Ensayo titulado

Inserting Game Theory in the Economics of Fuel Efficiency Standards

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Como requisito para obtener el grado de

Especialista en Teoría Económica

Bajo la dirección de

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Febrero 2011

INTRODUCTION

This essay draws its initial drive from a proposal made by the Center for Sustainable Transport of Mexico (CTSM) to the National Institute of Ecology (INE) in 2008 to undertake rigorous research on the Mexican automobile market and the existing economic policy instruments to accompany the design, implementation and monitoring of a fuel efficiency standard for passenger vehicles and light trucks in the country.[1] Mexico's notorious lack of such fuel standard has been observed internationally with concern due to the fact that the country's emission level from the transport sector amounts to 18% of all emissions in Mexico and the transport sector alone worldwide contributes 24% of emissions globally.[2] Mexico's world ranking in carbon emissions from the transport sector is among top 15, with over 100 million metrics tons of carbon (MMTc).[3]

The purpose of this paper is to suggest an alternative theoretical way to develop a policy to manage a resource of common use: fuel (gasoline). My main hint will be to look at the work of Elinor Ostrom, 2009 Economics Novel Prize, delving deeply around her idea of linking the Tragedy of the Commons to environmental affairs and so transfer some insights into the planning, designing and implementing of fuel economy standards for Mexico. To make my case I show how symmetrical games of Game Theory analyzed on the Nash Equilibrium can shed some light on issues such as voluntary agreements, or enforcing more regulatory measures of compliance, thereby revealing the underlying risks and losses of each action taken by government and industry sectors.

This paper is divided in three sections. In the first section the notions of fuel economy standards and the main mechanisms to make policy out of it are introduced, followed by the types of economic impact that it brings on both producers and consumers.

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[1] For a definition of "cars" and "trucks" see: http://www.icet.org.cn/adminis/uploadfile/reference/ 2004 0315.pdf p.10

[2] Center for Sustainable Transport of Mexico (2008): *MEDEC Study*. This study is part of the Clean Energy Investment Framework of the World Bank. The study evaluates the potential for reducing greenhouse gas emissions in Mexico over the next 20 years. It evaluates low-carbon interventions across key emission sectors in Mexico using a common methodology. Based on the interventions evaluated, it develops a low-carbon scenario through 2030. See http://siteresources.worldbank.org/INTMEXICO/Resources/MEDECExecutiveSummaryEng.pdf

[3] Feng, An (2004): CAFE Standards and Trends for US cars and light trucks: http://www.icet.org.cn/adminis/uploadfile/reference/20040315.pdf

This section also revolves around the implications for car size and technology affected by new policy on fuel economy standards as well as its implications. Later in section two, I describe the experiences of the United States, the European Union and Japan in designing and implementing fuel efficiency standards, problems faced, and the social and economic implications it had for each on both the automobile market and the car industry as a whole. While not supporting explicitly any one particular course of action taken by any of these governments, I distinguish emphatically how the relationships between government and the industrial bodies have been in each case and my argument lays significant weight on this factor as an instrumental key in the success of a fuel efficiency standard. In other words, my argument sustains that fuel efficiency standards are more likely to succeed in cutting down emissions inasmuch as relations between the public and the private build a procedural framework to cooperate, which I suggest can be inspired by the work of Ostrom.

In a nutshell, while the United States CAFE standards program sought to reduce emissions at a marginal level provided car producers could develop new car models with non-complying features, the European Union allowed for the creation of voluntary agreements that coveted to a large extent, rights and obligations from car producers, making the norm stringent yet void of mandatory instruments. Later consensus led to the formation of mix voluntary treaties with compulsory measures that are still ongoing with prospects of verification. Japan, by contrast, succeeded over the former two in initiating, maintaining and promoting a culture of cooperation between government and industry decision-makers.

In the third section I outline in a broad sense, for the brevity of this work, the notions of pool-resource management and a really general picture of the work of Ostrom. Then I leave the theoretical instruments in place to be used in the case of Mexico when sufficient date for fuel economy standards has been collected. In this way, this work leaves interesting opportunities for further research open as this field is relatively new in Mexico and rather scarce research on the field has been made by environmental economists, policy makers and other academics interested in the field. The games are explained in more detail in the work of Paloma Zapata[4] and the variety of possible games existing to evaluate the

[4] Zapata, Paloma. (2007). *Economía Política y Juegos No Cooperativos*. UNAM Facultad de Ciencias.

impact of cooperation between government and industry bodies is more diverse than it is presented in this essay.

1. ¿Why a Fuel Economy Standard?

Increasing environmental concerns have raised the need for limits on automobile fuel consumption as now CO_2 transport-related emissions account for 24% of all global emissions.[5] In different parts of the world, efforts have been made to mitigate the external costs that this pace of fuel consumption entails (air pollution, congestion, and green house gases) and policy makers are now figuring what the best economic tools are to bring about the highest social benefit from a series of regulations while maintaining everything else at the lowest possible social cost. The mechanisms implemented so far in developed countries, commonly known as Fuel Economy Standards (FES) intend to reach ambitious, yet achievable targets (if design is adequate) in the near future to significantly reduce and if possible, counterattack this negative trend. While taxation on gasoline has also been used as an instrument to control fuel consumption, this work leaves the issue of gasoline taxation largely underexplored and focuses chiefly on Fuel Economy Standards.

Several studies reveal that the macroeconomic impact of fuel efficiency policies over road transport during a 20 year scenario cannot be underestimated.[6] While certainly the implementations of climate policies come at a cost initially, the long term effects over the whole economy are remarkable. Key findings of these studies for the US include: Significant fuel cost savings by trucking companies and consumer savings on product shipping costs a net increase of 63,000 jobs economy-wide in 2020 and 124,000 in 2030; wage and salary income increases of $3.4 billion in 2020 and $8.4 billion in 2030 GDP increases of $4.2 billion in 2020 and $10.4 billion in 2030. Service, manufacturing, retail, insurance and real estate, and financing sectors see the largest employment increases while

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[5] World Resources Institute (2006): Climate Analysis Indicators Tool (CAIT) on-line database version 3.0., Washington , DC: World Resources Institute, available at http://cait.wri.org.

[6] Please consult the report by the Union of Concerned Scientists, *National Heavy Duty Truck Transportation Efficiency Macroeconomic Impact analysis* at http://www.ucsusa.org/assets/documents/clean_vehicles /Heavy-Duty-Truck-Transportation-Efficiency-Macro-Economic-Impact-Analysis.pdf. See also the engaging study –not concluded- of Terry Barker and Jonathan Rubin for a comparison between fuel efficiency and fuel taxation for the UK: http://www.wlu.ca/viessmann/ClimateChange/Barker_Rubin.pdf

petroleum-related employment decreases. A state-by-state breakdown shows employment gains are distributed widely throughout the country, with net job growth shown in every state.

Thus, by setting fuel economy standards on vehicle performance the impact sought is threefold: Petroleum dependency is grossly mitigated and thus is consumer's welfare increased, thereby reducing greenhouse gas emissions (GHG). An initial distinction must be made from the outset.[7] Fuel consumption refers to the amount of fuel used per unit distance; most commonly, liters per 100 kilometers (L/100 km), whereas fuel economy points at the distance traveled per unit of fuel used; most commonly miles per gallon (mpg) or kilometers per liters (km/L). The objectives of both of these measurement lines will be either to reduce fuel usage or to lower GHG emissions,[8] or both. For the purposes of this work, I will not distinguish between the objectives of the standards.

Limits on fuel consumption must be seen as a regulatory measure against indiscriminate use of petroleum, which as a non-renewable public good bears constantly uncertainty on market prices which tend to be always in flux bringing higher costs to society. GHG emission standards are set to comply with larger commitments taken on by most developed countries in an effort to cut down on emission levels across industries and sectors as framed during the Kyoto Protocol and other international agreements.[9]

The implementation of fuel economy standards poses a major challenge for policy makers in the sense that selecting criteria for regulation that truly justify the implementation of FES ensures successfully the achievement of the targets set without causing other costs to society and much less affecting individual welfare. Opinions are split as to how policy makers can most effectively bring about the optimal level of fuel consumption. Two important views of the discussion support attribute-based standards

[7] This distinction is widely recognized for policy purposes. See the works of Klaus Conrad & Michael Schröder, (1991). "An Evaluation of Taxes on Air Pollutants Emissions: An Applied General Equilibrium Approach" *Swiss Journal of Economics and Statistics*, Swiss Society of Economics and Statistics (SSES), vol. 127(II), pages 199-224, June. Harrington, Winston, (1997). "Fuel Economy and Motor Vehicle Emissions," *Journal of Environmental Economics and Management*, Elsevier, vol. 33(3), pages 240-252, July.

[8] Carbon Dioxide measures can be found at the site of the U.S. Environmental Protection Agency following this link: http://www.epa.gov/OTAQ/climate/420f05001.htm

[9] A list of International Environmental Agreements can be found at http://iea.uoregon.edu/

versus flat non-attribute standards.[10] When speaking of attribute-based standards policy makers must choose a characteristic in a vehicle on which to focus to work on the necessary technological improvements to achieve a specific target. Examples of attributes are vehicle's weight and carbon footprint. Non-attribute standards are targets set to all vehicle fleet under the same regulatory framework; this kind of standards tends to be less palatable politically and thus seldom voted for by policy makers.

On this account, attribute-based standards are more appealing to policy makers and manufacturers since focusing on one particular attribute makes targets more flexible for each manufacturer's average fleet to comply and thus policy schemes provide an easier way to attain policy objectives than non-attribute standards would.[11] The success of a Fuel Economy Standard will largely depend on key factors among which we can list the adequate design of standards, a set of regulatory institutions, effective monitoring and enforcement. I will come back to review in more detail the design of standards in the next section when I discuss the development of such standards in Japan and the United States. There exist vast a variety of market devices to provide the market with a structure in which the Fuel Economy Standard will be put forward, I will consider Robert N. Stavins'[12] categorical classification to be a useful guideline: it includes charge systems; tradable permits; market friction reductions; and government subsidy reductions. Taxation on gasoline is also seen as an efficient market-related mechanism to discourage fuel consumption as it is assumed that drivers will decide to drive less.[13]

From the lens of an economist, a Fuel Economy Standard presents both producers and consumers with alternative choices that are based on prices that reflect marginal social costs as it is required by the principle of efficiency. When there are external costs, like

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[10] See the recent works of German, John, (2009) "Fuel Economy Standards/GHG: Design Considerations" International Institute on Clean Transportation, available at: http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP200809.pdf

[11] For an extensive discussion on the decision between policy objectives and cost-benefit of fuel economy standards see the Discussion Paper (2008) "The Cost and Effectiveness of Policies to Reduce Vehicle Emissions" at the International Transport Forum

[12] Stavins, R.N. (2000), "Market-Based Environmental Policies", in: P.R. Portney and R.N. Stavins, eds., *Public Policies for Environmental Protection* (Resources for the Future, Washington, D.C.) p. 45

[13] Austin David and Terry Dinan, (2003) *The Economics Costs of Fuel Economy Standard Versus a Gasoline Tax,* A CBO Study Congress of the United States -Congressional Budget Office p.14 available at: http://www.cbo.gov/ftpdocs/49xx/doc4917/12-24-03_CAFE.pdf

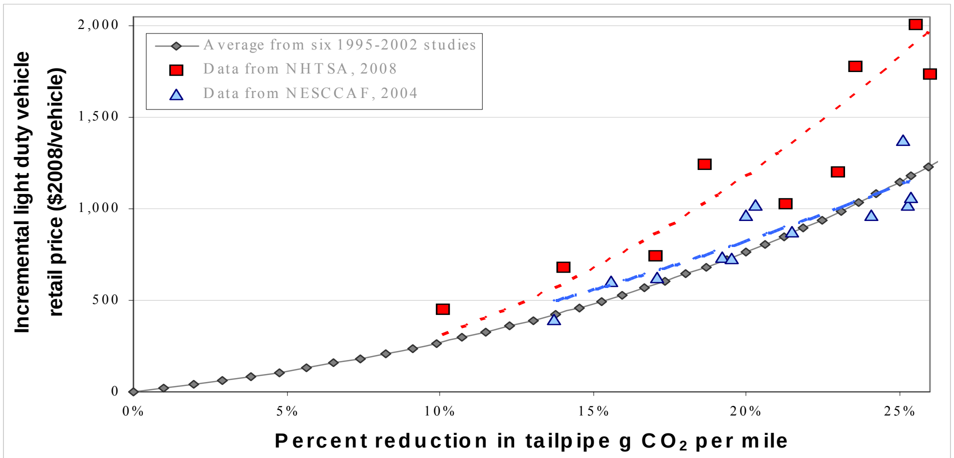
those related to greenhouse gases, local pollution and congestion, a way to align prices with marginal costs must be forthcoming.[14] From this assumption consumers and producers will try to optimize their behaviors to deliver the results that best adjust to the established targets. On the side of producers, these choices involve the type of technology that is employed to improve vehicle performance as well as the type of fuels and accessory features such as air conditioning systems. As R. Farrington and J. Rugh comment in their study, "Current air-conditioning systems can reduce the fuel economy of high fuel-economy vehicles by about 50% and reduce the fuel economy of today's mid-sized vehicles by more than 20% while increasing NOx by nearly 80% and CO by 70%".[15]

On one hand, a switch from conventional more pollutant technologies to green vehicle performance technologies always comes at an initial increased cost to vehicle owners. The costs for producers are also calculated to have sizeable increases when developing new technology and substituting older devices. There has been, however, a consensus amongst academics and policy makers that the new standards can be met with existing technologies. Yet compliance will be expensive, suggests Taft Foster, representing additional costs of up to several thousand dollars per vehicle. Foster continues his statement explaining that technology improvements must be reflected in higher efficiency of all components of engine (e.g. gasoline direct injection), transmission and drive train as well as from overall system technologies such as electric steering, alternator, road load reduction (e.g. light weighting, aerodynamics, lower rolling resistance) to name but a few.[16]

[14] The most general argument here is based on the partial equilibrium Pigouvian principle.

[15] Farrington R., and J. Rugh, (2000) "Impact of Vehicle Air-Conditioning on Fuel Economy, Tailpipe Emissions, and Electric Vehicle Range" National Renewable Energy Laboratory

[16] Foster Taft, (2009)., Raising Automotive Fuel Efficiency, The Federal Reserve Bank of Chicago "Chicago Fed Letter"



On the other hand, existing state, local, and federal taxes on gasoline already provide an incentive for consumers to reduce their consumption of gasoline: consumers will buy more-fuel-efficient cars and drive less as long as the costs of doing so are less than the tax-induced increase in the price of gasoline.[17] From this explanation of how Fuel Economy Standard works and the challenges it presents to policy makers, we can look at the development of such norms at a glimpse in countries like the United States and Japan.

To address the growing problematic of rampant fuel consumption in the automotive industry in conjunction with an expressed effort by the United States, the Federal Government issued a series of regulations known as CAFE (Corporate Automotive Fuel Economy). In the next section I disclose the general regulating schemes set in the United States.

2. CAFE STANDARDS

The history of fuel efficiency regulation for passenger cars and light vehicles in the United States dates back from a few decades ago. While it began as a precautionary measure to optimize oil in danger of shortage after the Arab Embargo in 1973, it later developed into a

[17] Austin David and Terry Dinan, (2003).

regulation to safeguard consumers from the effects of inflationary gas prices. To have an ample perspective of how CAFE standards have become more stringent over time, one has to notice that as of 1975 standards were 18.0 mpg for passenger cars and by 1990 it increased up to 27.5 mpg, remaining fixed until 2007 with the signature of the Energy Independence and Security Act.[18] The CAFE regulations fall behind several industrialized countries in the stringency and enforcement of its standards. Part of the reason for this is the legal structure of the standard and the nature of the agreements. CAFE regulations have only advanced at a very slow phase compared to targets in Europe or Japan as they have encountered heavy opposition within the automobile industry. The EISA is intended to put a halt to this uncompetitive tendency in America.

This Act aims at improving vehicle fuel economy. The Act set a goal for the national fuel economy standard of 35 miles per gallon (mpg) by 2020. This would increase the fuel economy standards by 40 percent and save the United States billions of gallons of fuel.[19] In 2002, a committee of the National Academy of Sciences wrote a report on the effects of the CAFE standard. The report's conclusions include a finding that in the absence of CAFE, and with no other fuel economy regulation substituted, motor vehicle fuel consumption would have been approximately 14 percent higher than it actually was in 2002. The National Highway Travel Safety Administration (NHTSA), the body regulation CAFE, began setting standards for light trucks based on vehicle size as defined by their "footprint" (the bottom area between the vehicle's four wheels). According to the study provided by ICCT, the new standard is based on a complex formula matching fuel economy targets with vehicle sizes. For the first three years, manufacturers can choose between truck-fleet average targets of 22.7 mpg in 2008, 23.4 mpg in 2009, and 23.7 mpg in 2010, or size-based targets.[20] The average fuel economy of each manufacturer's fleets of cars and light trucks must meet those standards, or the firm will be subject to a fine. All major automakers currently meet or exceed the standards.

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[18] See charts on the evolution of standards and performance by manufacturer at http://www.nhtsa.dot.gov/cars/rules/cafe/FuelEconUpdates/2003/index.htm

[19] See the Fact Sheet on the Energy Independence and Security Act Independence available at: http://georgewbush-whitehouse.archives.gov/news/releases/2007/12/20071219-1.html

[20] An, Feng and Deborah Gordon, (2007): *Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update,* Published by The International Council on Clean Transportation. Available at: http://www.theicct.org/documents/ICCT_GlobalStandards_2007_revised.pdf

Critics of CAFE standards, like the Congressional Budget Office, holds that while it is true that improved technologies help increase fuel economy and reduce carbon emissions, it is not necessarily a measure that will make consumers and producers (because they may encourage more driving and alter vehicle design) better off in the long term at current prices.[21] The CBO insists that an increase in the gasoline tax would reduce driving, leading to less traffic congestion and fewer accidents.

Formal sanctions are considered a part of CAFE standards when companies fail to comply with the standard in the average annual fleet car or light truck, currently $5.50 USD per 0.1 mpg under the standard, multiplied by the manufacturer's total production for the U.S. domestic market. Sanctions are important in the sense that producers have incentives to exceed the established standards. It is documented that Asian and American manufacturers have never paid civil penalties for failing to comply while most European automakers choose to pay really high quotes.[22]

More recently, a more extensive set of market devices has been introduced after the Energy Independence and Security Act including a scheme to trade and transfer credits resulting from exceeding the target and is offered to each manufacturer. Carmakers can transfer credits across categories in vehicles produced by the manufacturer or sell them to other manufacturers and non-manufacturers.

What is important to stress of CAFE standards for the purposes of this work is that carmakers from the very beginning are subject to a legally binding compliance system and thus both automakers and the state governments have all demonstrably opted for cooperation thereby avoiding sanctions. Later I will discuss the case of the European Union and the set of Voluntary Agreements (VA) negotiated between governing bodies and a representative body of carmakers. CAFE Reform remains a hot topic for a few years now to make the target more stringent for the car industry but undecided about what attributes are best to conform with the industry demands.

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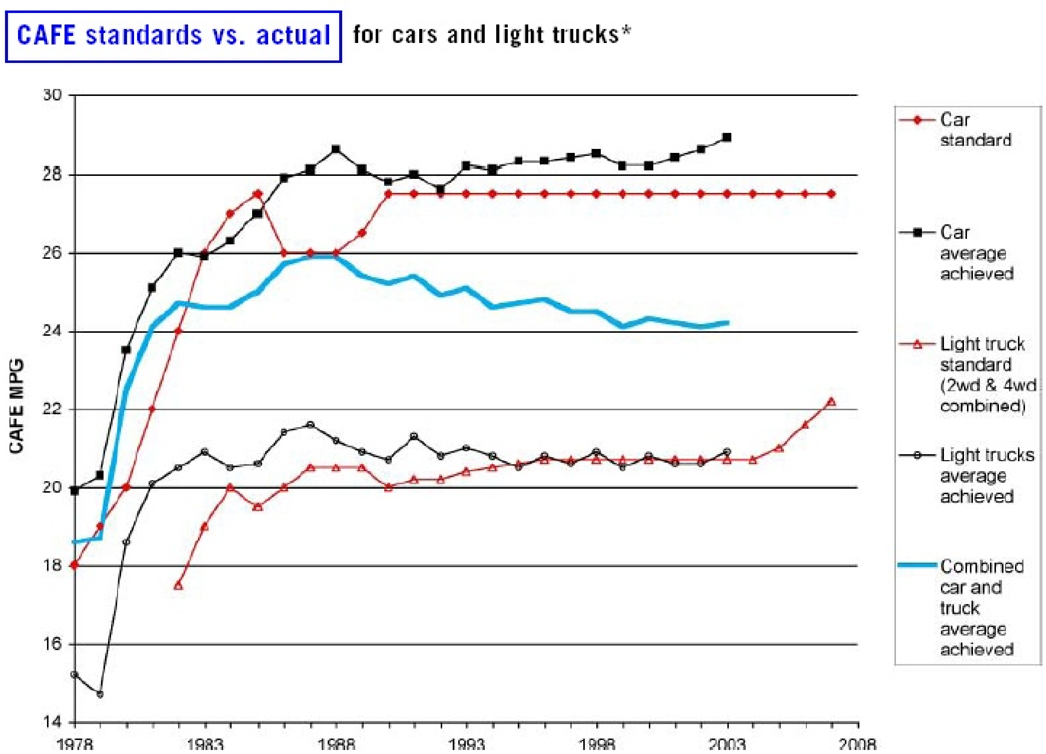
[21] Austin David and Terry Dinan, (2003), pp. 9-10

[22] See the section of The National Highway Travel Safety Administration for a complete explanation of sanctions for non compliance http://www.nhtsa.dot.gov/cars/rules/cafe/overview.htm

So far I have explained the purpose of designing Fuel Economy Standards and the implications that its implementation bears on producers and consumers. Policy makers need to determine the adequate standards and consider several aspects. These aspects include the numerical target, their timing and the structure of the standard for each type of vehicle and different vehicle manufacturer. Incrementing the target has always been the most contested issue among policy makers. In the next section I will explore briefly how this has been dealt with in Japan.



Japan is another example of developed country that has become a world leader in the success of its fuel economy standard program. The Japanese government first established fuel economy standards for gasoline and diesel powered light-duty passenger and commercial vehicles in 1999 under its "Top Runner" energy efficiency program.[23] In this model, fuel economy targets use attributes such as weight and class while employing similar market instruments used in CAFE like a credit transfer scheme to exchange across

[23] An, Feng and Deborah Gordon, (2007).

classes. It also applies penalties for non-compliance but differs from CAFE in that it does add a tax according to gross vehicle weight and engine displacement upon purchase. These financial incentives promote the purchase of lighter vehicles with smaller engines. For example, the Japan Automobile Manufacturers Association estimates that the owner of a subcompact car (750 kg curb weight) will pay $4,000 less in taxes relative to a heavier passenger car (1,100 kg curb weight) over the lifetime of the vehicle (JAMA 2007).

Further, manufacturers of products for which energy efficiency targets have been set are required to meet the standard on a sales weighted basis. This means that a manufacturer retains the freedom to produce a product that does not comply with the target in order to meet a particular consumer demand, provided he can offset this by the sale of other products with a higher energy efficiency.[24] The effort of manufacturers along with political support including tax incentives has been a key element in the success of the Top-Runner Program set in 1999. Translated into numbers, the average fuel-economy has improved about 22% from 1995 to 2004.[25]

According to Schipper, "a significant part of the improvements in Japan are related to the growing share of mini-cars (displacement under 600 CC) suggest that technology is not the only factor that can or will yield significant and rapid energy savings and CO2 restraint in new cars."[26] Schipper explains that technology has reduced the fuel required for a given car horsepower and weight markedly, but in the US (and to some extent Europe) this has been offset by greater new car power and weight. Further improvements in fuel economy depend both on technology to reduce fuel use per unit of weight or power, and a slowing, halting, or even reversal (i.e,. downsizing or down-weighting) of new vehicle power and/or weight beyond weight reductions in a given car class, i.e., downsizing.[27] However, this position remains largely contested as downsizing could compromise safety

[24] Consult ACEA website for more information on Japan's overall performance at http://www.acea.be/index.php/news/news_detail/japan_opts_for_integrated_approach/

[25] For a fuller account of Japan's Fuel Economy Standard please see Nordqvast Joakim, (2006). Evaluation of Japan's Top Runners Programme. Project executed within the framework of the Energy Intelligence for Europe programme,Contract number EIE-2003-114.

[26] Schipper, Lee., (2008). Automobile Fuel; Economy and CO2 Emissions in Industrialized Countries: Troubling Trends through 2005/6. EMBARQ-World Resources Institute, available at http://pdf.wri.org/automobile-fuel-economy-co2-industrialized-countries.pdf

[27] Schipper, Lee., (2008)., p.16.

in transit and increase accident fatalities.[28] Fuel economy standards "Top Runners" program in Japan differs from CAFE standards in the United States in the form of its political inception into the system. While targets are observed similarly lax in both countries, the arrangements made between government and automakers have been markedly more cooperative in Japan that in the United States. The Japanese government accepts that it has the *responsibility* to support the manufacturers efforts by tax incentives. Only by working closely together can the Japanese government and car industry ensure that the consumer will purchase fuel-efficient vehicles.

Similarly to the EISA in United States, Japan revised its fuel economy targets in 2006 to make them more stringent. According to the ICCT, this revision took place before the full implementation of the previous standards because the majority of vehicles sold in Japan in 2002 already met or exceeded the 2010 standards.[29] This new standard is projected to improve the fleet average fuel economy of new passenger vehicles from 13.6 km/L in 2004 to 16.8 km/L in 2015, an increase of 24 percent.

Similarly to CAFE standards, the Top Runner is a compulsory regulation and has been successful according to Naturvårdverket in that it includes that the program gives incentives for industry-wide environmental improvements, because the standards do not only look at the best product on the market, but also to the potential for other producers to realistically meet the standards.[30] The mandatory nature of the program forces producers to meet the standards. The standards apply to individual companies, which probably give more incentives to companies to comply than industry-wide standards such as the ACEA standards, which I discuss in the next section.

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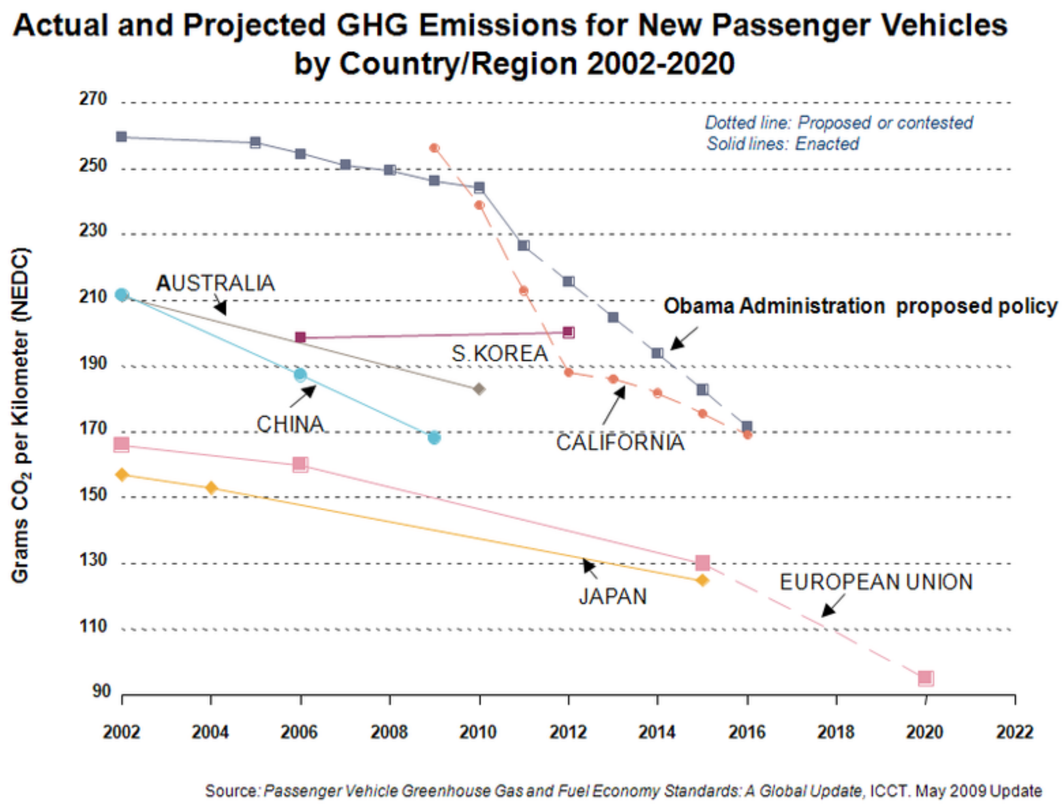
[28] See the works of the Kahane, C.J., 2003. "Vehicle Weight, Fatality Risk and Crash Compatibility of Model Year 1991-99 Passenger Cars and Light Trucks," NHTSA technical report DOT HS 809 662, Washington , DC, October 2003. Available at www.nhtsa.dot.gov/cars/rules/regrev/evaluate/pdf/809662.pdf

[29] An, Feng and Deborah Gordon, (2007).

[30] Naturvårdverket (2005). The Top Runner Program in Japan: its Effectiveness and Implicaitons for the EU. The Swedish Environmental Protection Agency, Stockholm.



3. The ACEA Agreement in the European Union

Contrary to the CAFE program in the United States and the Top-Runners program in Japan, The European Union has led an alternative course of action with relative greater success than its counterparts in the U.S and to some degree equally successful as Japan. The main difference taking place in Europe in implementing a strategy to cut down on emissions and reach ambitions fuel economy targets is that the European Union has signed voluntary agreements with the entire automobile industry as opposed to legally binding agreements made with each manufacturer. The voluntary agreements were in 1998 concluded with the European Automobile Manufacturers' Association (ACEA), the Japan Automobile Manufacturers Association (JAMA), and the Korea Automobile Manufacturers Association (KAMA).[31] This becomes the first industry-wide agreement known as the ACEA Agreement.[32] The target for new passenger fleet average CO_2 emissions are 140 g CO_2/km by 2008/9. The

[31] An, Feng and Deborah Gordon, (2007).

[32] It is worthy of mention that Voluntary Agreements to reduce carbon dioxide levels exist also at the supranational level within the EU.

Community's target for 2012 is 120 g CO_2/km. This longer-term target has not yet been included in any formal agreement with the car industry. This target was designed to achieve a 25 percent reduction in CO_2 emissions from passenger cars from 1995.[33]

However, the World Wide Fund for Nature in a recent study has questioned the suitability of such voluntary agreements not because its leaves a door open for to non-compliance, but for the lack of procedures that make these voluntary agreements a good fit for the institutional and political context of the EU. This analysis shows a number of fundamental shortcomings which, according to the WWF, could undermine the EU strategy to reduce CO_2 emissions from cars.

WWF enlists four main shortcomings inherent in the ACEA agreement which can be summarized as follows: The target of 140 g/km seems insufficient in the face of a growing number of car owners which make this target too lax to stabilize CO2 emissions from passenger cars at 1999 level by 2010. WWF observes that the ACEA agreement did not conform to the European Parliament and thus failed to ensure public participation. It critically accuses the commission for lacking alternatives to negotiate more ambitious targets. It also presents no sanctions for non-compliance, especially to address the issue of free-riders.[34]

But criticism towards ACEA comes also from the United States. An analysis recently released by the World Resources Institute (WRI) and the Sustainable Asset Management Group (SAM) reveals that the car companies are not disclosing CO2 reduction commitments or strategies to comply with a European Union agreement to lower auto emissions.[35] Amanda Sauer has raised his objections against ACEA: "The problem with the ACEA Agreement is that nobody knows what the auto companies are planning to

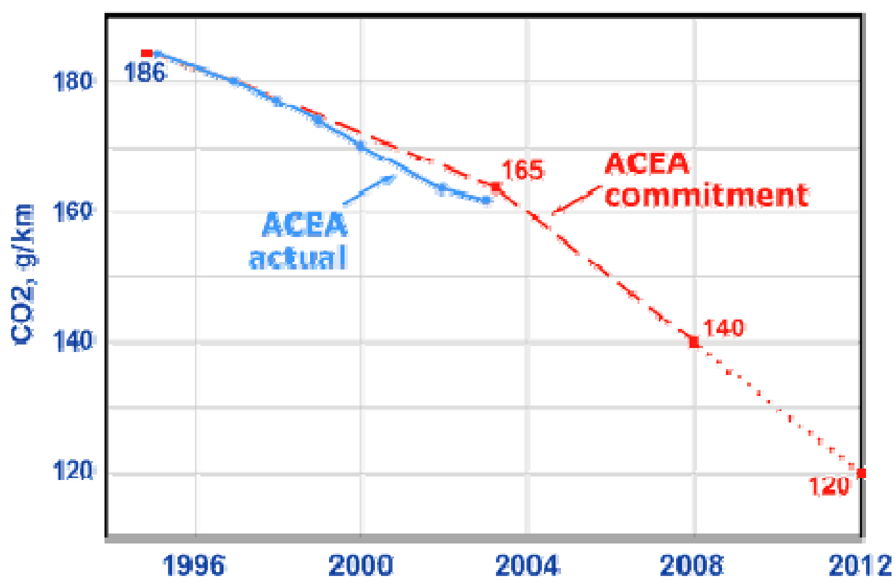
[33] An Feng, Amanda Sauer., (2004)., "Comparison of Fuel Economy Standards Programs and Greenhouse Gas Emission Standards Around the World". The Pew Center for Climate Change. Available at http://www.pewclimate.org/docUploads/Fuel%20Economy%20and%20GHG%20Standards_010605_110719.pdf

[34] Volpi Giulio, (2000) Will voluntary agreements at EU level deliver on environmental objectives? World Wide Fund for Nature. Discussion Paper available at: http://assets.panda.org/downloads/agreementonfueleconomy.pdf

[35] Denton, Peter.,(2005) Lack of Disclosure from European Automakers threatens Investors. WRI Features Abril 2005, Vol. 3 No. 4.

do to bring the industry to its 2008 target"[36] I have already discussed in previous chapters that, industry representatives in America and Europe opposed the continuous raising of standards due to the increasing production costs that fuel improvements entail.

The major findings in Sauers' analysis are that individual company commitments to bring the industry to this target are unknown. The lack of transparency about how companies will meet the ACEA Agreement target leaves investors in the dark because there is insufficient information to understand the financial implications of the Agreement on specific Original Equipment Manufacturers (OEMs). Data on company CO_2 performance has not been disclosed. Investors need this data to understand the likely costs and competitive implications each company faces to meet the obligations of the Agreement and to track OEM progress towards meeting their commitments. Sauer concludes her study stating that "without full disclosure of all relevant information about CO_2 reduction strategies, investors in any of these OEMs could face unforeseen risk."[37]



[36] Sauer, Amanda. (2005). Transparency Issues With ACEA agreements: Are Investors Driving Blindly? World Resouces Institute.
[37] Sauer, Amananda. (2005). p

Relationship between CO2 targets and Fuel Consumption in Europe

Target	Fuel consumption (ℓ) per 100 km	
	petrol	diesel
120 gCO2/km	5.1	4.6
140 gCO2/km	5.9	5.4

Source: Kågeson, 2005.

4. Theoretical Approach: Game Theory applied to Natural Resource Management

So far I have described the mechanisms with which Japan, the United States and Europe have dealt with the issue of establishing stringent fuel economy standards that contribute to ameliorate the rampant use and abuse of fuel consumption. These regulatory measures have been taken on board as a tool to linger the already impending petroleum scarcity and also to mitigate some of the effects (many of them already tangible) of global warming caused by GHG emissions resulting from fuel combustion. In this section I spell out Elinor Ostrom's theoretical approach to Common Pool Resource through Game Theory. My suggestion is that policy makers involved in designing the standards for fuel efficient vehicles can benefit from Ostrom's approach to Natural Resource Management, which, although applied at present to a variety of environmental problems, has not sufficiently been scrutinized to analyze this particular problematic in most existing Environmental Economics literature.

The objective of this theoretical move is to bring Ostrom's work to consideration for the development of fuel economy standards putting at the forefront of policy the link existing between fuel efficiency standards and common pool resource management. One of the ways to elucidate this link is by employing Game Theory as presented in the work of Ostrom in order to establish the conditions under which management of a common natural resource is most successful. For the purpose of this essay, Fuel will be considered the common natural resource. Similarly, when speaking of GHG, the atmosphere can be judged as the common natural resource for which Ostrom's approach results doubly useful.

In economics, a common-pool resource[38] (CPR), also called a common property resource, is a type of good consisting of a natural or human-made resource system (e.g. an irrigation system or fishing grounds), whose size or characteristics makes it costly, but not impossible, to exclude potential beneficiaries from obtaining benefits from its use. It is in this sense that fuel, as one of the most important derivatives from petroleum, can be studied from this lens. Unlike pure public goods, common pool resources face problems of congestion or overuse, because they are subtractable. A common-pool resource typically consists of a core resource (fuel being the example here), which defines the *stock variable*, while providing a limited quantity of extractable fringe units, which defines the *flow variable* (here comes the establishment of the standards). While the core resource is to be protected or entertained in order to allow for its continuous exploitation, the fringe units can be consumed.[39]

A common property regime is a particular social arrangement regulating the preservation, maintenance, and consumption of a common-pool resource. The use of the term "common property resource" to designate a type of good has been criticized, because common-pool resources are not necessarily governed by common property regimes. Examples of common-pool resources include irrigation systems, fishing grounds, pastures, forests, water and the atmosphere. A pasture, for instance, allows for a certain amount of grazing occurring each year without the core resource being harmed. In the case of excessive grazing, however, the pasture may become more prone to erosion and eventually yield less benefit to its users. In this study, the common pool resource to examine is fuel as a natural resource, measuring the impact of its use in the presence of Greenhouse Gas emissions. Because their core resources are vulnerable, common-pool resources are generally subject to the problems of congestion, overuse, pollution and potential destruction unless harvesting or use limits are devised and enforced. The use of many common-pool

[38] The text on this paragraph borrows heavily from similar explanations made by Gordon, Scot (1954) The Economic Theory of a Common Property Resource: The Fishery. *The Journal of Political Economy*. Vol. 62. No.2. Available at http://www.econ.ucsb.edu/~tedb/Courses/Ec100C/Readings/ScottGordonFisheries.pdf. Similar texts have been made public by environmental accountants at http://www.sandiegoaccountantsguide.com/library/Common-property-resource.php and later on Wikipedia, http://en.wikipedia.org/wiki/Common-pool_resource.

[39] This discussion can be followed on Hess, C. and Ostrom, E. (2001), "Artifacts, Facilities, And Content: Information as a Common-pool Resource", Workshop in Political Theory and Policy Analysis. See http://www.law.duke.edu/pd/papers/ostromhes.pdf

resources, if managed carefully, can be extended because the resource system forms a positive feedback loop, where the stock variable continually regenerates the fringe variable as long as the stock variable is not compromised, providing an optimum amount of consumption. This is not the case with fuel; excessive fuel consumption will lead to the eventual scarcity of petroleum and that is what makes the approach to fuel more challenging. Here consumption leads to deterioration of the stock variable, thus disrupting the flow variable for good.

Common-pool resources may be owned by national, regional or local governments as public goods, by communal groups as common property resources, or by private individuals or corporations as private goods. When they are owned by no one, they are used as open access resources. Having observed a number of common pool resources throughout the world, Elinor Ostrom noticed that a number of them are governed by common property regimes - arrangements different from private property or state administration - based on self-management by a local community. Her observations contradict claims that common-pool resources should be privatized or else face destruction in the long run due to collective action problems leading to the overuse of the core resource.

4.1 **Situating the Debate of the Tragedy of the Commons in Context**

While most modern reference to the debate on the Tragedy of the Commons refers us back to Garrett Hardin's seminal work 'The Tragedy of The Commons'[40] released in 1965, controversy about the limitedness of natural resources and the question of ownership has spurred since the early Greeks. Aristotle famously commented that "What is common to the greatest number has the least care bestowed upon it. Everyone thinks chiefly of their own interest."[41]

Harding addresses his view of the Tragedy of the Commons in his article with an example of a situation based on medieval land tenure in Europe. He places a group of herders sharing a common parcel of land, on which they are each entitled to let their cows graze. In Hardin's example, it is in each herder's interest to put the next (and subsequent)

[40] Hardin, G. "The Tragedy of the Commons." *Science* 162 (1968): 1243–1248

[41] Aristotle, *Politics*, 1262a Oxford: Clarendon Press, 1885. Vol. 1 of 2, pp30-37

cows he acquires onto the land, even if the quality of the common is temporarily or permanently damaged for all as a result, through over grazing. The herder receives all of the benefits from an additional cow, while the damage to the common is shared by the entire group. If all herders make this individually rational economic decision, the common will be depleted or even destroyed to the detriment of all.

Hardin was certainly the first scientist to point that some environmental concerns result from this unrestricted access to certain limited resources, mimicking the example of the herders with different scenarios of the "commons". He observed that the overpopulation of planet Earth was leading to an unavoidable Tragedy of *all* the Commons if one considers all natural resources to be those *commons*. These commons are the atmosphere, non-renewable energy resources, forests, oceans and fish stocks to name but a few.

Many modern large-scale ecological dilemmas share characteristics of commons problems: urban sprawl, polluted air and water, the collapse of fisheries and some wildlife populations, acid rain, global warming, and oil overuse. As Hardin and Lee[42], argued, non-renewable energy consumption such as fuel consumption is also a commons problem: as human populations reach high motorized capacity worldwide, the fuel one individual consumes is fuel another individual may in consequence not have. These problems are especially difficult, because additional to the fact of fuel not being renewable there is a second common resource resulting severely damaged: the atmosphere. These are large-scale problems with high rewards for individual/corporate defection and little incentive for costly cooperation.

Hardin asserted that certain market instruments ought to be introduced to assure protection to certain commons, in particular he called for greater government control of resources by means of privatization, regulation or simply by State ownership. This is the point where Ostrom's work becomes useful. She challenges Hardin's view by proposing

[42] Lee, R. D. "Comment: The Second Tragedy of the Commons." Population and Development Review 16 (1990): 315–322.

that traditional approaches to oversee the protection of the commons serve as a better guideline to build up more sensitive frameworks that include both, public-private participation. She recognizes that “When local users of a forest have a long-term perspective, they are more likely to monitor each other’s use of the land, developing rules for behavior,” she cites as an example. “It is an area that standard market theory does not touch.”[43]

Over many decades Ostrom has documented how various communities manage common resources – grazing lands, forests, irrigation waters, fisheries— equitably and sustainably over the long term. The Nobel Committee’s recognition of her work effectively debunks popular theories about the Tragedy of the Commons, which hold that private property is the only effective method to prevent finite resources from being ruined or depleted. Harding left unexplored the creation of common regime management mechanisms to administer the commons, assuming that private property was the only way out of the problem of depletion.

In this light, Ostrom demonstrates that the organized citizenry can equally share the responsibility to tackle the common’s problem. In this work I take Ostrom’s view in a slightly different direction to say that optimizing fuel efficiency is not solely the state’s responsibility but also that of the massive corporations that exploit it. To shed some light on how to manage this resource in a shared way, Ostrom identifies seven "design principles" of stable local common pool resource management:[44]

1. Clearly defined boundaries: Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself.
2. Congruence between appropriation and provision rules and local conditions: Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, material, andlor money.

[43] Ostrom. 1990. *Governing the Commons, The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press, pp. 234
[44] Ostrom. 1990, pp 180.

3. Collective-choice arrangements: Most individuals affected by the operational rules can participate in modifying the operational rules.
4. Monitoring: Monitors, who actively audit CPR conditions and appropriator behavior, are accountable to the appropriators or are the appropriators.
5. Graduated sanctions: Appropriarors who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both.
6. Conflict-resolution mechanisms: Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.
7. Minimal recognition of rights to organize: The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

For CPRs that are parts of a larger system:

- Nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

5. Symmetric Games

Definition 1:

N: Set of Players; Dj: set of strategies pure of player j; j_j: payment function of player j; $D = D_1 \times D_2 \times \ldots \times D_n$, elements of D are profiles of pure strategies. $s = (\sigma^1, \sigma^2, \ldots, \sigma^j, \ldots, \sigma^n)$.

A rectangular game cosists of a set N, a collection of sect Dj, ∀ j in N, and a collection of functions j_j, ∀j in N, where j_j: $\prod Dj \rightarrow R \quad \in N$

$$(N, \{Dj\}_{j\in N}, \{\Theta j\}_{j\in N})$$

Definiton 2:

A profile of pure strategies σ* is a Nash Equilibrium, if for each player j in N complies:

$\theta_j(\sigma^*) \geq j_j(\sigma^*| \sigma^j)$ $\forall$ j en Dj.

Θ σ

Bipersonal finite games are generally represented by a payment matrix.

	Cooperate	**Desert**
cooperate	**(a, a)**	**(e, f)**
desert	**(f, e)**	**(b, b)**

	cooperate	**desert**
cooperate	**(a, a)**	**(e, f)**
desert	**(f, e)**	**(b, b)**

	cooperate	**desert**
cooperate	**(a, a)**	**(e, f)**
desert	**(f, e)**	**(b, b)**

That is why they are named bimatricial games or rectangular games. Each game represents the payments of one strategy of player one and each payment column.

A game is sum-zero if:

Σ: $\Theta_j(\sigma) = 0$, $\forall\ \sigma \in D$

Symetric Games

In these games players can exchange roles For example: This game generates 3 Nash equilibria. $d \neq f \wedge e \neq g$

	I	II
I	(d, d)	(e, f)
II	(e, f)	(g, g)

i) $(d-f)(g-e)<0$. Which leads to two subcases:

$d>f \wedge e>g$, then (I, I) is the only Nash equilibrium (ep) of the game.
$f>d \wedge g>e$, then (II, II) is the only Nash Equilibrium (ep).

ii) $(d-f)(g-e)<0$ with $d>f \wedge g>e$ then the game has two Nash equilibria (ep), (I, I) y (II, II)

iii) $(d-f)(g-e)>0$ with $d<f \wedge g<e$, then the game has two Nash equilibria (ep), (I, II) y (II, I).

Here I present an example of how this kind of game could be initially used for understanding voluntary agreements between government and private sector. Government and the Automobile Industry Association agree on a set of procedures to determine the target for a specific car model over a time frame. The symmetry will be constituted as to whether the agreements are voluntary or compulsory, and in turn weather they effectively reduce or not GHG emissions.

i. If both entities decide to cooperate for setting the target that most increases fuel economy, then the price of fuel will go up and equally car makers would have to increase their costs for introduction of new technology. GHG emissions will considerably decrease.

ii. If government and car manufacturers act separately, then it means their decision only will focus on maintaining fuel prices unfixed at the expense of disallowing car manufactures' prices to rise in spite of technological innovations being introduced, then fuel economy targets will have to be less stringent. GHG emissions will not be mitigated as desired.

iii. If government does not get involved in watching, monitoring, and supporting with legislation at all to enforce the compliance of targets resulting from voluntary agreements, then car manufacturers will not comply with the targets, as evidenced by most voluntary agreements. In this scenario, GHG emissions will increase over time.

The game can be illustrated as follows:

P1 / P2	To Reduce	Not to reduce
reduce	(140, 140)	(-140, 100)
Not to reduce	(100, -140)	(0, 0)

N = {not to reduce, to reduce},

D = {to reduce, not to reduce},

(d-f)(g-e) > 0 en este caso **f < d** ∧ **g > e**,

In this case, the Nash equilibria (ep) are the strategy profiles as follows:

(I, I) = **(to reduce, to reduce)** and

(II, II) = **(not to reduce, not to reduce)**

Concluding Remarks

Significant research on fuel efficiency standards has been undertaken and has come a long way in most industrialized countries. However, the trend shows that the direction research is moving suggests a real need to bring governing bodies and industry representatives to engage in more social decision making. This process, we expect, looks into the economic impact of fuel economy standards more as a *managed commons*, and less as a traditional rational agent.

In Mexico there is a need for making information on car polluting levels available for research as research is already on course to assign different fuel standards for different vehicle models and sizes. The examples presented here illustrate how industrialized countries have dealt with this issue and hopefully this and more available information will prevent policy makers from falling into the same ditches.

The relevance of the work of Ostrom for this field has not yet been fully examined; it has focused more on environmental problems that have to do with deforestation, water use and other common pool-resource concerns. However, in this essay I have attempted to elucidate the connection between Ostrom's contributions to environmental situations which the commons and fuel efficieny standards. Adding Game Theory using the Nash Equilibrium illustrates Ostrom's point. The idea is to replicate the number of games and cases where particular situations can be represented through this methodology.

One the lacks of this work is the presence of econometrics analysis, this is partly due to the brevity of the essay and to the scarce information around, leaving plenty of variables out to be analyzed. However, the major strength it has for its readers is the diversity of games that can be used taking symmetrical or rectangular games as a point of departure. The theoretical approach exposed here makes it easy to the reader to take a number of different examples to predict behavior based on economic interest.

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Index

1. Introduction …………………………………………………………. 2

2. Why a Fuel Economy Standard? 4

3. The ACEA Agreement in the European Union ………………….. 13

4. Theoretical Approach: Game Theory Applied ...………………… 17

5. Situating the Debate: The Tragedy of the Commons…………….. 19

6. Symmetrical Games ……………………………………………… 19

7. Concluding Remarks …………………………………………….. 25