

**An Examination of the CAFE Standards and Mandatory Environmental
Regulations**

By

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Abstract

Purpose: The purpose of this study to understand how changes in the Corporate Average Fuel Economy (CAFE) standards affect fuel efficiency of foreign and domestic passenger cars.

Method: This project utilizes two interrupted time series regression analyses with comparison groups to test formal hypotheses. This research evaluates longitudinal trends before and after the manipulation of the CAFE standard in order to determine the effect the change has had on the fuel efficiency of both vehicle groups. *Results:* The interrupted time series regression analyses show that both foreign and domestic fuel economy averages significantly increased following the implementation of the CAFE standards. Additionally, the test show following the stagnation of the policy, there is a significant decrease in the trend lines of both vehicle groups.

About the Author



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Chapter One: Introduction

In today's global automobile market, fuel efficiency is a key feature many consumers demand. Ever increasing gasoline prices and longer commutes to and from work have caused consumers to reexamine the way in which they buy and use their automobiles. This change in behavior is a bit surprising considering the fact that in previous decades previous the United States was devoid of legislation which set a minimum fuel economy standard for a fleet. Prior to the establishment of a minimum standard, fuel economy was not as big a factor in the purchasing of an automobile for consumers and automobile makers failed to approach the issue citing a lack of consumer demand or government regulation.

However, by 1975 these attitudes changed due to the global oil market and domestic legislation. In the aftermath of the 1973 Arab oil embargo against the United States, Congress enacted legislation which set a minimum fleet fuel economy standard for all passenger cars sold in America. The Corporate Average Fuel Economy Standards, commonly referred to as the CAFE standards, established a minimum standard for fuel economy. While this legislation enacted a minimum standard, it also began a fervent debate on what is the best way to regulate fuel consumption in the United States.

While several aspects of this policy deserve investigation, this study focuses on the issue of mandatory environmental standards. By examining the history, the hallmark features and the economic effects of mandatory regulation, this study develops formal hypotheses relating to how changes in mandatory standards affect fuel efficiency of vehicles.

Research Purpose

This research utilizes regression analysis to test hypotheses relating to how changes in mandatory environmental regulation standards affect fuel efficiency of vehicles. This research specifically focuses on the impact the CAFE standards have on the fuel efficiency of passenger cars. This project uses two interrupted time series regression analyses with comparison groups to test the impact changes in fuel economy standards have on the fuel efficiency outputs for both foreign and domestic passenger cars. The research evaluates longitudinal trends before and after the manipulation of the fuel economy standards for the pair of interrupted time series regressions in order to test formal hypotheses. The results of this study will provide policymakers with an understanding of how adjustments in the minimum standard affect fuel efficiency outputs.

Chapter Preview

This study is organized in six chapters. Chapter Two of this study presents the historical background of the CAFE standards. The chapter discusses the events leading to the establishment of the CAFE standards, the development of the legislation, and fuel consumption trends of the United States since the implementation of the minimum standard. Chapter Three presents a thorough review of the relevant literature concerning the larger issue of federal mandatory environmental regulation. This chapter examines this issue by discussing the history of mandatory environmental regulation, highlighting its hallmark features and reviewing the economic externalities which are associated with this type of policy. Chapter Four presents an overview of the methodology used in this study. In this chapter, specific detail is given regarding the collection of data, the variables examined and the interrupted time series regression used in

this study. Chapter Five of this study presents the results of the two interrupted time series regression analyses. Chapter Six of this study analyzes the results of Chapter Five and presents conclusions of the research.

Chapter Two: Setting

Chapter Purpose

This chapter provides an analysis of the policy formation of the CAFE standards and a history of the benchmark requirements throughout the years. Later this chapter examines fuel consumption trends since the establishment of the CAFE standards.

Policy History of Fuel Efficiency Regulations

Prior to 1973, America's energy policy was guided by the assumptions that the private market could most affectively provide abundant and inexpensive fuel to the nation and that a comprehensive energy policy was not needed. Although limited regulation on energy production and consumption were in place in the United States during this period, these measures acted more as a stabilization mechanism for price control rather than any real attempt to curtail pollution and over consumption. The limited patch-work of state and federal regulation was "designed to encourage consumption with little emphasis on efficiency or [energy] independence" (Cochran et al. 2003, 108).

By October of 1973, in the midst of the Arab-Israeli War, these previously held assumptions regarding energy security and availability were challenged to their core. When Arab members of OPEC announced an embargo against the United States in response to the U.S. decision to re-supply the Israeli military, America experienced a severe energy shortage. The previously held assumptions relating to price stability and availability of oil were quickly

replaced with the realization that despite its economic and military supremacy, America was unquestionably at the mercy of these oil producing nations.

As fuel prices skyrocketed and supply fell, congressional leaders collectively recognized the need for legislation which would reduce consumption rates and increase energy independence. The patch-work method of regulating consumption previously employed by the government was rejected and replaced with more a comprehensive top-down approach – the CAFE standards (US State Department 2009).

Policy Formation

In 1975, Congress enacted The Energy Policy Conservation Act which added Title V, “Improving Automotive Efficiency,” to the Motor Vehicle Information and Cost Savings Act. This legislation established the CAFE provisions, legislation designed to “address concerns relating to energy conservation, energy security and to a lesser extent issues of air quality” (Geckil 2003, 50). The hallmark of the CAFE standards was the fact it was the first piece of legislation which sought to reduce energy consumption and increase fuel efficiency by increasing the fuel economy standards of passenger cars by double within a decade of implementation (Bamberger 2003). This lofty goal to double fuel economy of passenger cars to 27.5 miles per gallon (MPG) showed Congress felt a real need to curtail the ever increasing problem of over consumption – which at its core ties into larger issues of national defense, energy independence and environmental protection.

In order to achieve the goal of an average fuel economy of 27.5 MPG for cars by 1985, Congress set benchmarks throughout the intervening years. For 1978, Congress set fuel economy

levels to 18 MPG, 19 MPG the following year, and 20 MPG by 1980. Per the original legislation, the 1981-84 standards would be left to the discretion of the Department of Transportation (NHTSA 2009). By 1985, the CAFE standard for cars was 27.5 MPG. This standard was written into law by Congress and was not subject to the judgment of the agency as were the previous four years. The 1985 requirement was the last time the standard would be mandated by Congress. After this point, that decision was the responsibility of the Executive branch.

Table 2.1: CAFE Standard for Passenger Cars by Model Year

Source: National Highway Traffic Safety Administration (NHTSA)

Model Year	CAFE Standard	Model Year	CAFE Standard
1978	18	1993	27.5
1979	19	1994	27.5
1980	20	1995	27.5
1981	22	1996	27.5
1982	24	1997	27.5
1983	26	1998	27.5
1984	27	1999	27.5
1985	27.5	2000	27.5
1986	26	2001	27.5
1987	26	2002	27.5
1988	26	2003	27.5
1989	26.5	2004	27.5
1990	27.5	2005	27.5
1991	27.5	2006	27.5
1992	27.5	2007	27.5
		2008	27.5

After 1986, the power to set the CAFE standards returned to the discretion of the Department of Transportation. This return of power resulted in a lowering of CAFE standards initially. In 1986, the CAFE standard for cars was reduced to 26 MPG, an over 5% decrease from the standards set forth by Congress a decade previous. Given the fact that in only a decade the CAFE standard for cars was raised by 100%, the decrease in the standard stood in sharp contrast

to the spirit of the original legislation. Clearly the factors and the sentiments that had caused the original legislation were no longer present.

The crisis-based mindset which had galvanized lawmakers to take the unprecedented step of mandating efficiency outputs of automakers was no longer present. In the decade following implementation of the original legislation, several of the factors that had given birth to the bold policy of CAFE had faded away. First, America's relationship with OPEC and other oil producing nations had been restored. This restoration positively affected oil's price and availability to the U.S. market. Additionally during this period, the Reagan administration sought to reduce government regulation in a number of policy areas, but specifically in terms of environmental policy. This hostility towards regulation coupled with the fact that American automakers began to see market share losses due to the rise of foreign producers during this period resulted in the stagnation of the CAFE standards.

The lowered CAFE standard for cars continued throughout the Reagan administration on into George Herbert Walker Bush's term. By 1990, the CAFE standard for cars was amended and returned to the 1985 standard of 27.5 MPG (Kirby 1995). From 1985 till 2008, no administration had taken action to increase CAFE standards for passenger cars despite the fact that from 1975-1984, CAFE increased the fuel economy of the entire United States motor fleet (cars and light trucks) by 70% (Callahan 2004).

In May 2009, President Obama's administration announced an increase of the CAFE standards for the first time in 19 years. As reported in the November 17th edition of the *Wall Street Journal*, beginning in 2011, new CAFE standards for passenger cars will increase fuel economy levels to 35.5 MPG by 2016, an increase of nearly 18% (2010).

Fuel Consumption Trends

The total average fuel efficiency output for the entire US fleet following 1985 was affected by not only the stagnation of the CAFE standards but also by the increase of sales in the Sport Utility Vehicle (SUV) market. Heavier and less fuel efficient than their passenger car counterparts, SUVs were subject to the provision of the CAFE standards which regulated “light trucks,” which per the legislation is define as a vehicle not classified as a passenger car, with a gross vehicle weight rating of 6,000 pounds or less. By 1991, these vehicles were subject to a CAFE standard of 20.7 mpg for 2-wheel drive models and 19.1 mpg for 4-wheel models respectively (NTHSA 2009).

According to Coggburn and Rahm, when the original legislation was written in 1975, light trucks accounted for only 2 million of the 10 million new vehicles sold in the United States (2007). But since 1975, the growth of the light truck market in the U.S., fueled by a spike in SUV sales, increased dramatically. By 2001, 51% of the 17 million vehicles sold that year were classified as light-duty trucks (2007). Over the course of the decade of the 2000s, heavier, less fuel efficient vehicles began to dominate the market.

Table 2.2: Sales Figures of New Passenger Cars and Light Trucks: 1978-2008 (In Thousands)

Source: National Highway Traffic Safety Administration (NHTSA)

Model Year	Cars	Trucks	Total	Model Year	Cars	Trucks	Total
1978	11,314	4,109	15,423	1993	8,518	5,681	14,199
1979	10,673	3,480	14,153	1994	8,991	6,421	15,411
1980	8,949	2,494	11,444	1995	8,635	6,481	15,116
1981	8,489	2,289	10,778	1996	8,527	6,929	15,456
1982	7,956	2,582	10,538	1997	8,272	7,226	15,498
1983	9,148	3,163	12,312	1998	8,142	7,826	15,967
1984	10,324	4,159	14,483	1999	8,698	8,716	17,415
1985	10,979	4,746	15,725	2000	8,847	8,965	17,812
1986	11,404	4,919	16,323	2001	8,423	9,050	17,472
1987	10,192	5,001	15,193	2002	8,103	9,035	17,139
1988	10,547	5,245	15,792	2003	7,610	9,357	16,967
1989	9,779	5,067	14,845	2004	7,545	9,753	17,299
1990	9,303	4,846	14,149	2005	7,720	9,725	17,444
1991	8,185	4,365	12,550	2006	7,821	9,228	17,049
1992	8,213	4,904	13,117	2007	7,618	8,842	16,460
				2008	6,813	6,680	13,493

In addition to the fact Americans began driving less fuel efficient vehicles following 1985, Americans also increased the number of miles they drove on average. According to Dunn and Peel, the total number of miles driven by Americans increased by 1.5 billion miles since 1985 (2007). In short, during this period of CAFE stagnation, the U.S. added more drivers, who drove less efficient vehicles, farther than ever before.

This combination of factors has resulted in a motor fleet that actually consumes more today than in 1985. According to the General Accountability Office (GAO), the high water mark for fuel economy was achieved in 1987 with an aggregate average of 26.2 mpg. By 2004, this average was lower to 24.6 mpg (2007).

Chapter Three: Literature Review

Chapter Purpose

Mandatory environmental regulation has been the primary approach employed by the federal government to prevent environmental pollution. Through the use of top-down, command and control style regulation, the federal government has reduced consumption, promoted efficiency and increased environmental awareness in a number of policy areas (Callahan 2004). Despite these achievements, this method of regulating environmental issues is not without controversy or critics (Stewart 2001; Sergerson and Miceli 1998). Although the use of mandatory regulation was popular early in the development of environmental protection policy, new methods of regulating industry have taken root in the past few decades. For this reason, the literature on mandatory environmental regulation is divided and there is no universal agreement on its merits or flaws. This chapter reviews these arguments in an attempt to understand how changes in mandatory standards affect an industry.

This chapter examines the debate by exploring the relevant literature with specific examples. One of these examples featured in this review is the Corporate Average Fuel Economy (CAFE) standards, the legislation which governs fuel efficiency outputs for foreign and domestic passenger cars. This legislation is referenced in part because the CAFE standards employ a mandatory environmental regulation approach and provide this study with a concrete example of theories of the mandatory method mentioned in the literature. Additionally, this study references this legislation because many of the arguments for and against the use of mandatory environmental regulation are also found in the debate concerning the CAFE standards.

First, this chapter provides a history of the mandatory environmental regulation. Next, this literature review examines the mandatory approach's hallmark features. This section is followed by a review of the literature pertaining to voluntary environmental regulation, a counter approach employed by governments in recent years. By reviewing the hallmarks of the voluntary approach, this section expands upon the reader's understanding of the mandatory approach through the use of a comparative analysis. Lastly, this chapter examines the economic impacts of mandatory environmental regulation on industry, an aspect of this discussion which is highly debated in the literature. It is from this review of the literature that a set of formal hypotheses are developed to explain how changes in the mandatory requirements affect efficiency outputs for an industry.

Hallmarks of the Mandatory Environmental Regulation Approach

Relying upon relevant literature, this section of the chapter takes a systematic approach to understanding the components of mandatory environmental regulation, namely its operational approach and its impacts upon industry. From this understanding, a set of hypotheses are developed to explain how changes in mandatory standards affect efficiency outputs.

History of Mandatory Environmental Regulation

Mandatory environmental regulation began during the late 1960s and early 1970s, most notably with programs like the Clean Air Act, the Clean Water Act and the CAFE standards. The signature feature of these types of programs was the fact they were top down, federally mandated

policies in which the federal government through the use of its agencies administered concrete regulations and pollution limits on specifically targeted industries. For the first half of the environmental regulation policy era, this approach of mandatory regulations was the method most commonly employed by the federal government. Beginning in 1961 through 1980, twenty-five of these types of mandatory regulation measures were enacted (Welbon 1988).

According to Welbon (1988), this method of regulating environmental issues was employed by the federal government for two primary reasons. Prior to the era of federal environmental regulation, the states acted as the primary governing bodies for environmental protection. However, since universal mandates and requirements on pollution controls could not be enforced on every state, gaps in coverage arose. Due to these gaps in coverage, universal federal mandates were seen by a many citizens as the best method to correcting this problem and thus these types of top-down policies were birthed. During this period, the idea that the federal government should “emerge as the dominant force in environmental regulation” was one held in high regard by several segments of the population (Welbon 1988, 28; Buttel 2003).

With the federal government acting as the primary enforcer of environmental regulation, some pollution containment rates improved following implementation. However, despite the increases in cleaner air and water rates, some observers felt the increased role of the federal government and diminished role of the states would lead to ineffective policy and an intrusion into states’ and localities’ jurisdiction.

Additionally, mandatory regulation was employed on the federal level during this period in order to establish a universal baseline minimum standard across the states. This minimum standard would allow states the ability to exceed these standards in specific problem areas.

Current examples of this idea can be seen in California's decades-long attempt to reduce air pollution. While the federal government through the use of the Clean Air Act's mandatory regulation approach requires certain air minimums, the state of California has routinely exceeded this mark.

From a review of the literature, several hallmarks of the mandatory approach emerge. It is from these systemic hallmarks that hypotheses relating to how changes in mandatory standards affect efficiency outputs are developed.

The Prescriptive Nature of Mandatory Regulation

Mandatory environmental regulation is characterized by the fact it is governed by law and not negotiated contracts. Under this approach of regulating an industry, producers are subject to regulations which limit "the quantity of pollution emissions or the use of specific abatement technology" (Henriques and Sadorsky 2008, 143). By specifying the exact method by which an industry can operate, the mandatory environmental regulatory approach is highly prescriptive in nature.

The prescriptive nature of mandatory environmental regulation creates two outcomes. First, in order to regulate an industry in a prescriptive manner, expertise is needed by the regulating body. This increases both the size of the regulatory agency and their operating budget. For the agency to effectively prescribe the operational methods employed by the industry, significant investment in human capital and technology is needed. Additionally, development of elaborate testing methods for the specific industry also has to occur (Henriques and Sadorsky 2008). This was such the case for the CAFE standards.

Per the legislation, the CAFE standards are handled in a bi-agency approach. For its part, the National Highway Traffic Safety Administration (NHTSA) is responsible for the administrative tasks of establishing and amending the CAFE standards as well as promulgating regulations thereof. The NHTSA also creates definitions, clarifies vehicle lines as either “cars” or “trucks,” reviews petitions for exemption and enforces non-compliance. Additionally, the agency is responsible for data collection and annual reporting of its findings. This data collected and the annual reports by NHTSA provide the basis for the statistical analyses employed later in this study. For its part, the Environmental Protection Agency (EPA) is responsible for calculating the average fuel economy for each manufacturer and certifying CAFE compliance (EPA 2009).

Critics of mandatory environmental regulation would point to the bi-agency approach employed by CAFE as proof that these types of policies are wasteful and ineffective. According to Henriques and Sadorsky (2008, 143), this type of command-and-control regulatory action has severe limitations, namely “expense and protracted development,” which only increase cost to both the firm and the regulatory body. Furthermore, due to the extended protracted development of mandatory regulation, these types of programs actually hurt the chances of industry and government to promote continued pollution prevention. While the authors concede mandatory regulation can induce short-term gains in reduction of emissions or efficiency outputs, as seen following the implementation of the Clean Air Act and the Clean Water Act, Henriques and Sadorsky feel these types of programs affect the long term health of an industry. In looking at the longitudinal trends of fuel efficiency outputs, their hypothesis could explain in part the variability of the efficiency output trend lines in both foreign and domestic passenger cars since the 1960s.

In addition to increased cost and protracted development, the literature also states the prescriptive nature of mandatory environmental regulation creates a second outcome. The infringement upon industry with legislated specific rules and modes of operating can create hostility between the regulators and the regulated industry. Since baseline pollution controls are mandated by government, the relationship between industry and government is one of subservience (Lyon and Maxwell 2001). As one could expect, this dimension of subservience in the relationship can be counterproductive to the development of a strong, cooperative partnership. It is for this reason more recent attempts to regulate environmental issues have taken a counter approach to mandatory environmental regulation, and sought voluntary associations.

Voluntary Environmental Regulation: A Counter to the Traditional Mandatory Approach

Under a voluntary method of regulating environmental concerns, government seeks cooperation between business and other third-party organizations in order to “set forth a specific rationale to identify and guide the pursuit of improved environmental performance” (Darnell and Sides 2008, 95). The core difference between the voluntary approach and the mandatory approach employed by the first generation of large scale top-down environmental programs is the fact the voluntary agreements are governed by negotiated contracts and not mandated law.

In the view of supporters like Sergerson and Miceli (1998), this approach encourages proactive cooperation between industry and regulators. This cooperation can reduce conflicts in both the short term and the long term, thereby mitigating one of the key complaints found in the literature concerning the mandatory system; regulation breeds hostility and contempt. Furthermore, devoid of the hostility which permeates through the relationship of a mandatory

regulation, supporters of this method feel the likelihood of productive partnerships between the regulated industry and the regulatory body increases with the use of voluntary contracts.

Additionally, supporters feel with cooperation as the basis of the relationship, voluntary regulation increases the “ability [of industry] to meet environmental targets more quickly” and eliminates the prescriptive aspects of the mandatory approach (Sergerson and Miceli 1998, 110). Instead of having to rely on the mechanisms of government and the “protracted development” which typically accompanies environmental regulation policies, voluntary contracts can expedite the process through unilateral or multilateral agreements between government, industry and other third parties (environmental protection groups, business coalitions, etc.).

Blackman (2008) found in both developed and developing countries, this method of voluntary agreements has increased in usage over the years. He attributes the increase use of this system to the fact that governments can incentivize voluntary systems for firms, an aspect not typically found in mandatory regulation. By employing this method of incentives, Blackman feels governments can accomplish better results with less cost to the parties involved.

Cutter and Neidell also found increased use of this approach by firms throughout the world. According to these authors, this approach has increased in use (aside from purely altruistic reasons) because it “affects profits through changes in consumer demand” (2009, 253). Because firms do not want to appear to their consumer base as anti-environmental protection, firms seek out these voluntary measures to promote their “corporate environmentalism.” In their findings, it behooves firms to engage in voluntary agreements because it simultaneously increases their company profile, increases their profits and provides more flexibility to the firm than a mandatory regulation. Furthermore, Cabugueira found “the growing ‘environmental

awareness' of the different economic agents" requires these firms to participate in techniques which promote, or give the appearance of promoting, good corporate environmentalism (2001, 121).

Mandatory Firmness and Voluntary Flexibility

Since the voluntary environmental regulation is negotiated for a specified term, this approach allows for greater flexibility for industry to address short term economic concerns. For Stewart, it is this change in approach which has the ability to combat environmental issues far better than the traditional approach which in his view has "reach[ed] its inherent limits and is no longer capable of ensuring sustainable progress" (2001, 21). This view is widely held in the literature (Black 2008; Cutter and Neidell 2009). In these authors' view, the use of the mandatory approach only encourages baseline compliance and not continued advancement.

While the economic effects of environmental regulation are discussed at length later in this chapter, it should be pointed out that supporters of the voluntary environmental regulation feel this method protects firms from economic disaster far better than the mandatory environmental method. Additionally, by voluntarily entering into an agreement, the firm can promote ecological sensitivity, giving the firm a marketing advantage over a competitor who may not enter into a similar type of agreement.

In the mandatory approach, in which all regulated industries are required to meet minimum standards, the ecological sensitivity marketing advantage is not a unique selling point for an individual firm and therefore any investment the firm makes in promoting their brand as environmentally friendly is not rewarded. In short, proponents of the voluntary approach claim

industry would be hesitant to exceed minimum standards as such a venture could have a diminished return.

While the literature (Sergerson and Miceli 1998; Henriques and Sadorsky 2008) does state voluntary regulation can be used as a tool to reduce cost and increase the likelihood of continued pollution prevention, the literature also suggest that mandatory standards do provide a distinct advantage over voluntary agreements in terms of reporting and enforcement of universal standards.

Although great flexibility is given to a firm in a voluntary agreement, authors Lyon and Maxwell (2001) feel historically this has been at the cost of transparency in the process and accountability in the results. This lack of transparency in the process damages the credibility of voluntary agreements because ex-post analysis of the results is difficult to accomplish (Lyons and Maxwell 2001). Although the mandatory regulation is less flexible, it does provide better accounting of the results for two reasons. First, the process of regulation is more transparent. This transparency allows for a better understanding of the methodology employed in the process and what metrics are measured in the results. Additionally, in terms of reporting, the mandatory approach's lack of flexibility is useful because all data from the various firms regulated in the program report using the same units of measurement. This allows for a better understanding of the reported data and makes comparisons between firms easier and more accurate.

The inflexibility of mandatory environmental programs has an additional attribute. Since universal mandates are not put on industry as a whole in voluntary agreements, firms outside the voluntary agreements have no incentive or obligation to comply with these regulations. For this reason, large scale environmental regulatory programs have shied away from the voluntary

approach in order to establish at least a baseline minimum for the industry. By creating universal mandates through the use of the mandatory approach, government can deflect claims of favoritism in the regulating process. Given this information, it is understandable why Congress developed early environmental standards using the mandatory approach. Although critics have cited its flaws in terms of cost and growth, a strong argument could be made that if some mandatory programs like the CAFE standards did employ a voluntary approach, just as much time and money would be exhausted regulating each individual automaker with a unique contract. Additionally, universal standards would not be achieved as larger firms could use their economic and political capital to fight such agreements.

Mandates and Penalties of the Mandatory Approach

The second hallmark of the mandatory approach is its reliance on mandates and penalties. In order to combat the issue of selective participation found in the voluntary approach, mandatory environmental regulation requires compliance for all members of an industry through the use of penalties. The use of penalties in the mandatory approach has sparked much debate in the literature.

Working from the economic principle that firms are rational actors looking to maximize profits, Watson argues the use of penalties in the mandatory approach act as a deterrent to environmental degradation. He states this hallmark of the mandatory approach is most successful when the penalties for violating the law are greater than the economic gains received for said violation (2001). Without the threat of consequences, industry's obligation to environmental protection is fleeting (Camisón-Zornoza and Boronat-Navarro 2010). Therefore, a successful

mandatory regulation must be one in which the fines are significant and meaningful. Devoid of this attribute, Watson feels the full potential of the regulation will not be met. This idea induces much debate.

For supporters of the mandatory approach, the fine and penalty structure within the method must be strong and meaningful. However, Stewart (2001) and Blackman (2008) argue increasing of penalties only further weakens firms and increases the scope of already an ineffective system of management.

Specific to the CAFE standards, critics have claimed the programs non-aggressive penalty structure is a major problem area of the legislation. A 2007 General Accounting Office report stated some luxury automobile producers, namely BMW and Mercedes-Benz, have routinely failed to meet the standard over the years because the penalties per vehicle enforced by the government for non-compliance are small and cost-shifted to their consumers, a segment of the population who tend to have more means than consumers of more modestly priced vehicles. The failure to meet the standard only reinforces Watson's idea that when the penalty structure of a mandatory regulation is weak, violations of the standards are more likely to occur, and thus the regulation becomes less effective.

Tenn and Yun (2005) took this idea one step further when they found that some penalty structures employed in the mandatory approach can actually discourage improvements in pollution controls and efficiency outputs. Their research found specific to the CAFE penalty structure, "adding a fuel efficient car (to a manufacturer's fleet) does not always lower the CAFE penalty" for a firm due to the unique method in which fuel economy is measured by the NHTSA

(2005, 53). When the penalty system of a mandatory regulation produces this outcome, two externalities occur.

First, industry is less likely to produce for the fringe, niche market since such a move would have little impact on decreasing their pollution levels and/or penalties. Additionally, these types of failed penalty structures only encourage the status quo in terms of efficiency outputs, thereby reaffirming the arguments found in Sergeron and Miceli (1998).

Economic Impacts of Mandatory Environmental Regulation

Undoubtedly the most contentious aspect of any environmental regulation debate is its economic impact on industry. Traditionally, the literature has suggested that compliance with “environmental regulation can significantly affect production cost” (Joshi et al. 2001, 172). It is for this reason industry generally takes a highly cautious (perhaps contentious) approach to regulation, especially mandatory environmental regulation. In the past, the increased cost burden of environmental regulation has been targeted by some industries, namely the automotive, steel, paper and chemical industries, as a core reason for their lack of competitiveness in the global market. In short, industries feel environmental regulation “imposes significant cost, slows productivity growth and thereby hinders the ability of firms” (Jaffe et al. 1995, 133). From this perspective, increases in mandatory environmental standards only weaken the health of a firm.

Fear of economic hardships as a result of mandatory environmental regulation has been a constant subject in both policy discussions and scholarly literature for the better part of the last three decades. This fear of economic turmoil as a result of environmental regulation has been a

core concern of policymakers during the development of most large scale environmental policies.

For this reason, policymakers at times craft legislation to give relief to industry to help make the transition to the new standard. This relief typically takes the form of either shared up-front costs or general economic safeguards, which are not specific to a certain time period like the former. In the CAFE legislation, Congress provided economic safeguards to industry in a variety of ways, including ensuring that any future increases in fuel standards beyond the original legislation would have to consider both the “technological feasibility and economic practicability” of such a move (NTHSA 2009). While tax credits and shared cost may be a more visible act of economic safeguarding for an industry, vague language in legislation or a lack of political will can be just as effective.

How do the Compliance Cost of Environmental Regulation Affect Industry?

According to much of the literature, the financial burden of mandatory standards affects industry in several ways. First, in order to comply with environmental regulation requirements, industry may have to change its production methods and at times their factories. This change in production methods requires significant initial investment from industry. Large environmental regulatory programs like the Clean Air Act’s New Source Review showcase the cost of compliance. Under New Source Review, the EPA requires businesses who release pollutants during the manufacturing process to acquire a permit and install air scrubbers to help clean the exhaust (Nash and Revesz, 2007).

One of the latest examples of this increased cost to industry can be seen in new proposed regulation affecting power plants in Texas. The March 17th edition of *The Houston Chronicle*

reported per a proposed rule change by the EPA, coal-fired power plants would be required to “install scrubbers and other pieces of costly equipment to reduce emissions of the pollutants by 2015” (2011). Although highly effective in reducing pollution, this rule change would cost the industry more than \$10 billion over the course of a decade. This large price tag is not too surprising considering that in 1995, the EPA stated the annual cost of complying with environmental regulation exceeded \$125 billion (Jaffe et al. 1995).

In addition to the increased cost in terms of facilities, environmental regulation can affect production cost in terms of increased labor expenditures. The retooling and retraining of staff to operate within the new regulated market can be another additional expenditure to industry. If a new, more skilled labor force is needed to operate under the new regulation, this labor expenditure is increased even further. Even more harmful to businesses is the fact this retooling expenditure is concentrated to a specific time frame prior to the enforcement of the regulation and not spread out evenly over the life of the policy. This initial cost of the regulation on industry can have a dramatic effect on its balance sheet and thus increase industry’s resolve to fight the legislation or rule change.

If the change required by environmental regulation is small, the industry may have the upfront capital to implement the change. However, if the change in regulation has a large effect and additional capital is needed by industry, environmental regulations can produce additional financial liabilities for an industry outside its normal scope of production and investment. Devoid of the extra capital to implement the changes required by law, industry could be forced to acquire additional sources of funding through loans, asset sales or mergers. Depending on the scope of the legislation, the financial health of the company and the cost-sharing aspects of the legislation (if any), environmental regulation can transform the balance sheet of an industry significantly.

The literature also suggests changes in environmental mandatory standards may actually be beneficial to larger firms in an industry as the cost of compliance can be better shouldered by larger firms than their smaller sized counterparts. Jaffe et al. found “larger firms may find it less costly to comply...if higher prices from regulation reduce competition” (1995, 154). That stated, this idea really depends on the number and size of the firms in an industry.

Counterview

While the general consensus has been that changes in environmental regulation standards have ultimately been responsible for added cost to the bottom line of many industries especially in terms of initial cost, some of the literature suggests this traditional view is incorrect. According to Porter and van der Linde (1995a), the prevailing view that there is an inherent and fixed trade-off between ecology and the economy in the use of mandatory environmental regulation is incorrect. This viewpoint stands in sharp contrast to the conventional understanding of how mandatory environmental regulation affects an industry.

For these authors, “properly designed environmental standards can trigger innovations that lower the total cost of a product or improve its value” (Porter and van der Linde 1995a, 120). In their view, regulation does not act as a weight to industry but rather a force to spark innovation. Without this push from government, firms are less likely to innovate due to fiscal restraints or perceived fiscal restraints. Instead of taking the traditional view that environmental regulation is an unfunded mandate to industry, supporters of this viewpoint argue that compliance cost actually act as an investment for an industry.

Porter and van der Linde believe pollution controls imposed by government can be an important step to wrangling out inefficiencies in the production of a good. Citing case examples

including the Dutch flower industry, the Robbins Company and the multinational company 3M, the authors present evidence that strict environmental regulation mandated by government directly affected the financial health of these companies in a positive manner (1995a, 121).

Authors Jaffe et al. (1995, 132) also support this notion that advances in efficiency, mandated by environmental regulation, can act as “a net positive force by driving private firms and the economy as a whole to become more competitive in international markets.” The rationale behind this argument is as follows. Due to high regulatory standards, industry is induced into the development of better technology. It is from this technological advantage that production cost for an industry is reduced. Although significant investment in research and development is needed initially, this investment can produce cost-saving benefits in future production. In short, some “early mover” firms may see advantages by pushing products which will increase in popularity in the near future (Jaffe et al. 1995). Shaw and Stroup (2000, 13) also found this point to be true stating “producers who are the first companies to discover better ways to reduce pollution can profit by keeping cost down.”

Ritcher’s (2004, 19) research also echoed this idea citing examples related to mandatory regulation and issues of highway safety and efficiency outputs. Ritcher feels these types of requirements can be “highly effective drivers of change.” She argues devoid of this investment mandated by government, the innovations which led to improved statistics in safety and efficiency would not have occurred as quickly.

While it runs counter to the traditional view found in the literature, supporters of this method state that since “innovations allow companies to use a range of inputs more productively- from raw materials to energy to labor,” firms mandated by environmental regulation have the

ability to increase their competitiveness in the marketplace (Porter and van der Linde 1995a, 121). And while critics of this method (Stewart 2001, Henriques and Sadorsky 2008) would strongly disagree with this assessment, authors like Porter and van der Linde would argue mandatory governmental regulation removes inefficiencies in the industrial process quickly – at times more quickly than the private sector may want. From this position of increased efficiency, cost savings occur.

This outcome of lowering production cost via environmental regulation is termed by Porter and van der Linde as “innovation offsets” (1995b, 98). In their view, there is a direct correlation between inefficiencies in the manufacturing process and higher pollution outputs because higher pollution outputs demonstrate the lack of full utilization of the finite resources. For this reason, Porter and van der Linde state reduction of pollution outputs signal a more efficient production of a product (1995b). It is from this place of improved efficiency, firms have a distinct advantage over firms (typically outside the country of the first firm) not subject to the same governmental regulations. By properly complying with environmental regulation, firms can benefit and “actually enhance competitiveness” (Porter and van der Linde, 1995b, 99).

Greene (1998, 609) takes this notion of mandatory environmental regulation as an effective tool to improve competitiveness and increased efficiency a step further. He rejects the notion that “domestic auto manufacturers were constrained by the CAFE standards” in terms of competitive advantage. While he does mention the gap in market share between domestic and foreign auto producers did close following the implementation of the CAFE standards, he credits this shift to two specific factors not related to the establishment of mandatory environmental efficiency standards. Greene identifies the loss of market share by domestic auto producers following the establishment of the CAFE standards as part of a larger trend of globalization. He

believes regardless if a standard had been established, domestic market share would have seen a decrease in new car sales as foreign producers, specifically Japanese producers, had been encroaching upon the American market since the 1950s (1998).

Additionally, Greene states rises in the price of oil in 1979 directly resulted in an increase of foreign new car sales. This increased cost of fuel prices “drove consumers to smaller cars, a niche market dominated by the imports” (1995, 608). The sales figures of 1979 tend to lend credence to Porter’s notion of the “first mover” firms. As the cost of operating the product increases, customers move to a product with increased efficiency. At that point, the competitive advantage in new car sales was with the foreign producers.

Greene’s analysis is specific to one particular policy, but it does contextualize the larger points advocated by Porter, van der Linde and Jaffe et al. It is from these general theories and categories established in this literature review that formal hypotheses are developed. In the next section of this chapter, this literature review explains these hypotheses and provides the literature sources from which they were developed.

Conceptual Framework

In social research, conceptual frameworks are “connected to outcomes or problem resolution as they aid in making judgments” (Shields and Tajalli 2005, 5). It is for this reason, this research employs this technique. The conceptual framework for this research is displayed in the following table.

Table 3.1: Conceptual Framework

Hypotheses	Sources
H1: The presence of the CAFE standard will cause aggregate fuel economy of passenger cars to improve.	Bamberger 2003 Geckil 2003 Henriques and Sadorsky 2008 Lyon and Maxwell 2001 Sergerson and Miceli 1998
H2: Any stagnation or reduction of CAFE standards will result in stagnation or reduction of aggregate fuel output levels.	Geckil 2003 Henriques and Sadorsky 2008 Joshi et al 2001 Lyon and Maxwell 2001 Stewart 2001 Watson 2005

Table 3.1 provides two hypotheses relating to the impact changes in mandatory requirements of the CAFE standards have on producers of passenger cars. In addition to stating these hypotheses, the conceptual framework shows their connection to the literature which guided the development of this research. By relying on this literature, this research seeks to explain the effects changes in mandatory environmental regulation have on fuel efficiency outputs for both foreign and domestic passenger cars.

Chapter Summary

This chapter examined the concept of federal mandatory environmental regulation through a four part analysis. First, this chapter recounted the policy history and development of this type of legislation which began in the late 1960s and early 1970s. From this examination, the

hallmark features of mandatory environmental regulation were discussed. This chapter made comments regarding both the prescriptive nature and universality of the mandatory system. Later, this chapter examined voluntary environmental regulation as a comparative analysis to the traditional model of mandatory regulation. Through the use of this comparison, key features, flaws and attributes of both methods were brought to the forefront. Lastly, this chapter examined the literature relating to the economic effects mandatory environmental regulation may have on a particular industry. The first half of this section discussed the traditional view that mandatory environmental regulation slows both growth and economic gains. The latter half of this section presented the arguments of scholars who take a counter position to this traditionally held view and advocate that this type of regulation can be beneficial to a firm.

It is from a review of the literature on mandatory environmental regulation that this study has developed formal hypotheses relating to how changes in minimum standards affect efficiency outputs. The next chapter of this research explains how this study operationalizes the data collected in order to test these hypotheses.

Chapter Four: Methodology

Chapter Purpose

The purpose of this chapter is to describe the procedure used to test the formal hypotheses presented in Chapter Three. To test these hypotheses, this study employs an interrupted times series design. The specifics of this model, its strengths, its weaknesses, and its scheme design are addressed in this chapter.

Figure 4.1: Longitudinal Fuel Averages with Interruption Points

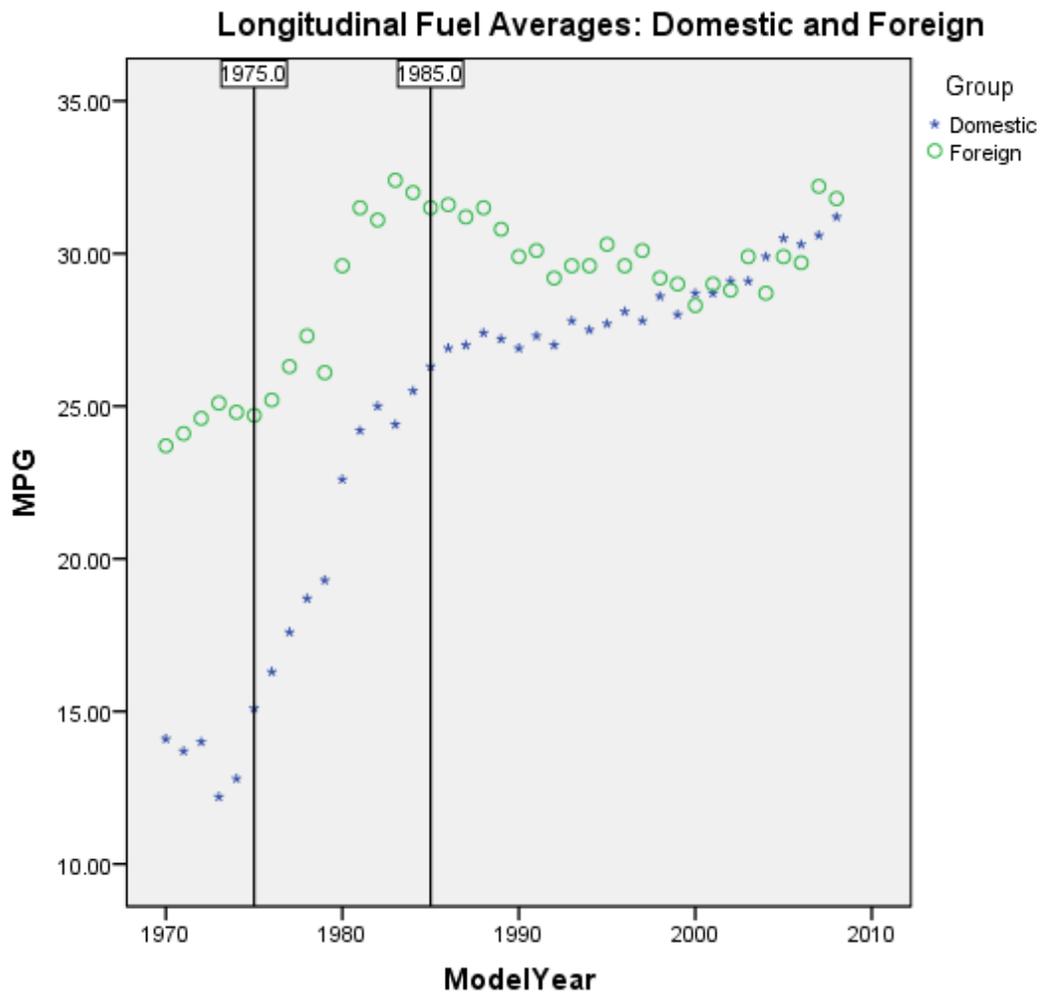


Figure 4.1 presents the longitudinal fuel economy trends for both vehicle types. This study employs a set of interrupted time series analyses in order to determine the effect of two separate major changes in the CAFE policy. The first of these events is the establishment of the standard, marked in Figure 4.1 as the interruption point of 1975. The second change to the CAFE standard, denoted in Figure 4.1 as 1985, represents when authority to set the fuel economy levels was given to the Executive branch. The first hypothesis presented in Chapter Three correlates to the first time series analysis. The second hypothesis presented in Chapter Three correlates to the second time series analysis.

Table 4.1: Hypotheses

H1: The presence of the CAFE standard will cause aggregate fuel economy of passenger cars to improve.
H2: Any stagnation or reduction of CAFE standards will result in stagnation or reduction of aggregate fuel output levels.

Operationalization

In order to test the effect of mandatory minimum environmental standards on efficiency outputs, this study employs a set of interrupted time series analyses. This method is employed in order to examine the efficiency trends of domestic and foreign cars before and after the manipulation of the CAFE standards.

The dependent variable for both hypotheses is the aggregate average fuel efficiency of passenger cars. This information was retrieved from annual CAFE reports produced by the NHTSA. Because this study employs two interrupted time series regression analysis with comparison groups, two operationalization tables are presented. Table 4.2 provides information

relating to the regression beginning in 1970 through 1984, while Table 4.3 provides information relating to the regression for years 1975-2008.

Table 4.2: Operationalization Table Time Series 1970-1984

<u>Variable</u>	<u>Definition</u>	<u>Unit of Measurement</u>	<u>Data Source</u>
<u>Dependent Variable</u>			
Fuel Economy Outputs	Fuel economy outputs averages for passenger cars per model year.	Miles per gallon.	US Department of Transportation – NHTSA
<u>Independent Variables</u>			
<ul style="list-style-type: none"> • Time 	A counter representing time intervals (years).	1-15.	Manually Created
<ul style="list-style-type: none"> • Level 	The level of change in efficiency for domestic cars after the interruption point in 1975.	0= Before the interruption point. 1= After the interruption point.	Manually Created
<ul style="list-style-type: none"> • Program 	The change in the efficiency trends of domestic cars before and after the 1975 CAFE standards went into effect.	0=Prior to the establishment of the CAFE standard. 1,2,3,4... following the implementation of the program.	Manually Created
<ul style="list-style-type: none"> • Group 	Separates the two categories of passenger cars as either domestic or foreign.	0= Domestic 1= Foreign	Manually Created
<ul style="list-style-type: none"> • Group X Time 	Reports the difference in trends before the interruption point.	The product of variables in Group and Time.	Manually Created: Computed via SPSS
<ul style="list-style-type: none"> • Group X Level 	Reports the difference in levels immediately after the program begins.	The product of variables in Group and Level.	Manually Created: Computed via SPSS
<ul style="list-style-type: none"> • Group X Program 	Reports the net efficiency differences between domestic and foreign cars.	The product of variables in Group and Program.	Manually Created: Computed via SPSS

Table 4.3: Operationalization Table Time Series 1975-2008

<u>Variable</u>	<u>Definition</u>	<u>Unit of Measurement</u>	<u>Data Source</u>
<u>Dependent Variable</u>			
Fuel Economy Outputs	Fuel economy outputs averages for passenger cars per model year.	Miles per gallon.	US Department of Transportation – NHTSA
<u>Independent Variables</u>			
<ul style="list-style-type: none"> Time 	A counter representing time intervals (years).	1-34.	Manually Created
<ul style="list-style-type: none"> Level 	The level of change in trend lines for domestic cars after the interruption point in 1985.	0= Before the interruption point. 1= After the interruption point.	Manually Created
<ul style="list-style-type: none"> Program 	The change in the efficiency trends of domestic cars before and after the 1985 CAFE standard manipulation.	0=Prior to the establishment of the CAFE standard. 1,2,3,4... following the implementation of the program.	Manually Created
<ul style="list-style-type: none"> Group 	Separates the two categories of passenger cars as either domestic or foreign.	0= Domestic 1= Foreign	Manually Created
<ul style="list-style-type: none"> Group X Time 	Reports the difference in trends before the interruption point.	The product of variables in Group and Time.	Manually Created: Computed via SPSS
<ul style="list-style-type: none"> Group X Level 	Reports the difference in levels of change immediately after the 1985 standard is manipulated.	The product of variables in Group and Level.	Manually Created: Computed via SPSS
<ul style="list-style-type: none"> Group X Program 	Reports the net efficiency difference in trends after the 1985 program manipulation.	The product of variables in Group and Program.	Manually Created: Computed via SPSS

Design

By measuring the dependent variable of fuel efficiency outputs before and after the intervention point (changes in the CAFE standard), this study determines the effect the interruption points (manipulation of the mandatory standard) had on fuel economy outputs.

To determine the effect, this study examines the linear trends of both fleet types at two different interruption points. The first interruption point occurs at model year (MY) 1975. This is the first year in which the CAFE standards governed fuel efficiency outputs for the two vehicle types. This first analysis spans years 1970-1984. The regression analysis begins at MY 1970 as this was the first point at which NHTSA had fuel economy data for both types of vehicles. Data on fuel efficiency for years prior to 1970 are incomplete. The first time series regression analysis concludes at MY 1984, the year before the authority to set the CAFE for passenger cars left Congress and move to the Executive branch.

The second interruption model analyzes data from MY 1975 through MY 2008, with the interruption point occurring at MY 1985. As in the first time series model, this second model measures the linear regression both pre and post the intervention in order to assess the effect on both foreign and domestic passenger cars. The second interruption point, MY1985, was chosen because it marks the point at which authority to set the CAFE standards had moved from Congress to Department of Transportation. This move ultimately led to a stagnation of fuel economy standards. This time series regression will demonstrate how this policy decision affected fuel economy outputs.

Data Collection

All data points of aggregate fuel economy outputs for foreign and domestic passenger cars since 1970 are gathered through reports from the US Department of Transportation, specifically the National Highway Traffic Safety Administration. Aggregate fuel economy for a fleet, a single manufacturer of a line of passenger cars (e.g. Ford, Toyota, Honda, etc.), is computed through the following equation.

$$\frac{\text{Total Production Volume}}{\frac{\#VehicleA}{FuelEconomy} + \frac{\#VehicleB}{FuelEconomy} + \frac{\#VehicleC}{FuelEconomy}} = \text{Fleet Fuel Economy Average}$$

Example

Model	MPG	Production Volume
Vehicle A	22	130,000
Vehicle B	20	120,000
Vehicle C	16	100,000

$$\frac{350,000}{\frac{130,000}{22} + \frac{120,000}{20} + \frac{100,000}{16}} = 19.27 \text{ MPG}$$

It is from these individual fleet fuel economy averages for a specific year that aggregate averages for foreign and domestic vehicles are computed. This equation is used in this study as it is the way in which the NHTSA calculates average fleet fuel economy.

Defining Domestic v. Foreign Passenger Cars

Because automobile companies can produce both a domestic line and an international line which may be re-imported back into the United States, some companies like Ford and Toyota, can appear in a specific year as both a domestic producer (DP) and an import producer (IP). When this is the case, this study applies the fleet aggregate fuel economy average (described above) for only the category it applies to. For example, Ford products designed for international sale, which may be re-imported into the United States, only affect Ford’s foreign fuel economy average and not its domestic average. In short, if the final product of an auto producer requires importation for a specific MY, that segment of their business would be coded as a foreign model. This study employs this rationale because it models the system used by NHTSA, the primary agency responsible for the administration of the CAFE program.

Table 4.4: Domestic v. Foreign Manufacturers

<i>Model</i>	<i>Type</i>	<i>Model</i>	<i>Type</i>
ALFA-ROMEO	IP	LOTUS	IP
AMC	DP	MASERATI	IP
ASTON MARTIN	IP	MAZDA	IP
BMW	IP	MAZDA	DP
CHECKER	IP	MERCEDES	IP
CHRYSLER	DP	NISSAN	IP
DAEWOO	IP	NISSAN	DP
DAIMLERCHRYSLER	DP	PORSCHE	IP
DAIMLERCHRYSLER	IP	QUANTUM	DP
EXCALIBUR	IP	SUBARU	IP
FORD	DP	SUZUKI	IP
FORD	IP	SAAB	IP
GM	DP	SUBARU	IP
GM	IP	ROLLS ROYCE	IP
HONDA	DP	TOYOTA	DP
HONDA	IP	TOYOTA	IP
HYUNDAI	IP	VW	IP
JAGUAR	IP	VOLVO	IP
KIA	IP	YUGO	IP

Table 4.4 provides a general understanding of how the NHTSA designates an auto producer as a foreign producer, a domestic producer or at times both. Please note this table from year to year is not stagnant. Factors such as mergers, bankruptcy, changes in product lines and trade agreements drastically affect its composition. Given this reality, no two years present the same data. For this reason, this study has chosen not to present each foreign and domestic table for each model year. Presenting 39 separate tables would distract from this study. However, it should be noted that careful attention was paid to the distinction between foreign and domestic when calculating aggregate fuel economy for each model year.

Schematic Research Design

Tables 4.3 and 4.4 below present the format of the analysis. For each time period (yearly observations) in the interrupted time series analyses, there is a pre and post observation period. Within each of these pre and post interruption periods, observations, noted as “O” are observed for both foreign and domestic aggregate fuel outputs. From these observations of both passenger car types, a linear regression is made. This study measures the change in these linear regressions following the interruption points for both vehicle types and time periods.

Table 4.5: First Interrupted Time Series Analysis (1970-1984)

	Before Interruption	T	After Interruption
Domestic Fleet Fuel Economy Average	$O_{1970} \dots O_{1974}$	X	$O_{1975} \dots O_{1984}$
Foreign Fleet Fuel Economy Average	$O_{1970} \dots O_{1974}$	X	$O_{1975} \dots O_{1984}$

Table 4.6: Second Interrupted Time Series Analysis (1975-2008)

	Before Interruption	T	After Interruption
Domestic Fleet Fuel Economy Average	$O_{1975} \dots O_{1984}$	X	$O_{1985} \dots O_{2008}$
Foreign Fleet Fuel Economy Average	$O_{1975} \dots O_{1984}$	X	$O_{1985} \dots O_{2008}$

Design Strengthens

Interrupted times series analysis is a strong quasi-experimental method of evaluating trends. By allowing for data collection pre and post the application of a treatment, the effects of said treatment can be thoroughly evaluated. By using a set of interrupted time series analyses, this study is able to explain the effects of both the increase in minimum standards as well as the

effects of stagnation of minimum standards later in the life of the policy. In the first time series analysis, 30 total observations are collected, with the intervening point occurring at observation 10. In the second time series analysis, 68 total observations are collected, with the intervening point occurring at observation 21.

Design Weaknesses

Interrupted time series models are limited by the fact the data collected is not randomized, thereby making the model quasi-experimental. The model is designed to focus exclusively on a single event and therefore, broad application to a larger phenomenon from these findings would be incorrect.

While other factors can affect an auto producers decision to increase the production of more fuel efficient cars, this study seeks to only understand how mandated governmental regulation impacts fuel economy rates for these producers. This study does not consider other facts which could affect an auto producer's decision to introduce more fuel efficient cars like the price of oil, market trends or company preference.

Statistics

This project utilizes interrupted times series regression, a method of statistical analysis which measures linear trend lines pre and post an intervening point within a given time frame. The following equation provides the basis for both interrupted time series regressions in this study.

$$Y= b_0+b_1T+b_2L+b_3P+b_4G+b_5GT+b_6GL+b_7GP$$

The unstandardized coefficients in the equation above represent the following. The first coefficient b_0 represents the baseline value of Y, the dependent variable of average fuel economy. The coefficient b_1T (Time) represents the fuel efficiency trend of domestic cars prior to the interruption point. The coefficient b_2D (Level) represents the change in level of efficiency of domestic cars after the intervening point. Coefficient b_3P (Program) represents the change in efficiency trends of domestic cars prior to and after the intervening point. Coefficient b_4G (Group) represents the dichotomy of foreign and domestic passenger cars. Coefficients b_5GT (GroupTime), b_6GD (GroupLevel), and b_7GP (GroupProgram) represent the difference between the groups prior to the intervening point (b_5GT), the difference between the groups' change of levels (b_6GL) after the intervention and the net difference in fuel efficiency of domestic and foreign fleets after the interruption point (b_7GP).

Human Subject Statement

This research relies solely on quantitative data compiled by the US Department of Transportation and the National Highway Traffic Safety Administration. No human subjects were studied, surveyed or consulted in the creation of this research.

Chapter Five: Results

Chapter Purpose

The purpose of this chapter is to analyze the results from the set of interrupted time series regressions in order to test the formal hypotheses presented in Chapter Three. The results will demonstrate how changes in the CAFE standard affect the fuel efficiency outputs for both foreign and domestic passenger cars.

Interpretation of the Regression Analysis Results: 1970-1984

In the first interrupted time series regression analysis, the aggregate fuel economy averages for domestic passenger cars are compared to the aggregate fuel economy averages for foreign passenger cars before and after the interruption point of 1975, the start date of the CAFE standards. It is from this regression analysis that Hypothesis 1: “The presence of the CAFE standard will cause aggregate fuel economy of passenger cars to improve” is tested. Table 5.1 provides the regression coefficients results.

Table 5.1 – Coefficients 1970-1984

Model	Coefficients				T	Sig.
	Unstandardized Coefficients		Standardized	Beta		
	B	Std. Error				
(Constant)	14.590	.898			16.256	.000
Time	-.410	.271	-.298		-1.515	.144
Level	1.427	.884	.113		1.614	.121
Program**	1.665	.287	.980		5.811	.000
Group	4.530	3.487	.381		1.299	.207
Group X Time	.730	.383	.939		1.908	.070
GroupXLevel*	-3.113	1.250	-.247		-2.491	.021
Group X Pro*	-1.038	.405	-.538		-2.563	.018

a. Dependent Variable: MPG; $R^2 = .99$

Note: ** = significant @ .01, *=significant @ .05

Figure 5.1: Time Series Regression 1970-1984

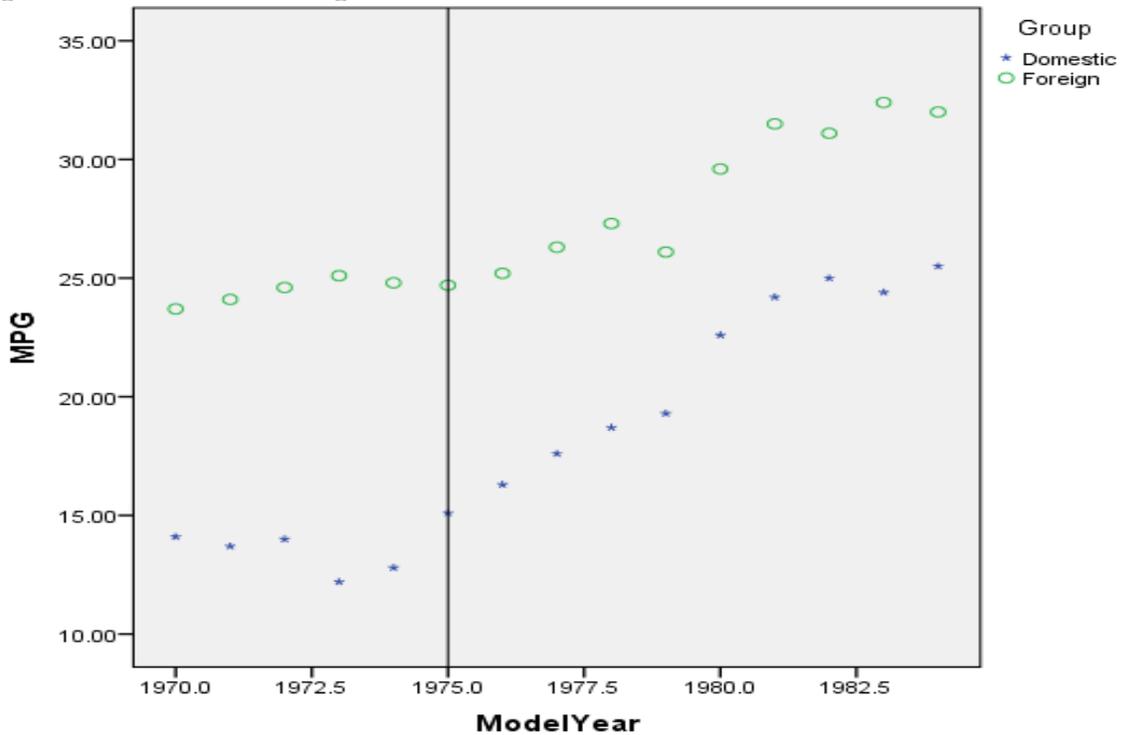


Table 5.1 provides the results of the regression analysis for years 1970-1984. The first three coefficients (Time, Level, and Program) pertain to trend lines of domestic fuel economy. The last three coefficients on Table 5.1 (Group x Time, Group x Level, and Group x Program) pertain to the foreign trend lines relationship to the domestic trend lines.

The table shows that prior to the enforcement of the CAFE standards, there was no trend in efficiency of domestic cars. In other words, fuel efficiency of domestic cars was not improving prior to the establishment of the CAFE standards. This result is reflected in the insignificance of the coefficient Time (-.41). The results also demonstrate there was no immediate jump or drop in fuel efficiency right after the implementation of the program for domestic cars (Level =1.43). The analysis shows that every year following the implementation of the CAFE standard, domestic fuel economy began increasing by 1.6 MPG per year. This finding supports the Hypothesis 1. With the implementation of the CAFE program, fuel economy levels increased.

The fifth coefficient in Table 5.1 (Group X Time) represents the difference in efficiency trend lines of domestic and foreign cars before implementation of the CAFE standards. Despite the fact that foreign automobiles had on average a higher fuel economy than their domestic counterparts, there was no significant difference in the slope of the two trend lines prior to 1975.

While the Group X Time coefficient is not significant, the Group X Level coefficient proves to be significant (-3.11). This coefficient shows there was an immediate jump in efficiency in domestic cars relative to foreign cars right after the implementation of the CAFE standard in 1975. Considering the low fuel economy average of domestic cars and the fact

foreign fuel economy rates were already above the new imposed standard, this result is not too surprising.

Lastly, the Group X Program coefficient in Table 5.1 is significant (-1.08). This coefficient is the most important finding of the analysis as it describes the change of slopes between foreign and domestic fuel economy averages after the implementation of the program. This data proves that as a result of the implementation of the CAFE standards, average domestic fuel economy rates increased at a higher rate than foreign averages during this period.

In summation, the interrupted time series regression analysis, specifically the two coefficients Program and Group X Program, support the hypothesis that CAFE standards were effective in improving the efficiency of domestic and foreign passenger cars.

Interpretation of the Regression Analysis Results: 1975-2008

Exactly in the same method as the first interrupted time series regression, the second interrupted time analysis compares the aggregate fuel economy averages for domestic passenger cars to the aggregate fuel economy averages for foreign passenger cars before and after the interruption point. The second analysis examines both a different time range (1975-2008) and presents a different interruption point. For this analysis, the interruption point occurs at 1985, as this was the point in which responsibility for setting fuel economy minimum standards was passed from Congress to the Executive branch. As stated previously in this study, the yearly increases of the minimum CAFE standard seen in first ten years of the program were not to be found following 1985. It is from this interrupted time series regression that Hypothesis 2: “Any

stagnation or reduction of CAFE standards will result in stagnation or reduction of aggregate fuel output levels” is tested. Table 5.2 provides the regression coefficient results.

Table 5.2: Interrupted Time Series Regression 1975-2008

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	13.967	.607		23.023	.000
Time**	1.255	.098	3.381	12.838	.000
Level	-.491	.642	-.061	-.764	.448
Program**	-1.072	.101	-2.396	-10.592	.000
Group**	9.987	.858	1.371	11.641	.000
Group X Time*	-.368	.138	-1.130	-2.665	.011
Group X Level	-1.730	.908	-.227	-1.905	.062
Group X Pro	.142	.143	.284	.995	.324

a. Dependent Variable: MPG; R² = .95

Note: ** = significant @ .01, *=significant @ .05

Figure 5.2: Time Series Regression 1975-2008

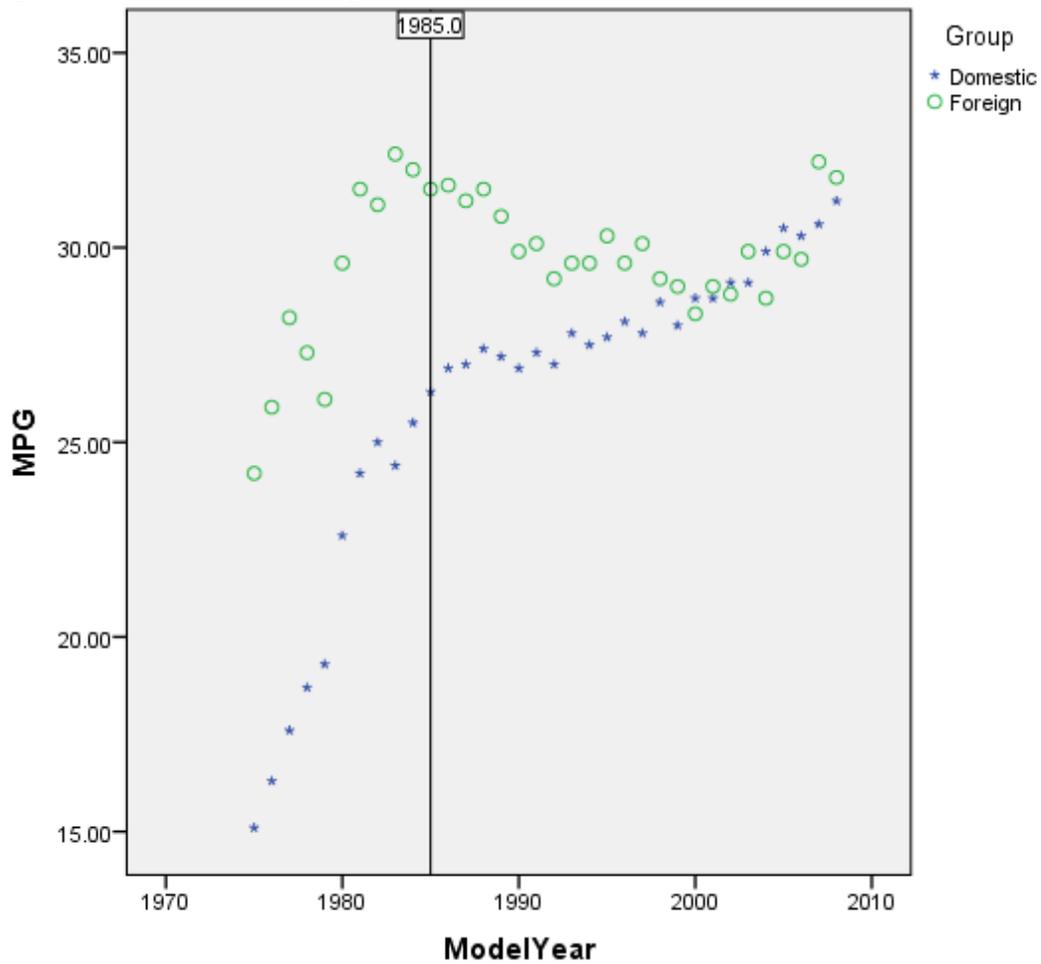


Table 5.2 provides the results of the regression analysis for years 1975-2008. As with the first time series analysis, coefficients Time, Level, and Program pertain to trend lines of domestic fuel economy and coefficients Group x Time, Group x Level, and Group x Program pertain to the foreign trend lines relationship to the domestic trend lines.

In Table 5.2, the first coefficient Time, the domestic trend line prior to the interruption point, is significant (1.26). This result demonstrates that during the period in which the CAFE minimum standards were the responsibility of Congress (1975-1984), domestic fuel economy averages were annually improving. The Level coefficient in Table 5.2 shows no significance.

Therefore, this study concludes that the change in CAFE minimum setting authority from Congress to the Executive and the stagnation of the standard had no immediate effect on domestic fuel economy averages.

Perhaps the most interesting finding is the fact that the Program coefficient is significant. This coefficient represents the change in domestic fuel economy averages before 1985 and after when the responsibility to set the CAFE standard was passed to the Executive branch. This result shows that domestic fuel economy began to diminish in relation to the earlier trend line following the transfer of authority to the Executive and the stagnation of the standard. This finding supports Hypothesis 2: As fuel economy standards decrease or stagnate, fuel economy outputs will also decrease or stagnate.

In the second portion of this analysis, the Group x Time coefficient proves to be significant, meaning there is a significant difference between the domestic and foreign trend line averages during the first years of the CAFE standard. This result shows the domestic average trend line grew at a faster rate than did the foreign trend line between the years of 1975 through 1984. However, the Group x Level coefficient was not significant. This result shows there was no difference between the domestic and foreign trend lines immediately following the 1985 interruption point.

Lastly, coefficient Group x Program is not significant. From this finding, it is clear there is no significant difference between rate of change in the domestic trend line pre and post the interruption point and the foreign trend line for the same period. Given the fact that both trend lines flattened following the 1985 interruption point, this finding is not too surprising. This

finding stands in contrast to the progress the domestic trend line made in relation to the foreign trend line during the first decade of the CAFE program.

Chapter Summary

The results of the two interrupted time series analyses support both hypotheses presented this study. The first regression analysis supports the first hypothesis that the implementation of a standard increased fuel efficiency. This is supported by the significant results of the Program coefficient in Table 5.1. The second regression analysis supports the second hypothesis; as minimum standards become stagnant, so do fuel economy trend lines. The Program coefficient in the second analysis (Table 5.2) shows that following the interruption point of 1985 (the beginning of standard stagnation) domestic efficiency significantly decreased from its previous trend line during 1975-1984. In closing, the results of the two regression analyses support the hypotheses.

Chapter Six: Conclusion

Research Summary

The purpose of this study is to test how changes in mandatory CAFE minimum standards affect fuel economy outputs. By utilizing two interrupted time series regression analyses, this study assesses the effect changes in mandatory minimum standards have on fuel efficiency outputs for both foreign and domestic passenger cars.

The first chapter of this study introduces the research and provides the reader with a general understanding of the key issues addressed. The second chapter of this study provides a policy history of the CAFE standards, the background events which led to the policy inception and an analysis of United States fuel consumption trends over the past four decades. The third chapter of this study presents the issues and debates concerning the larger issue of mandatory environmental regulation. From this review of the literature in this chapter, two formal hypotheses are developed. In the fourth chapter, this study provides a clear, detailed explanation of the methods used to test the formal hypotheses. This chapter provides the reader with operationalization tables, schematic design tables and an explanation of the interrupted times series regression model used in this research. The fifth chapter of this research presents the findings of the two interrupted time series regression analyses. Lastly, this chapter offers interpretations of the results and a recommendation to policy leaders regarding the CAFE program.

Assessing the Results

The results of the two interrupted time series analyses support the hypotheses presented in Chapter Three. Beginning with the first time series analysis, the significant coefficient of Time demonstrates that prior to the establishment of a minimum standard, fuel economy rates were devoid of a positive trend line. Additionally, the significant coefficient Program illustrates that due to the establishment of a standard and yearly increases of said standard, the domestic fuel economy average increased by more than 1.6 MPG every year more than before the implementation of the policy. These results support the arguments of authors like Geckil (2003) and Greene (1998).

One interesting finding in the first analysis is the fact the Group x Program coefficient is significant. This coefficient measures the difference between the trends of the two programs after the program went into effect. This test found that domestic fuel economy averages increased significantly more than their foreign counterparts. While this finding does show that raises in minimum standards do affect both vehicle types positively, it may lend some credence to the views of authors Black (2008) and Cutter and Neidell (2009).

In their view, domestic fuel economy averages increased at a higher rate than their foreign counterparts during the period (1970-1984) because the import vehicles were on average already compliant to the new standard and thus lacked the same incentive to increase efficiency at the same rate. In short, these authors advocate that in a mandatory system governed by penalties and devoid of significant incentives, firms already above the standard will increase their efficiency rates at a slower pace than firms below the standard.

In the second analysis, the coefficients Time and Program demonstrate how the trend lines changed following 1985. The significant coefficient Time shows that prior to the

interruption point, the domestic line featured a positive trend. The significant coefficient Program shows that following the interruption point, the domestic trend line significantly decreased compared to the trend line prior to the interruption point. These results support the second hypothesis presented in Chapter Three.

Examining the Longitudinal Trends: A Point of Clarification

One point of clarification needs to be made regarding the longitudinal trends of both fleet types for the second regression analysis. As seen on Figure 5.2, there is somewhat of an increase in both foreign and domestic trend lines beginning around the year 2000. As previously stated in this study, there are a number of different reasons why a producer could decide to make a more fuel efficient passenger car including rises in the price of oil, customer preference or corporate environmentalist.

In reviewing the longitudinal trend lines of both vehicle types, some or all of these factors could have played a role in the decision to increase fuel efficiency beginning around 2000. The answer is not clear. However, what is clear is the fact these increases were not due to increases in the federal standard. And since this research seeks to only understand the relationship between fuel economy rates and mandatory minimum standards, a definitive answer to why both vehicle types began to increase around the year 2000 is outside the scope of this research.

Suggestions to Policy Makers and Future Research

From the results of the interrupted times series regression analyses, it is clear both vehicle types see an increase in fuel economy standards during the period in which a minimum standard

was in place and increasing yearly. The results of the tests demonstrate that without a standard in place and yearly increases of the standard, fuel economy trend lines for both vehicle types show no significant trend.

While the tests prove the mandatory system of regulating fuel economy is effective at ensuring baseline compliance, the lack of significant increasing trends for both vehicle types during the period of stagnation is troubling. It is clear from the results that stagnation occurs. However, what is not as clear is specifically why this occurs. This research has presented arguments from authors who advocate that the lack of upward trend in fuel economy levels during the period of stagnation is a symptom of the larger system of mandatory environmental regulation. That particular hypothesis is outside the scope of this study but should be explored in future research.

Specific to the CAFE standards, it is clear that ensuring nearly all producers meet baseline compliance is within the scope of the program. However, it also appears the policy is unable to cultivate upward fuel economy trend lines without raises in the CAFE standards. While several tools could be used to help reverse this trend, it stands to reason these reforms in policy would have to be incentive based, a concept firmly at the heart of voluntary environmental regulation. While mandatory increases in fuel economy standards are an effective tool in increasing fleet fuel economy averages, it is the recommendation of this study that more voluntary incentive based techniques are also used in this policy. By providing the incentives for producers, government can more effectively ensure increased fuel economy during periods of CAFE stagnation.

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