later amended because it was noted that a negative correlation existed between the minimum vehicle age requirement set by a program and the total emissions reduction. Intuitively we know that older cars generate the most emissions, and that raising the minimum age would thus realize a greater emissions reduction. Inspecting the numbers we realized that the number reported by the 2009 U.S. CARS program (336,608) was inordinately proportioned to all other program numbers. The U.S. CARS program represented an outlier in the data, and in an attempt to normalize our calculations the program was deleted. Table 89 details available emissions (tons) reductions by program:

Table 89: Program Emissions (tons) Reductions

Program	*Emissions (tons) Reduction*
Delaware Vehicle Retirement Program	16
High Emitter or Scrap I (HEROS)	28.1
Illinois EPA	51
Unocal South Coast Recycled Auto Program (SCRAP II)	64
Old Car buyback program (2006-2010)	66
REMOVE Program Phase VI	104
REMOVE Program Phase VIII	156
Total Clean Cars Program	245.6
Consumer Assistance Program (2001)	274.5
REMOVE Program Phase VII	304
REMOVE Program Phase IV	325
Vehicle Buy-Back Program (1995- 1996)	325
REMOVE Program Phase V	360
REMOVE Program Phase I	400
REMOVE Program Phase II	525
Vehicle Buy-Back Program (1997 - 1998)	525
REMOVE Program Phase III	590
Unocal South Coast Recycled Auto Program (SCRAP)	6400
United States	336608

Once the 2009 U.S. CARS program was removed, our issue with the minimum vehicle age was rectified. However, other correlations appear to have also shifted dramatically. For this reason calculations with and without the U.S. program have been included in this analysis:

Table 90: Correlation Summary - Factors Affecting Program Environmental Performance (2009 U.S. CARS program included)

N =	17	11	19	17	17
	Total Program Investment	Number of Vehicles Retired	Maximum Incentive	Program Duration	Minimum Vehicle Age Requirement
Total Emissions Reduction *r* value	.99	.49	.97	-0.23	-0.49
Statistical Significance to Total AVR Population	✓	✓	✓	✕	✓

(See Appendix A for included Programs)

Table 91: Correlation Summary - Factors Affecting Program Environmental Performance (2009 U.S. CARS program excluded)

N =	16 Total Program Investment	10 Number of Vehicles Retired	18 Maximum Incentive	16 Program Duration	16 Minimum Vehicle Age Requirement
Total Emissions Reduction *r* value	.009	.13	-.05	-.27	.21
Statistical Significance to Total AVR Population	✕	✓	✓	✕	✓

(See Appendix A for included Programs)

One might note the drastic differences in tables 90 and 91. The 2009 U.S. CARS program, with an investment of 3.2 billion out performs the next highest invested program in our group by 3,162,000,000. As well the program retired nearly 640,000 more vehicles than the next comparable program in the group.

It would not be prudent to speculate about whether or not the U.S. CARS program is flawed. However, one can confidently state that it is drastically larger than other programs, and that though the programs are much smaller the number reported by the U.S. CARS program does not seem relative in comparison. Data about how emissions (tons) reduction numbers were tested and reported is not available. Transparency about how numbers are reported may solve this debate.

We should also address the sheer lack of reporting on total emissions (tons) reductions across all programs. While many of the statutes found do require that a program report its emissions reduction data, the requirement has not been enforced. Not only is the reporting requirement not enforced, but also many of the programs that did report numbers in inconsistent manners. The most appropriate direction for further ecological study of AVR programs is to ensure consistency in how emissions (tons) reduction numbers are reported.

Finally, we must acknowledge that emissions (tons) reduction numbers are but one way environmental aspects of an AVR program might be tested. If accurate vehicle lifecycle cost analysis and/or smogcheck data over the lifetime of a vehicle were available, the numbers would perhaps present a more accurate way to calculate the environmental impact of removing vehicles from the road. In the past the price of a ton of carbon has been used to articulate how a program performs monetarily. The cost of carbon was not used in our analysis, as the number is almost always in flux. In summary, a host of environmental indicators exist with which to judge the performance of AVR programs, however their availability may complicate an analysis.

The capacity to judge AVR program performance based on environmental indicators is problematic. Environmental indicators of program performance have not been recorded by a number of programs, due to the difficulty of obtaining such information and separate program objectives. By way of analyzing programs that did record such information, assumptions can be made about how various program factors affect environmental performance.

Findings

Accelerated Vehicle Retirement programs identified for this analysis vary in scale and articulated objective. Program distinctions are significant and beneficial for understanding how and why given programs result in different levels of effectiveness. Though programs articulate a number of “primary” objectives, to that end a program will be most effective when it retires a maximum number of vehicles. Comparing factors affecting program performance across 75 programs can offer insight into how future AVR programs might be most effective.

Through content and statistical analysis, we were able to extrapolate correlations among data from past programs and factors affecting program performance. Each of the factors: total monetary investment, minimum and maximum incentive amount offered to participants, program duration, and the minimum vehicle age required to participate affect program performance. It is essential to remain aware that the five factors are not wholly responsible for how a program performs, and that other factors such as current economic cycle, existing auto ownership, culture, and availability of information on a program may also play a role in a program’s performance.

Additionally, statistical analysis exposed how dependencies among articulated program objectives and certain program attributes: performance, investment, population, location and spatial scale. Analyzing dependencies and factors affecting program performance provides a basis to develop a framework for future AVR programs.

Factors Affecting Program Performance

Five factors were identified that affect program performance:

- Total Monetary Investment
- Minimum Participant Incentive Amount
- Maximum Participant Incentive Amount
- Program Duration, and
- Minimum Vehicle Age Requirement.

As AVR programs are implemented in the future, planners and government officials alike should note the relationships uncovered in this analysis in order to design the most effective program for their particular area. Litanies of relationships were exposed through our analysis. However, the ways in which each factor positively or negatively affects one another, and total program performance, can be summarized by the following:

1. An increase in the total monetary investment in a program will increase the number of vehicles retired, minimum participant incentive, and maximum participant incentive.
2. An increase in the minimum participant incentive for a program will increase the total number of vehicles retired, total monetary investment in a program, and maximum participant incentive.
3. An increase in the maximum participant incentive for a program will increase the total number of vehicles retired, total monetary investment in a program, and the minimum participant incentive.
4. An increase in program duration will decrease the total number of vehicles retired, the total monetary investment in a program, both the

minimum and maximum participant incentives for a program, and the minimum vehicle age requirement to participate in a program.

5. An increase in the minimum vehicle age requirement for a program will decrease the number of vehicles retired, the total monetary investment in a program, both the minimum and maximum incentive amounts offered by a program, and a program's duration.

Impact of Objectives

The objectives a program stipulates can shape a program's performance. Program objectives were classified by order and type. The order of articulated objectives were categorized as: primary, secondary, and tertiary. Objective types were categorized as: economic, environmental, and "other." Objectives categorized as "other" include road safety, reduction of the minimum vehicle age, and the elimination of two-stroke engines (Hungary.) The degree to which articulated objectives are dependent on program variables can be summarized by the following:

1. The order of objectives articulated by an AVR program is dependent on the type of objective. An AVR program's primary objective is 42% more likely to be an environmental objective than an economic objective. Economic objectives are 17% more likely to be a program's primary objective, rather than a secondary objective. A program's tertiary objective is likely to be an objective other than economic or environmental 45% of the time.

2. A program's level of performance is dependent on type of primary objective. High performing programs stipulate primary economic objectives 66% of the time.
3. A program's level of performance is not dependent on its articulated secondary or tertiary objective.
4. The level of investment in a program is dependent on a program's primary objective. Eighty-two percent of programs with a high level of investment articulate primary economic objectives.
5. The level of investment in a program is not dependent on articulated secondary or tertiary objectives.
6. The type of objective articulated by a program is dependent on where a program is conducted. European programs articulate economic objectives 83% of the time, while North American programs stipulate environmental objectives 82% of the time.
7. The type of objective stipulated by a program is dependent on the level of development in an area where an AVR program is conducted. Areas with high populations stipulate economic objectives 66% of the time, while areas with low populations stipulate economic objectives only 44% of the time.
8. The type of objective stipulated by an AVR program is dependent on the governmental scale that conducts the program. Programs conducted at the national scale stipulate economic objectives 100% of the time, while programs conducted at the regional and state level stipulate environmental objectives 29% and 25% respectively.

9. The average number of vehicles retired is much larger (377,602.54) for programs with economic primary objectives than programs with environmental primary objectives (55,875.42).

Ecological Impact

How factors affecting program performance dictate how positively or negatively a program impacts the environment is a chief concern for planners that might design future programs. Five factors were tested against a ecological impact, including:

- Number of Vehicles Retired
- Total Monetary Investment
- Maximum Participant Incentive
- Program Duration, and
- Minimum Vehicle Age Requirement

Though past programs have not focused exclusively on how well they benefit or hurt the environment, an AVR program's ability to affect total emission (tons) output in a given area is important for future programs. As knowledge and interest in global warming and how it is impacted by mobile emissions sources continues to rise, planners and policymakers may use AVR programs as a weapon to combat atmospheric deterioration. How factors affecting program performance effect the environment can be summarized by the following:

1. An increase in the number of vehicles retired will increase the total emissions (tons) reduction.
2. An increase in the total monetary investment in a program will increase the total emissions (tons) reduction.
3. An increase in the maximum participant incentive offered by a program will increase the total emissions (tons) reduction.
4. An increase in a program's duration will decrease the total emissions (tons) reduction.
5. An increase in the minimum vehicle age requirement for a program will most likely increase the total emissions (tons) reduction.

Summary

Our analysis concludes that larger monetary investments (total program investment, minimum participant incentive, and maximum participant incentive) ensure greater program performance in terms of the number of vehicles retired and ecological impact. The benefit of an AVR program is commensurate with the cost of a program. Program performance is sensitive to the participant incentive amount offered, and is highest for those programs that offer higher incentives. Programs with longer durations and higher minimum vehicle age requirements will encounter diminished program performance.

Objectives stipulated for AVR programs can motivate different levels of program performance. The highest performing programs are those that articulate primary economic objectives, and are also those programs with the greatest level of investment. As programs with higher levels of investment retire more vehicles, our analysis of objectives is in line with our analysis of factors affecting program performance. Programs that primarily focus on stimulating vehicle sales (economic objective) retire more vehicles than those with an environmental focus.

Framework Design

In order to formulate a framework for future implementation of AVR schemes it is necessary to combine conclusions arrived at through analysis of past AVR programs. The framework provides guidance for structuring an AVR program, and for evaluating a program based on objective. AVR programs can be conducted at various spatial and governmental scales. No two AVR programs are exactly the same, and certain program variables will vary according to the size of the area in which an AVR program is conducted. Because no two AVR programs are the same, developing an all-encompassing framework for implementation could take several forms.

One way to limit the number of forms a framework for AVR implementation might take is to utilize existing plan structures. The Government Performance Results Act of 1993 (GPRA,) detailed on page 69 is the most obvious and accessible template in which to base a framework for AVR implementation around. GPRA requires that federal government agencies formulate goals and performance monitoring plans for all proposed programs (Heen 2000 1). Under GPRA, agencies must also measure and report program outcomes (Heen 2000 1). Employing the GPRA template, a strategic and performance plan were created first for programs with an economic objective and secondly for programs with an environmental objective, based on findings throughout our analysis. Tables 92 - 95 detail the four plans.

Table 92: Strategic Plan Framework for Economically Focused AVR Programs

Goals	Objectives	How to Achieve	External Factors	Evaluation
Leverage an AVR program to increase value, strength, and overall competitiveness of automobile industry	Build coalitions between policymakers and auto industry stakeholders. Develop an integrated, clear way to disseminate program information.	Stipulate economic stipulation as primary program goal Research past AVR programs to show viability of such programs as economic motivators. Embark on intense, concise public relations campaign	Economic downswings Lack of vehicle data Ability to reach all would-be participants	Number of vehicles retired Number of new vehicles purchased Number of dealership contacts.
Introduce AVR as a pathway to attaining a new, reliable alternative to "clunkers"	Identify new vehicle models that align with stipulated AVR program goals. Construct competitive incentive scheme to entice customers to participate in program	Converse with automobile manufactures about increasing the availability of approved vehicle models. Identify inexpensive vehicle options available to program participants Distinguish incentive amounts adequate to lure maximum participation	Lack of control over vehicle production Deficiency of inexpensive vehicle models that also meet set program criteria Shortage of funds available	Identification of substitute vehicle models Program participation

Table 93: Strategic Plan Framework for Environmentally Focused AVR Programs

Goals	Objectives	How to Achieve	External Factors	Evaluation
Stimulate mobile source emissions reductions through the initiation of an AVR program	Create models illustrating the effects of driving an older vehicle vs. a new vehicle in terms of emissions output Identify public misinformation about CO_2 emissions prior to program initiation.	Stipulate vehicle emissions reduction as primary program goal Research current in-use vehicle models and develop diagrams that show emissions output vs. new vehicle options Survey general public about perception of CO_2 emissions 3 months prior to program	Public neglect of environmental concern Lack of vehicle data Amount of participation	Number of vehicles retired Number of new vehicles purchased Total emissions reduction
Introduce inexpensive new vehicles as an environmentally friendly alternative to driving a "clunker."	Identify low-impact new vehicle models, and their price points, to participants throughout program duration. Survey would be participants about effective program incentives.	Converse with automobile manufactures about most environmentally friendly vehicle options. Identify inexpensive vehicle options available to program participants Distinguish incentive amounts adequate to lure maximum participation	Lack of environmentally friendly vehicle models Deficiency of inexpensive vehicle models Shortage of funds available	Identification of substitute vehicle models Program participation

Table 94: Performance Plan Framework for Economically Focused AVR Program

Goal	Operational Processes	Performance Indicator	Benchmark and basis for Comparison	Means to Validate Measured Values
Retire 100,000 Vehicles to stimulate automotive Industry	Establish Economic Stimulation as Primary Program Goal Greater Investment = Greater Program Performance Greater Incentive Amounts = Greater Program Performance Shorter Program Duration = Greater Program Performance Reduced Minimum Vehicle Age Requirement = Greater Program Performance	Above Average Program Participation .000257 increase in vehicles retired per dollar invested. 124.32 increase in the number of vehicles retired per dollar added to minimum incentive 88.02 increase in the number of vehicles retired per dollar added to maximum incentive.	100,000 participants Total Investment = 389,686,103.70 Minimum Inventive Amount = 804.31 Maximum Incentive Amount = 1135.98	Statistical Analysis found in Accelerated Vehicle Retirement: Toward a Conceptualized Framework for Design and Implementation

Table 95: Performance Plan Framework for Environmentally Focused Program

Goal	Operational Processes	Performance Indicator	Benchmark and basis for Comparison	Means to Validate Measured Values
Retire 100,000 Vehicles to reduce total emissions (tons)	Establish Total Emissions (tons) reduction as Primary Program Goal Greatest Number of Vehicles Retired = Greatest Emissions (tons) reduction Greater Investment = Greater Emissions (tons) reduction Greater Incentive Amounts = Greater Emissions (tons) reduction Shorter Program Duration = Greater Emissions (tons) reduction Reduced Minimum Vehicle Age Requirement = Greater Emissions (tons) reduction	Above Average Program Participation .49790 increase in emissions reduction per vehicle retired .000105 increase in emissions reduction per dollar invested. 84.68 increase in in emissions reduction per dollar added to maximum incentive.	100,000 participants Total Emissions Reduction 49,790.88	Statistical Analysis found in Accelerated Vehicle Retirement: Toward a Conceptualized Framework for Design and Implementation

Implementation of an AVR framework based on the GPRA template and recommendations from this analysis can help to shape future AVR programs so that they attain both program objectives and maximum performance.

Roles for Planners

Opportunities exist at all levels of planning for planners to formulate ways to cope with increasingly automobile – dependent populations. While long-term approaches such as mass-transit and congestion pricing should be scrutinized, short-term approaches must also be considered. Accelerated Vehicle Retirement offers a blunt instrument with which planners can affect rapid change. Because AVR programs typically require a sizeable initial investment, local level planning agencies have shied away from such programs. However, with proper program design and well-articulated objectives, AVR programs can be designed to affect economic and ecological change at a variety of governmental levels.

Planning agencies house the research tools necessary to design AVR programs to fit their particular areas. A large pool of past programs can be scrutinized to determine how to best design an AVR program. Many local Air Quality Management Districts can provide a wealth of information about how AVR programs can work at a more local level. Implementing AVR programs at the local level can provide planners opportunities to meet stringent air quality attainment level set by the Clean Air Acts and generate an economic upsurge. The roles planners play in attaining air quality standards and economic development are important to communities of all sizes. Planners possess the means necessary to ensure AVR programs are designed well.

Contributions

This project contributes to the literature on AVR by providing a clearinghouse of data focused on AVR programs to date. By means of exposing relationships between various factors affecting program performance and program objectives, the project articulates the structure of how future programs might be designed. The project contributes to the professional field of planning by revealing actions planners can take to ensure future AVR programs are designed in such a way that articulated program goals are met. The analysis of factors affecting AVR performance will be useful to policymakers as they endeavor to regulate our current automobile-dependent society.

Limitations and Recommendations for Further Research

The research presented in this thesis is fluid, and will alter as AVR programs continue to be implemented. Like the surge of AVR programs that took place, more programs will likely take place as the world struggles to cope with a "new economy." This project only considered factors affecting program performance and the objectives articulated by AVR programs; it did not consider the relationship of program performance to the total number of vehicles registered in a particular area, the true impact of automobile manufacturers on program performance, regional specific emissions standards for vehicles, or true political motivation behind program implementation. Because of time and financial constraints the framework designed in this analysis was not tested. In the future it will be important to not how the recommendations provided in this analysis transform as future AVR programs are completed. Throughout the analysis, language, currency, and familiarity with automobiles in foreign nations presented barriers. Data mining often resulted in conflicting approximations, only to be confirmed much later. As well, the analysis most likely suffers from an American view of vehicle miles traveled, economic status, and environmental concern. Appealing avenues for future research include looking at AVR from a non-American perspective, juxtaposing the cost of AVR implementation to current conjectures of carbon pricing, and design of a more in-depth framework.

Summary

It can be inferred from our analysis that while great numbers of AVR programs have taken place in the past, a consistent framework for design and implementation has not been present. Had key relationships among program variables been published, a more consistent sample of AVR implementation would be available. Still, because of lack of recorded data for aspects in several programs, our assumptions cannot be generalized to all past AVR programs.

The relationships uncovered in this analysis provide a framework with which planners can develop future AVR programs as a means of attaining a specified program goal. As the data contained in this project has not been collectively assembled till now, the project exists as a fountain for future researchers to drink from and as a guide for entities considering AVR implementation. AVR program performance is dependent on the type of objective set forth by a program's managing agency. Programs are correlated with a host of variables affecting program performance. Planners and policymakers alike must develop systems to cope with the peripheral consequences of an auto-dependent society. One solution to ills resultant of a society depending on automobile travel is AVR. This analysis has provided an investigation of past AVR programs, and a framework within which planners can most effectively implement AVR programs in the future.

APPENDICES

Appendix A. Table Citations and Excluded Programs

Table 6

ACEA, 2009; ACEA, 2010; Adda and Cooper, 2001; Arcemont, Gary, 2011; Alberini et al., 1995; Allan et al., 2009; Autoplus.fr, 2010; Baltas & Xepapadeas, 1999; Bay Area Air Quality Management District, 2010; Bay Area Air Quality Management District, 2010b; Bearden, 1996; BIS, 2010; British Columbia Scrap-It, 2010; California Air Resources Board, 2005; California Air Quality Management District, 2009; California Board of Auto Repair, 2009; Canadiandriver.com, 2009; Cayting, 2011; Cyprus Blog, 2009; Cyprus Mail, 2010; Cyprus-Forum.com, 2010; de Alina, 2009; Dill, 2001; Dutch Daily News, 2009; ECMT, 1999; GAO, 2010; Global Trade Alert, 2010; Hahn, 1995; IHS Global Insight, 2010; International Energy Agency, 2010; International Monetary Fund, 2010; Jacobs, 1990; Joshi, 2010; OECD, 2010; PR Newswire 1993; Retire Your Ride, 2011; Romania-Insider.com, 2010; Root, 2010; San Joaquin Valley Air Pollution Control District, 2007; San Joaquin Valley Unified Air Pollution Control District, 2000; San Joaquin Valley Unified Air Pollution Control District, 2005; Santa Barbara County Air Pollution Control District, 2006; Santa Barbara County Air Pollution Control District, 2006b; Santa Barbara County Air Pollution Control District, 2006c; Santa Barbara Edhat, 2010; Smathers, 2011; Teskey, 2010a; Sokol & Harmacy; Teskey, 2010b; Texas Commission on Environmental Quality, 2011; Transport Canada, 2010; University of California, Los Angeles, 1999; Williams, J., 2010

Table 16

Central Intelligence Agency, 2011

Table 17

California Department of Finance; Southern California Association of Governments, 2000; U.S. Census Bureau, 2011.

Table 18

U.S. Census Bureau, 2011

Table 19

Calgary Economic Development, 2011; Central Intelligence Agency, 2011; Ministry of Citizens' Services Government of British Columbia, 2011

Table 20

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Table 21

ACEA, 2009; ACEA, 2010; Autoplus.fr, 2010; BIS, 2010; Canadiandriver.com, 2009; Cyprus Blog, 2009; Cyprus Mail, 2010; Cyprus-Forum.com, 2010; de Alina, 2009; Dutch Daily News, 2009; GAO, 2010; Global Trade Alert, 2010; IHS Global Insight, 2010; International Energy Agency, 2010; International Monetary Fund, 2010; Joshi, 2010; OECD, 2010; Retire Your Ride, 2011; Romania-Insider.com, 2010; Root, 2010; Teskey, 2010a; Teskey, 2010b;

Table 22

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Resources Board, 2005; California Air Quality Management District, 2009; California Board of Auto Repair, 2009; Dill, 2001; Hahn, 1995; Jacobs, 1990; PR Newswire 1993; San Joaquin Valley Air Pollution Control District, 2007; San Joaquin Valley Unified Air Pollution Control District, 2000; San Joaquin Valley Unified Air Pollution Control District, 2005; Santa Barbara County Air Pollution Control District, 2006; Santa Barbara County Air Pollution Control District, 2006b; Santa Barbara County Air Pollution Control District, 2006c; Santa Barbara Edhat, 2010; University of California, Los Angeles, 1999; Williams, J., 2010

Table 23

Alberini et al., 1995; Allan et al., 2009; Bearden, 1996; Cayting, 2011; Dill, 2001; Hahn, 1995; Smathers, 2011; Texas Commission on Environmental Quality, 2011

Table 24

British Columbia Scrap-It, 2010; Sokol & Harmacy; Transport Canada, 2010

Table 25

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ACEA, 2009; ACEA, 2010; Autoplus.fr, 2010; BIS, 2010; Canadiandriver.com, 2009; Cyprus Blog, 2009; Cyprus Mail, 2010; Cyprus-Forum.com, 2010; de Alina, 2009; Dutch Daily News, 2009; GAO, 2010; Global Trade Alert, 2010; IHS Global Insight, 2010; International Energy Agency, 2010; International Monetary Fund, 2010; Joshi, 2010; OECD, 2010; Retire Your Ride, 2011; Romania-Insider.com, 2010; Root, 2010; Teskey, 2010a; Teskey, 2010b;

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Table 28

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Table 29

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Table 30

Adda and Cooper, 2001; Allan et al., 2009; Baltas & Xepapadeas, 1999; Dill, 2001; ECMT, 1999

Table 31

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Fund, 2010; Joshi, 2010; OECD, 2010; Retire Your Ride, 2011; Romania-Insider.com, 2010; Root, 2010; Teskey, 2010a; Teskey, 2010b;

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Table 33

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Table 36

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Table 37

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Table 39

British Columbia Scrap-It, 2010; Sokol & Harmacy; Transport Canada, 2010

Table 40

Adda and Cooper, 2001; Allan et al., 2009; Baltas & Xepapadeas, 1999; Dill, 2001; ECMT, 1999

Table 41:

Number of Vehicles Retired

Excluded Programs – Total Monetary Investment: Greece, Unocal South Coast Recycled Auto Program (SCRAP III), Unocal South Coast Recycled Auto Program (SCRAP IV), Consumer Assistance Program 1, Consumer Assistance Program 3, REMOVE Program Phase I – IV, Delaware Vehicle Retirement Program, Illinois EPA, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, Alberta Clean Air Scrappage Pilot Project, Denmark, France, France, France, Greece, Spain, Ireland, Norway, Italy, Italy

Included Programs – Minimum Participant Incentive: Cyprus 1, Greece, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, United States, Old Car buyback program, Illinois EPA, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, France, Spain, Spain, Italy, Italy, Argentina

Excluded Programs – Maximum Participant Incentive: REMOVE Program Phases I

REMOVE Program Phase II-VIII, Denmark, France, Greece, Italy

Excluded Programs – Program Duration: Unocal South Coast Recycled Auto Program (SCRAP II-IV), REMOVE Program Phases I – VIII, Denmark, France, Italy

Excluded Programs – Minimum Vehicle Age: Consumer Assistance Program California Consumer Assistance Program (all years), REMOVE Program Phase I-VIII, High Emitter or Scrap I (HEROS), France, Hungary, Italy, Italy

Table 42

Number of Vehicles Retired

Excluded Programs – Total Monetary Investment: Greece, Unocal South Coast Recycled Auto Program (SCRAP III), Unocal South Coast Recycled Auto Program (SCRAP IV), Consumer Assistance Program 1, Consumer Assistance Program 3, REMOVE Program Phase I – IV, Delaware Vehicle Retirement Program, Illinois EPA, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, Alberta Clean Air Scrappage Pilot Project, Denmark, France, France, France, Greece, Spain, Ireland, Norway, Italy, Italy

Included Programs – Minimum Participant Incentive: Cyprus 1, Greece, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, United States, Old Car buyback program, Illinois EPA, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, France, Spain, Spain, Italy, Italy, Argentina

Excluded Programs – Maximum Participant Incentive: REMOVE Program Phase I-VIII, Denmark, France, Greece, Italy

Excluded Programs – Program Duration: Unocal South Coast Recycled Auto Program (SCRAP II-IV), REMOVE Program Phases I – VIII, Denmark, France, Italy

Excluded Programs – Minimum Vehicle Age: Consumer Assistance Program California Consumer Assistance Program (all years), REMOVE Program Phase I-VIII, High Emitter or Scrap I (HEROS), France, Hungary, Italy, Italy

Table 43

Total Monetary Investment

Included Programs - Minimum Incentive: Cyprus, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, Spain, United States, Old Car buyback program, REMOVE Program Phase I, REMOVE Program Phase II, REMOVE Program Phase III, REMOVE Program Phase IV, REMOVE Program Phase V, REMOVE Program Phase VI, REMOVE Program Phase VII, REMOVE Program Phase VIII, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Argentina

Excluded Programs – Maximum Incentive: Greece, Unocal South Coast Recycled Auto Program (SCRAP III), Unocal South Coast Recycled Auto Program (SCRAP IV), Consumer Assistance Program, Consumer Assistance Program, Delaware Vehicle Retirement Program, Illinois EPA, Scrap-It Pilot Program, Scrap-It Program, Alberta Clean Air Scrappage Pilot Project, Denmark, France, France, France, Greece, Spain, Spain, Ireland, Norway, Italy, Italy

Excluded Programs – Program Duration: Unocal South Coast Recycled Auto Program (SCRAP III), Unocal South Coast Recycled Auto Program (SCRAP IV), Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Delaware Vehicle Retirement Program, Illinois EPA, Scrap-It Pilot Program, Scrap-It Program, Alberta Clean Air Scrappage Pilot Project, Denmark, France, France, France, Greece, Spain, Spain, Ireland, Norway, Italy, Italy, Old Car buyback program

Excluded Programs – Minimum Vehicle Age Requirement: Greece, Unocal South Coast Recycled Auto Program (SCRAP III), Unocal South Coast Recycled Auto Program (SCRAP IV), Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, High Emitter or Scrap I (HEROS), Delaware Vehicle Retirement Program, Illinois EPA, Scrap-It Pilot Program, Scrap-It, Alberta Clean Air Scrappage Pilot Project, Denmark, France, France, France, Greece, Hungary, Spain, Spain, Ireland, Norway, Italy, Italy

Table 44

Total Monetary Investment

Included Programs - Minimum Incentive: Cyprus, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, Spain, United States, Old Car buyback program, REMOVE Program Phase I, REMOVE Program Phase II, REMOVE Program Phase III, REMOVE Program Phase IV, REMOVE Program Phase V, REMOVE Program Phase VI, REMOVE Program Phase VII, REMOVE Program Phase VIII, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Argentina

Excluded Programs – Maximum Incentive: Greece, Unocal South Coast Recycled Auto Program (SCRAP III), Unocal South Coast Recycled Auto Program (SCRAP IV), Consumer Assistance Program, Consumer Assistance Program, Delaware Vehicle Retirement Program, Illinois EPA, Scrap-It Pilot Program, Scrap-It Program, Alberta Clean Air Scrappage Pilot Project, Denmark, France, France, France, Greece, Spain, Spain, Ireland, Norway, Italy, Italy

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Excluded Programs – Minimum Vehicle Age Requirement: Greece, Unocal South Coast Recycled Auto Program (SCRAP III), Unocal South Coast Recycled Auto Program (SCRAP IV), Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, Consumer Assistance Program, High Emitter or Scrap I (HEROS), Delaware Vehicle Retirement Program, Illinois EPA, Scrap-It Pilot Program, Scrap-It, Alberta Clean Air Scrappage Pilot Project, Denmark, France, France, France, Greece, Hungary, Spain, Spain, Ireland, Norway, Italy, Italy

Table 45

Minimum Incentive Amount

Included Programs – Maximum Incentive Amount: Cyprus, Greece, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, Spain, United States, Old Car buyback program, REMOVE Program Phase I- VIII, Illinois EPA, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, France, Spain, Spain, Italy, Italy, Argentina

Included Programs – Program Duration: Cyprus, Greece, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, Spain, United States, Old Car buyback program, REMOVE Program Phase I- VIII, Illinois EPA, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, France, Spain, Spain, Italy, Italy, Argentina

Included Programs – Minimum Vehicle Age: Cyprus, Greece, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, Spain, United States, Old Car buyback program, REMOVE Program Phase I- VIII, Illinois EPA, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, France, Spain, Spain, Argentina

Table 46

Minimum Incentive Amount

Included Programs – Maximum Incentive Amount: Cyprus, Greece, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, Spain, United States, Old Car buyback program, REMOVE Program Phase I- VIII, Illinois EPA, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, France, Spain, Spain, Italy, Italy, Argentina

Included Programs – Program Duration: Cyprus, Greece, Italy, Luxembourg, The Netherlands, Portugal, Portugal, Slovakia, Slovakia, Spain, United States, Old Car buyback program, REMOVE Program Phase I- VIII, Illinois EPA, Drive a Clean Machine, High Pollution Vehicle Retirement Pilot Program, Scrap-It Pilot Program, Scrap-It, France, Spain, Spain, Italy, Italy, Argentina

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Table 47

Maximum Incentive Amount

Excluded Programs – Program Duration: UNOCAL SCRAP II-IV, France and Greece (Group 5)

Excluded Programs – Minimum Vehicle Age Requirement: California Consumer Assistance Programs 1-7, HEROS, Denmark, France, Greece, Hungary, Italy, Italy

Table 48

Maximum Incentive Amount

Excluded Programs – Program Duration: UNOCAL SCRAP II-IV, France and Greece (Group 5)

Excluded Programs – Minimum Vehicle Age Requirement: California Consumer Assistance Programs 1-7, HEROS, Denmark, France, Greece, Hungary, Italy, Italy

Table 49

Program Duration

Excluded Programs – Minimum Vehicle Age Requirement: UNOCAL SCRAP II-IV, California Consumer Assistance Programs 1-7, Denmark, France, Greece, Hungary, Italy, Italy

Table 50

Excluded Programs - Minimum Vehicle Age Requirement: UNOCAL SCRAP II-IV, California Consumer Assistance Programs 1-7, Denmark, France, Greece, Hungary, Italy, Italy

Table 52

ACEA, 2009; ACEA, 2010; Autoplus.fr, 2010; BIS, 2010; Canadiandriver.com, 2009; Cyprus Blog, 2009; Cyprus Mail, 2010; Cyprus-Forum.com, 2010; de Alina, 2009; Dutch Daily News, 2009; GAO, 2010; Global Trade Alert, 2010; IHS

Global Insight, 2010; International Energy Agency, 2010; International Monetary Fund, 2010; Joshi, 2010; OECD, 2010; Retire Your Ride, 2011; Romania-Insider.com, 2010; Root, 2010; Teskey, 2010a; Teskey, 2010b;
2010b;

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Table 54

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Table 58

Arcemont, Gary, 2011; Bay Area Air Quality Management District, 2010; Bay Area Air Quality Management District, 2010b; Bearden, 1996; California Air Resources Board, 2005; California Air Quality Management District, 2009; California Board of Auto Repair, 2009; Dill, 2001; Hahn, 1995; Jacobs, 1990; PR Newswire 1993; San Joaquin Valley Air Pollution Control District, 2007; San Joaquin Valley Unified Air Pollution Control District, 2000; San Joaquin Valley Unified Air Pollution Control District, 2005; Santa Barbara County Air Pollution Control District, 2006; Santa Barbara County Air Pollution Control District, 2006b; Santa Barbara County Air Pollution Control District, 2006c; Santa Barbara Edhat, 2010; University of California, Los Angeles, 1999; Williams, J., 2010

Table 59

Alberini et al., 1995; Allan et al., 2009; Bearden, 1996; Cayting, 2011; Dill, 2001; Hahn, 1995; Smathers, 2011; Texas Commission on Environmental Quality, 2011

Table 60

British Columbia Scrap-It, 2010; Sokol & Harmacy; Transport Canada, 2010

Table 61

Adda and Cooper, 2001; Allan et al., 2009; Baltas & Xepapadeas, 1999; Dill, 2001; ECMT, 1999

Table 90

Ecological Impact

Included Programs – Number of Vehicles Retired: Unocal South Coast Recycled Auto Program (SCRAP), Unocal South Coast Recycled Auto Program (SCRAP II), Old Car buyback program, Consumer Assistance Program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, High Emitter or Scrap I (HEROS), Delaware Vehicle Retirement Program, Total Clean Cars Program, Illinois EPA, United States

Included Programs – Total Monetary Investment

Included Programs – Maximum Participant Incentive: Unocal South Coast Recycled Auto Program (SCRAP), Unocal South Coast Recycled Auto Program (SCRAP II), Old Car buyback program, Consumer Assistance Program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, High Emitter or Scrap I (HEROS), Total Clean Cars Program, United States, REMOVE Program Phase I-VIII

Included Programs – Program Duration: Unocal South Coast Recycled Auto Program (SCRAP), Old Car buyback program, Consumer Assistance Program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, High Emitter or Scrap I (HEROS), Delaware Vehicle Retirement Program, Total Clean Cars Program, Illinois EPA, United States, REMOVE Program Phase I - VIII

Include Programs – Minimum Vehicle Age Requirement: Unocal South Coast Recycled Auto Program (SCRAP), Unocal South Coast Recycled Auto Program (SCRAP II), Old Car buyback program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, Delaware Vehicle Retirement Program, Total Clean Cars Program, Illinois EPA, United States, REMOVE Program Phase I-VIII

Table 91

Ecological Impact

Included Programs – Number of Vehicles Retired: Unocal South Coast Recycled Auto Program (SCRAP), Unocal South Coast Recycled Auto Program (SCRAP II), Old Car buyback program, Consumer Assistance Program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, High Emitter or Scrap I (HEROS), Delaware Vehicle Retirement Program, Total Clean Cars Program, Illinois EPA

Included Programs – Total Monetary Investment

Included Programs – Maximum Participant Incentive: Unocal South Coast Recycled Auto Program (SCRAP), Unocal South Coast Recycled Auto Program (SCRAP II), Old Car buyback program, Consumer Assistance Program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, High Emitter or Scrap I (HEROS), Total Clean Cars Program, REMOVE Program Phase I-VIII

Included Programs – Program Duration: Unocal South Coast Recycled Auto Program (SCRAP), Old Car buyback program, Consumer Assistance Program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, High Emitter or Scrap I

(HEROS), Delaware Vehicle Retirement Program, Total Clean Cars Program, Illinois EPA, REMOVE Program Phase I - VIII

Include Programs – Minimum Vehicle Age Requirement: Unocal South Coast Recycled Auto Program (SCRAP), Unocal South Coast Recycled Auto Program (SCRAP II), Old Car buyback program, Vehicle Buy-Back Program, Vehicle Buy-Back Program, Delaware Vehicle Retirement Program, Total Clean Cars Program, Illinois EPA, REMOVE Program Phase I-VIII

Appendix B. Subgroup Analysis

Number of Vehicles Retired

How are the number of vehicles retired in a program affected by that program's total monetary investment, offered individual incentive, length of duration, and minimum vehicle age requirement?

Investment

Insufficient data resulted in an inability to calculate correlations between the total amount invested in a program and the total number of vehicles retired for Groups 4 and 5. Table 94 details correlations for individual programs and total program investment.

Table 96: Correlation Table: Total Investment and Number of Vehicles Retired

Group	*Correlation Coefficient*	*Coefficient of Determination*	*%*	*Slope*
Group 1: Worldwide Programs (2009 - 2010)	0.92420853	0.85416140	85%	0.000247302
Group 2: California Programs (1990 - 2010)	0.88738871	0.78745873	78%	0.000625629
Group 3: U.S. State-Based Programs (1992 - 2010)	0.99999741	0.99999483	99%	0.000311097
All Groups	0.77415292	0.59931275	59%	0.000256617

Minimum Incentive

When only one incentive amount was known, that data was categorized to be the maximum incentive amount. Therefore, the minimum incentive amount was known for very few programs. Insufficient data resulted in an inability to calculate correlations between a program's minimum incentive and the total number of vehicles retired for Groups 2 and 4. Table 95 details correlations for all programs

Table 97: Correlation Table: Minimum Incentive and Number of Vehicles Retired

Group	*Correlation Coefficient*	*Coefficient of Determination*	*%*	*Slope*
Group 1: Worldwide Programs (2009 - 2010)	0.67915941	0.46125750	46%	232.624658
Group 3: U.S. State-Based Programs (1992 - 2010)	0.98985433	0.97981160	98%	18.70691739
Group 5: Worldwide Programs (1992 - 2000)	0.66402903	0.44093455	44%	1663.395474
All Groups	0.30089911	0.090540273	9%	124.3298422

Maximum Incentive

The maximum incentive amount offered to program participants was located for all programs except the 1991 – 1993 Greek program.

Table 98: Correlation Table: Maximum Incentive and Number of Vehicles Retired

Group	Correlation Coefficient	Coefficient of Determination	%	Slope
Group 1: Worldwide Programs (2009 - 2010)	0.42065868	0.17695372	17.7%	106.7
Group 2: California Programs (1990 - 2010)	0.45359418	0.20574768	20.6%	25.08
Group 3: U.S. State-Based Programs (1992 - 2010)	0.88822989	0.78895234	78.9%	13.66
Group 4: Canadian Programs (1996 - 2002)	0.87031408	0.75744659	75.7%	47.78
Group 5: Worldwide Program (1992 - 2000)	-0.12691684	0.01610789	1.6%	-41.65
All Groups	0.61263598	0.37532284	37.5%	88.02

Program Duration

Program duration was calculated by first finding the number of days between a programs' start and end date. The calculated number of days was then divided by 31, the approximate average number of days in a given month. Duration values represent the approximate number of months of a program's tenure. Several programs are ongoing. For an exact list of program dates, see Table 6.

Table 99: Correlation Table: Program Duration and Total Number of Vehicles Retired

Group	*Correlation Coefficient*	*Coefficient of Determination*	*%*	*Slope*
Group 1: Worldwide Programs (2009 - 2010)	0.08778092	0.00770549	0.8%	6464.63
Group 2: California Programs (1990 - 2010)	0.01174187	0.00013787	0.0%	5.66
Group 3: U.S. State-Based Programs (1992 - 2010)	0.92343825	0.85273821	85.3%	1342.35
Group 4: Canadian Programs (1996 - 2002)	-0.09206049	0.00847513	0.8%	-7.98
Group 5: Worldwide Program (1992 - 2000)	-0.06242563	0.00389696	0.4%	-2500.39
All Groups	-0.13562891	0.01839520	1.8%	-1008.05

Minimum Vehicle Age Requirement

The minimum vehicle age requirement for a vehicle to be eligible for a given program was not found for California's Consumer Assistance Program, Denmark, and the 1992 French program. Hungary, Italy's 1997 and 1998 pro grams, and the California HEROS program based eligibility on other factors, and were thus excluded.

Table 100: Correlation Table: Minimum Vehicle Age and Total Number of Vehicles Retired

Group	*Correlation Coefficient*	*Coefficient of Determination*	*%*	*Slope*
Group 1: Worldwide Programs (2009 - 2010)	-0.25096514	0.06298350	6.3%	-52750.42903
Group 2: California Programs (1990 - 2010)	-0.49639624	0.24640923	24.6%	-1044.859935
Group 3: U.S. State-Based Programs (1992 - 2010)	-0.91356090	0.83459351	83.5%	-13845.5
Group 4: Canadian Programs (1996 - 2002)	-0.90251464	0.81453267	81.5%	-2796.721311
Group 5: Worldwide Program (1992 - 2000)	0.23005221	0.05292402	5.3%	20204.77273
All Groups	-0.23725438	0.05628964	5.6%	-47904.7066

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