

**INDUSTRY ENVIRONMENTAL PERFORMANCE AND
REGULATION IN THE AUTOMOBILE INDUSTRY**

by

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The ESRC Centre for Business Relationships, Accountability, Sustainability and Society

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Abstract

This work provides an analysis of the impact of regulation on the environmental performance of the automobile industry. It therefore seeks to contribute to the 'greening of industry' body of literature by discussing the relationship between environmental regulation and the auto industry technological development, commercial imperatives and wider social benefits in the context of the 'license to operate' framework.

Three case studies have been conducted. The first is the pioneering tailpipe emissions regulations from the state of California, in the United States. This original legislation was the stepping stone in the development of automobile air emissions regulations around the world. California is still the leader in environmental regulation regarding air emissions, with the establishment of the Zero Emissions Vehicles Program (ZEV), and both are discussed in the same case study. The second case study is the Brazilian experience with ethanol. This event constitutes the first attempt to use an alternative fuel to propel vehicles on a large scale. The third case study is the European Union end-of-life vehicle directive that incorporates the extended producers' responsibility principle to address waste from vehicles in the end-of-life phase.

The three case studies are discussed using the 'license to operate' framework, so providing an empirical understanding of the relationship between environmental regulation and auto industry technological development, commercial imperatives as well as the wider social benefits in these context specific cases; they also show how regulation has been able to foster corporate environmental performance in the automobile industry.

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Chapter 1 – Introduction

1.1 - Introduction

Industry holds a crucial role in humankind's effort towards sustainable development. Local communities, scientists and environmental groups indicate environmental negative externalities produced by industry. Policy makers and legislators, in response, find ways of addressing these issues by creating environmental regulation. However, in practical terms, the implementation of environmental measures falls to industry. Generally, industry has to adopt specific technologies, bearing the associated costs, including the abandonment of sunk-costs and the risks relating to the core adjustments of any entrepreneurial activity.

The impacts caused by the adoption of environmental regulation to the industry have been a topic of discussion in the policy making and business management areas in recent years. Initially, environmental regulations were perceived as being detrimental to business. The pioneering 'command-and-control' measures adopted to tackle the first environmental problems were strongly opposed by industry. This view was challenged in the 1990s with the emergence of the 'greening of industry' perspective that saw environmental regulation as inducing positive effects. A polarised debate emerged between those who perceived environmental regulation as fostering innovation and creating economic profit (Porter and Van der Lind, 1995), and those who saw regulation as being solely a source of cost to the industry (Palmer et al., 1995). This dispute eventually evolved into a more nuanced understanding of the effects of environmental regulation to firms and society in terms of innovation and environmental benefits (Reinhardt, 2000).

The automobile industry is an important field to investigate the effects of regulation on industry. Due to its magnitude and importance, it has been one of the first industrial sectors to be targeted by environmental regulation and has served as a benchmark for

other regulated industries (Wells and Orsato, 2005). The regulatory pressure that the sector has received has been directly related to technological development. There has been a clash between the best available technologies that can be used to address an environmental issue and the business imperatives of the industry at the time.

In this respect, this work investigates the effects of environmental regulation on the environmental performance of the automobile industry, taking into account not only the central concerns of regulators, but also other areas that have been affected by regulators in the short and long term. As indicated by Press (2007), having a clear understanding of these effects and the factors that have influenced the industry has not been possible until recently. The assessment of the effects of regulatory policy in relation to the environment and the competitiveness of firms has not been feasible because of the lack of consistent data in relation to the innovation and environmental effects of these measures. Aside from this, *ex-post* analyses have systematically been more precise and provide clearer insights into the secondary effects of environmental policy (Press, 2007).

This thesis aims to contribute to the recent body of literature termed the 'greening of industry' within the context of the licence to operate model. The research looks at the effects of environmental regulation on the automobile industry taking an *ex-post* analysis. In this regard, elements of business strategy and business political strategy are used to understand how the industry's behaviour has been influenced by regulation and the factors that have been conducted for specific outcomes.

1.2 - Area of interest and scientific field

The area of interest where this thesis aims to contribute is the field defined as the 'greening of industry'. The field understands that industry plays a prominent and decisive role in the process of change towards more a sustainable society. According to

the Greening of Industry Network (2009), the 'greening of industry' aims to align industrial development policies with sustainable development principles. Therefore, the following concepts are taken as the basis for the research conducted in the field:

(1) - Sustainable development is a global imperative. Development must take into account the carrying capacity of the environment and focus on increasing the quality of life of present and future generations.

(2) - Major changes in production and consumption systems are required to meet the needs and aspirations of a growing world population which needs to use environmental resources in a sustainable manner.

The term 'greening of industry' was generated in the early 1990s where the focus of research was on the environmental change of the industry. In recent years, the scope has been enhanced to consider the broader issues of sustainability in the industrial system. The industrial system includes not only the industry (supply) but also consumption (demand). The inclusion of the consumer as an important stakeholder in the industrial process of change has significant consequences for the future progress of the field (GIN, 2009).

The field also gives significant relevance to the growing role that technological development can play in the path toward a more sustainable society. Technology has been perceived as a crucial element in the industrial process of change impacting on the quality of life of present and future generations. Relevant to this discussion is the Factor X school of thought that understands that technological improvements can result in dematerialisation or the eco-efficiency improvements in a quantitative measure between 4 and 20 (Reijnders, 1998). Von Weiszäcker et al. (1997) provided one of the most influential studies in this area, where 50 cases of technological improvements are documented showing a doubling improvement in welfare while the consumption of natural resources in customary products and services is reduced in half.

The process of rapid globalisation provides complementary significance to technological developments as the achievements can be extended to markets at an international level. Multinational firms have enhanced the connection between different nations and regions of the world, by extending the gains from research and the development of new technologies (GIN, 2009).

1.3 - Broad topic

The broad topic of this thesis can be summarised as the empirical investigation of the impact of environmental regulation on the technological development of the automobile industry, taking into account economic and social demands. A stylised debate around this issue is given in this section, showing different sides of the topic. A deeper discussion on this issue is conducted in the literature review chapter.

The growth in the ‘greening of industry’ literature on the effects of environmental regulation to industry has been accompanied by the historical development of environmental thinking in society and by the chronological development of environmental regulation (Fisher and Schot, 1993). Initially, the industry’s preoccupations with the effects of environmental regulation started with the primary wave of environmental regulations that began in the 1960s and 1970s. Industry in general resisted the implementation of environmental regulation that was based on the ‘command-and-control’ approach (Kagan, 1994). For firms, environmental regulations were perceived as an additional cost and compliance was respected only when it was legally obligatory. This industry behaviour has been termed as ‘resistant adaptation’ (Fiorino, 2006). Under this perception, environmental regulation would reduce the profitability of the industry (Palmer et al., 1995).

In the 1980s, regulation forced businesses to initiate actions with respect to industrial waste and the use of natural resources. The use of certain raw materials and the production of toxic wastes was restricted or banned (Fuchs and Mazmanian, 1998). Industry responded with the development of codes of conduct, and the use of alternative materials. In the United States, for example, the chemical industry has been a pioneer in creating the Responsible Care program (Delmas and Montiel, 2008). The focus was on reducing the future liabilities that could be imposed by environmental regulation and not on adopting wider innovative measures. In certain places, the adversarial legalism of the legal system has been responsible for creating divergent relationships and industry has taken a pro-active role in pursuing law suits (Kagan, 2001).

In the 1990s, the environmental dimension began to be perceived as a strategic aspect of business. Proactive industry environmental strategies with the purpose of gaining economic benefits and enhancing the public image of the industry as an entity were indicated (Sharma and Vredenburg, 1998). The 'greening of industry' literature provides a rapidly growing body of literature around the effects of environmental regulation to industry. The early work in the field consisted of the documentation of successful case studies that verified how the adoption of environmental regulation generated environmental benefits accompanied by financial gain (Schidheiny, 1992). The term 'triple bottom' line was used to indicate that the integration of the social and economic terms is required if real progress is to be observed in the environmental dimension for businesses (Elkington, 1994). The emergence of the field came to question the previous understanding that environmental regulation would significantly enhance industries' aggregate costs. Later work presented a more strategic aspect of greening, focusing on the role that environmental regulation could play in indicating areas of future investment (Fiorino, 2006). The forces behind the trend have also been studied, looking at the conditions under which greening would emerge in an industry and provide benefits (Roome, 1998).

As a result of this, some of the literature in this field has centred on managerial tools that

enhance the concept of greening in firms and institutionalise internal actions. The most practical work on internal change has focused on the development of industry codes of environmental management practice (Nash and Ehrenfeld, 1997), environmental management systems (Cognlianese and Nash, 2001) and industry self-regulation (Rees, 1997). Terms such as 'sustainability' and 'environmental stewardship' emerged with wider preoccupations that included impacts on local communities and on the end-of-life management of products. According to Fiorino (2006), the focus of the literature had shifted from bottom-line cost reduction savings to top-line value in terms of greater market share and the proactive management of the environment. Established entities such as The World Business Council for Sustainable Development (WBCSD) have also defended this outcome, under an industry-wide understating of more than 200 key international companies to take the business leadership in policy development and demonstrating the business contribution to sustainable development and to shared best practices (WBCSD, 2010).

Most of the 'greening of industry' literature from this period is optimistic with respect to the ways in which industry can reap benefits from environmental regulation. The Porter and Van der Lind hypothesis (1995) that argued for the correlation between strict environmental regulation and industry profit, and the work of Hart (1997) that understood that a sustainability vision is necessary for industry were widely quoted.

The positive perception that opportunities for product stewardship and clean technologies would provide a profitable outcome for industry followed the notion that environmental regulation could provide positive outcomes for firms and was widespread in the 'greening of industry' literature (Fiorino, 2006). This includes the authors influenced by the Porter and Van der Lind hypothesis (Porter and Van der Lind, 1995) and Hart (1997), as well as other authors such as those of the schools of the factor X (Von Weiszäcker et. al., 1997), and the eco-efficiency (Schmidheiny, 1992). As a consequence, some research evolved to consider industrial efforts that were beyond the simple compliance with environmental regulation and became more proactive behaviour (Gunningham et al, 2003). According to

the prevailing understanding of this body of knowledge, many firms have enacted or looked for ways of improving on being simply obedient to the environmental rule as this would generate benefits to the firm.

This progressive behaviour has been the concern of the field in recent years. The present perception in the field is that greening can be translated into a constant and verifiable effort by industry to do better than simply comply. It is characterised by a more nuanced vision of the effects of regulation to the industry that look at the conditions under which environmental regulation can provide benefits to industry (Reinhardt, 2000).

1.4 - Empirical focus - the automobile industry

The automobile industry has traditionally been targeted by environmental regulators, due to the scale of the industry and the vast array of negative environmental externalities generated. The internal combustion engine-based automobile became one of the most important industrial icons of the 20th century. It completely reshaped the way modern society perceives mobility. Nowadays, the use of the automobile is widespread with the world fleet reaching over 600 million cars in 2006 (The Society of Motors Manufacturers and Traders Limited - SMMT, 2007). Car ownership is still perceived as an indispensable part of modern identity (Mann and Abraham, 2006), which along with growing disposable incomes worldwide provides the basis for the continued expansion in demand for new cars.

Automakers, coerced primarily by regulation, have had to adapt the automobile to modern environmental mandates. The current automobile is much more efficient in terms of energy use and power per volume, for example, and in relative terms may be perceived as less harmful to the environment than the first models. However, the modern

automobile is much heavier and produces about the same fuel economy as the older vehicles. In short, the automobile is still an unsustainable product in its present form (Nieuwenhuis and Wells, 2003) since aggregate fuel economy has not improved much due to the increase of vehicle weight and addition of extra components. It still produces a large number of negative externalities, and if the scale of vehicle ownership is taken into account, the environmental damage is particularly disturbing (Graedel and Allenby, 1998).

The negative environmental consequences of automobile use have been subject to a detailed analysis from the environmental view point in several studies, including MacLean and Lave (1998), Sullivan et al., (1998), Graedel and Allenby (1998) and Graedel et al.(2002). These authors use life cycle analysis to investigate the impact of the automobile on the natural environment. The flow of materials is explored in all the phases of the life cycle of the product (Graedel and Allenby, 1998). In this sense, a better grasp of the negative environmental externalities can be gained and corrective actions can be suggested (Robert, 2000). Life cycle analysis is also relevant to link the material flow analysis to the core principles of sustainability in a step towards a closed-loop economy (Robert, 2002).

The life cycle of the automobile is complex. The product is composed of a large number of auto-parts built out of a wide range of materials, using a wide range of industrial processes and involving a great number of firms (Graedel et al., 2002). The life cycle of an automobile can be divided into six stages:

- Raw material extraction; several elements found in the natural environment are extracted, including: coal, limestone, iron ore, several types of alloys, bauxite, copper, lead, zinc, silica, kaolin, natural gas, petroleum, natural rubber and other metals. These materials are then processed, refined, mined, drilled, distilled or processed. The vast amount of raw materials required to produce an automobile reflect the different amount of substances that compose the auto-parts.

- Auto-part production; the processed materials are used to form metal ingots, plastic pellets, rubber pellet and auto paint. These are ready to be used in the manufacturing process in order to make auto-parts. The auto part production phase involves many firms that supply the vehicle assemblers with a very large amount of auto-parts.

- Vehicle assembly; the manufacturing part of the life cycle of the automobile is where the automobiles are produced as the vehicle is assembled. During this phase, the auto-parts are attached to the all-steel-body structure that also supports the internal-combustion engine. Paint is applied to the plastic and metal parts. The painting process releases a considerable amount of polluting gases.

- Retail and distribution; before reaching the consumer the vehicle is packed and shipped. The distribution network of the industry is globally dispersed as the retail and sales network are widely dispersed, while the production tends to be located in a smaller number of regions.

- Vehicle use; during the period that the vehicle is being used by the consumer, other auto-parts are required to provide the necessary maintenance to the vehicles on the road. This is a crucial phase for the environmental impact of the automobile as a large number of polluting gases are emitted from the internal combustion engine. Vehicle emissions consist of: carbon dioxide - CO₂, particulate matter - PM, nitrogen oxides - NO_x, volatile organic compounds - VOCs and carbon monoxide - CO (Organization for Economic Co-operation and Development, 1995).

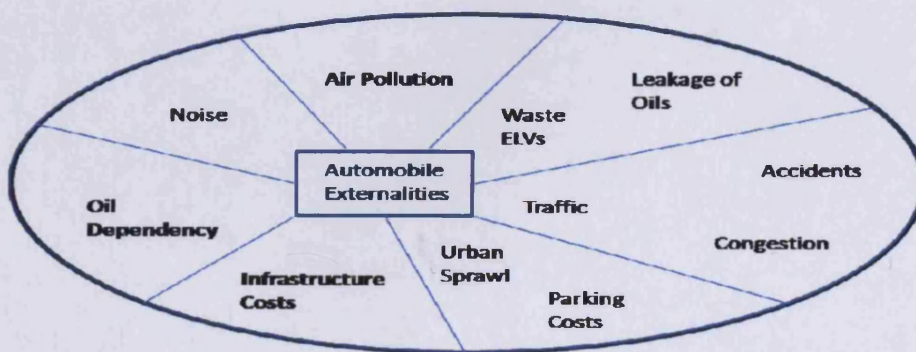
- End-of-life phase; when the car reaches its end-of-life phase it constitutes a sizable volume of waste that needs to be dismantled, decontaminated and recycled. Some parts of the vehicle are destined for remanufacturing, while others are more suitable for recycling. In Europe, if treated according to the European Union End-of-Life Vehicle Directive - EU ELV directive, the hulk of the automobile is shredded

and scrap metal can be fed back into the system. However, a considerable amount of material waste is generated.

The initial environmental preoccupation relating to the automobile has been air pollution, since this constitutes the most visible negative externality in large city centres (Faiz et al., 1996). However, the scope of regulation has been expanded with the introduction of broader environmental preoccupations related to sustainable development and an analysis of the life cycle of the automobile (Nieuwenhuis and Wells, 1994).

Figure 1.1 presents a summary of the automobile environmental negative externalities which have been addressed by regulation (Delucchi, 2003). The types of automobile environmental externalities include: air pollution, noise, oil dependency, infrastructure costs, end-of-life waste, traffic with accidents as well as congestion costs and urban sprawl including parking costs. Air pollution, oil dependency and end-of-life waste are direct environmental costs, while the other types of automobile externalities relate more to urban arrangement issues.

Figure 1.1 – Types of automobile externalities addressed by regulation



Source: Adapted from Delucchi (2003).

The most relevant negative environmental externality is air pollution. Reserved studies

have been conducted on the economic cost of air pollution and the savings from its abatement (Small and Kazimi, 1994) and (Madison et al. 1996). Emission limits have changed over time, with wide implications with issues such as the type approval and wider safety regulation being discussed. In recent years, the production of carbon dioxide emissions has gained wider importance as climate change has become a crucial issue in the environmental and policy making arenas (Houghton et al., 2001). Air pollution has been regulated from several sources, including the production, the use (tail pipe and crank case emissions) and from the end of life (OECD, 1986). The specific case of the CO₂ emissions, have only recently been indirectly regulated via fuel economy targets (e.g. The US Corporate Average Fuel Economy rules - CAFE rules). The EU measures newly introduced are the first to tie vehicle manufacturing targets to a system of fines. Due to governmental regulation and engine development, a decrease has been observed in the average CO₂ emissions of new vehicles sold. According to SMMT (2007), from 1997 to 2007 the reduction has been of 13.1% per annum. However, in aggregate terms, global emissions have been rising exponentially. Firstly, the world fleet has rapidly increased. The average world annual growth rate of the automobile fleet was 4.6%, from 1960 to 2002 (Dargay et al., 2007). Secondly, the average distance travelled has also increased, which counterbalances the increase in fuel economy. From 1997 to 2002 in the United Kingdom, the average distance travelled increased by 5% (SMMT, 2007).

Regardless of several decades of environmental regulation and the adoption of more advanced technologies, the environmental burden caused by the automobile industry is significant. According to the European Environmental Agency – EEA (1995), the transportation sector alone is responsible for 24% of emissions in Europe.

Aside from the environmental dimension, a relevant aspect of the modern automobile industry is the economic state of the industry. In aggregate terms, the automobile industry has been struggling financially for several years (Vlasic and Bunkley, 2008). Consecutive financial losses and minimal profit margins have become a pattern for the majority of

automakers. Traditional firms, such as General Motors and Ford Motor Company, have seen their stock value drastically reduced during the past few decades (Marketwatch, 2008a) and (Marketwatch2008b). Recently, there has been major governmental intervention to save General Motors and Chrysler Motor Company from bankruptcy in the United States (The New York Times, 2010). The industry has responded with a series of strategic business shifts based on cost minimisation, quality improvement, organisational flexibility, design for manufacturing and lean thinking. Synergic mergers and acquisitions have also been used as a solution and have proved to have controversial effects (Wells and Nieuwenhuis, 2001). However, the modern business of producing automobiles has been shown to be characterised by increasing competition and low profitability. The automakers claim that one of the causes of this degenerated state of the industry is the increasing pressure caused by environmental regulations which require large investments in research and development in areas that challenge their main business model. The automobile was not originally designed with environmental preoccupations in mind, and the adaptation processes over the years have been largely incremental (Zapata and Nieuwenhuis, 2010). The mainstream automobile is still based on the internal combustion engine and on the all-steel body structure. These two elements have been the pillars of the business of making cars since the early days of mass production and are unsustainable in environmental terms (Wells and Nieuwenhuis, 2001).

The fragile economic state of the automobile industry and the claim that environmental regulations put additional pressure on the business model of the industry is a relevant element that needs to be considered by governments when establishing environmental regulation. Several attempts to provide better regulation roadmaps have been made, including the Bellagio Memorandum on Motor Vehicle Policy (The Energy Foundation, 2001) and EU Cars 21 high level group (European Commission, 2006). However, these wide frameworks have failed to provide more practical applications to the industry, and they can be criticised for the lack of stakeholder involvement and very broad indications of how regulatory policy should be designed.

1.5 - Focused topic and research question

In this section, the central research question of this thesis is provided with a short description of the reasons why this constitutes the central thread of analysis and the broad topic previously discussed.

The main focus of this research question is on looking at the impacts of environmental regulation on industry, contrasting the newer ideas of the 'greening of industry', in which it is assumed that industry can reap benefits from environmental regulation, with a more traditional view that assumes that regulation has been costly.

Up to the present, social scientists have not offered complete answers to this issue. This thesis therefore aims to aid the progress towards responding to this intricate subject by providing an account of the past regulations and how they have affected the industry in economic, social and environmental terms. As indicated by Press (2007), having a clear understanding of these effects which have influenced the industry has not been possible until recently because of the lack of consistent data in relation to the innovation, the environmental effects of these measures and the discrepancy between *ex-ante* analysis and *ex-post* analysis.

The main research question of this investigation is as follows:

- **What is the relationship between environmental regulation and auto industry technological development, commercial imperatives and wider social benefits?**

A few elements of the central research question must be defined:

Environmental regulation: Environmental regulation has been defined as regulation that has an environmental element for the legal norm. The definition of environmental

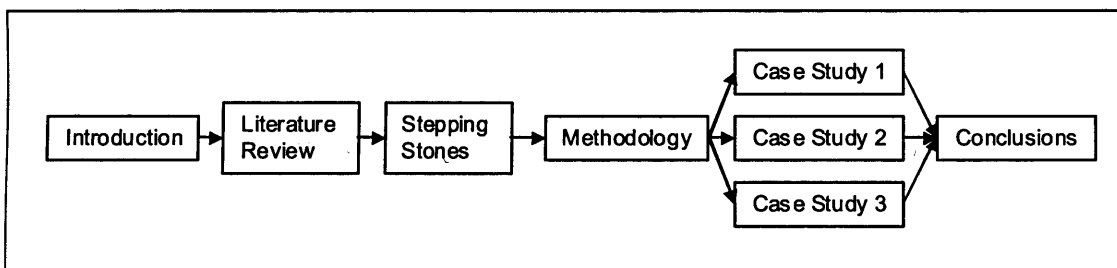
regulation follows a broad understanding of a regulation that may have a significant positive impact in relation to the environment.

Auto industry technological development: The importance given to technology development relates to the cost of research and development to adapt the internal combustion engine to the new law requirements, or to development a new automobile.

1.6 - Structure of the thesis

The thesis is divided into 8 Chapters and Figure 1.2. provides a graphical representation of these. In Chapter 1 there is an introduction to the area of interest and scientific field of the thesis. Details in relation to the broad topic and the empirical focus are discussed, along with the research question, which will be at the centre of the investigation throughout.

Figure 1.2 – Structure of the Thesis.



Chapter 2 consists of the critical literature evaluation or literature review. This considers previous theoretical developments in the field, and initially two generations of the

'greening of industry' literature in relation to the effects of environmental regulation are discussed. Following the elements discussed in the first part of the literature review, the chapter provides further detail in relation to the strategic use of government regulation and the potential beyond compliance behaviour that may be adopted by industry towards environmental regulation.

Chapter 3 provides the researchable propositions that will be investigated by the case studies. In order to do so, the chapter provides a deeper discussion of the 'license to operate' framework, and a general contextualisation of the framework to the automobile industry.

Chapter 4 gives a justification of the methods selected, including the research design and the case study design. The case study, combined with historical analysis, is the core methodological tool used in the thesis. Hence, special attention is given to the justification of the case studies selected and the data collection instruments. A case study protocol is presented to enhance the comparability between the selected cases.

Following the case studies, Chapter 5 considers the air emissions regulations in the United States, Chapter 6 looks at the Ethanol Regulations in Brazil and Chapter 7 is concerned with the End-of-life Vehicle Regulations in the European Union. The cases are guided by the researchable propositions and follow the case study protocol presented in the Chapter 4.

The case study on air emissions regulations in the United States uses a historical account of the federal emissions regulations and also those in the state of California. The chapter discusses the initial tail pipe emissions, originally presented in California and later taken up by the Federal government between 1950 and 1990. Following this, the Zero Emissions Vehicle Program (ZEV) is examined. The ZEV was a drastic, pioneering environmental initiative conducted by the California Air Resources Board (CARBS) which was met with considerable resistance by the automakers.

The ethanol regulations in Brazil describe the first large scale experiment to introduce ethanol fuel, which is derived from sugar cane and used as a substitute for petrol. The Proalcool program adopted in Brazil was a government-led initiative to tackle energy security in the country during the 1970s. This chapter gives a historical description of the factors that led the government to adopt this initiative, focusing on the formation of the legal, social and economic licenses. The role of the government here is further highlighted; not only did it serve as the primary source of direct and indirect subsidies, it also established a firm strategy to foster the development of ethanol engines in government-owned research centres and to support the early adoption of ethanol-only engines. Here, the primary and secondary effects of the regulation are also presented.

The case study of the end-of-life vehicle directive in Europe provides another important dimension to the case study selection. The chapter begins with a description of the implementation process of the directive, and introduces the conceptual framework of the extended producer's responsibility, which constitutes its central theoretical concept. The main elements of the EU ELV directive then follow. The chapter ends with a brief analysis of the primary effects of the directive.

Chapter 8 makes the concluding remarks. The conclusions aim to provide a contribution to the 'greening of industry' body of knowledge. This is presented in sections that include the empirical evidence provided by the case studies and the implications for policy makers and industry.

Chapter 2 - Literature Review

2.1 - Introduction

The literature review is focused on the 'greening of industry' body of knowledge that this thesis aims to contribute to. In the literature, theoretical frameworks from the business strategy literature, with elements of the corporate political strategy subfield, are utilised in order to build the stepping stones of a theoretical framework that is presented in the next chapter.

Industry has been particularly sensitive to environmental dimensions in the past 20 years, as deeper and systemic studies on the relationship between industry and the natural environment have emerged. Similarly, research has been preoccupied with how industry should respond to the environmental pressures, including the tension posed by regulation. This has been an important matter especially for large industries where regulation has forced the adoption of specific technologies (Kleiner, 1991). In the same way, and in a world under economic pressure, this is relevant for governments which aim to produce more effective environmental regulation which is simultaneously efficient and less costly to industry.

Taking a stylised view on the general effects of regulation, three major categories of effects can be identified: (1) economic effects; (2) environmental effects; (3) innovation effects. The economic effects relate to the competitiveness of the industry and to firm profitability and market share while environmental effects refer to the reduction of negative environmental externalities and wider impacts on natural resource use. Additionally, the innovation effects look at how regulation has been able to force or stimulate innovation activities or technologies in the industry.

Despite this rather instructive categorisation, the three types of effects are deeply interrelated. The economic effects are directly linked to the innovation effects as changes

in the technologies used for production impact on the investment cycles, especially on the utilisation of sunk costs and the maximisation of economies of scale. Both of these changes also impact on the environment. It is also assumed that the technology and management used dictate natural resource consumption and the sorts of negative environmental externalities production.

The initial focus of this 'greening of industry' literature review is on the economic effects of environmental regulation, when significant technological developments are required. However, the development in the literature follows a more general understanding of the interconnection between the types of effects, and environmental and innovation effects are given more prominence. Relevant to this investigation is the link between economic and innovation effects that constitute the basic argument taken by Porter and van der Lind (1995b) in their initial proposition.

Environmental regulations that require significant advances in technology directly affect the business model of the firm and are of greater importance to the economic impacts upon the industry (Nieuwenhuis and Wells, 1997). It is also assumed that for the automobile industry to become more sustainable, major changes in the product itself are necessary, and this requires considerable technological development that will eventually provide a positive environmental impact. The link between the effects of environmental regulation therefore seems to be a crucial issue for the development of the field.

2.2 - The first generation of the 'greening of industry' literature regarding the effects of environmental regulation

Until the mid 1990s there was a wide understanding that environmental regulations would directly incur greater production costs for the regulated industry. Siebert clearly summarises this view: "The traditional view is that improved environmental performance increases production costs and thus necessarily harms economic

performance. Such an argument is easy to establish based on economic theory.” (Siebert, 1985, p.125)

With the emergence of the ‘greening of industry’, a different perception of the issue has been brought forward following a diverse set of theoretical assumptions. In general terms, the ‘greening of industry’ constitutes a research area that focuses on the role that industrial firms can play in the transformation towards a more sustainable society. As indicated by Groenewegen and Fischer (1996), the greening change has the potential to profoundly reshape industries and not only includes their strategies, but also their business models.

Initially, successful case studies of greening were documented where environmental regulation was able to generate environmental benefits while having positive economic outcomes and profitable technological innovations (Shmidheiny, 1992). The driving forces behind the successful case studies were researched, including technological solutions adopted by industry and the perception of the problem. The documentation of successful cases was perhaps a reflection of a widespread optimism towards the potential for inventive and profitable solutions for environmental problems. There has also been a bias in journals towards ‘positive’ outcomes, especially in the business literature.

The Porter and van der Linde hypothesis was often cited as the basic assumption behind the optimistic greening trend (Porter and van der Linde, 1995b). The win-win hypotheses received a vast amount of attention due to its positive view which suited the illustrative successful case studies and backed up the willingness of researchers on the ‘greening of industry’ to find positive results. In this respect, the theoretical approach proposed by Porter and Van der Linde (1995a) introducing the notion of the double-dividend was groundbreaking as it provided the theoretical basis for a proactive industry position regarding the environment. According to the theoretical approach:

Properly designed environmental standards can trigger innovations that lower the

total cost of a product or improve its value. Such innovations allow companies to use a range of inputs more productively- from raw materials to energy to labor- thus offsetting the costs of improving environmental impact and ending the stalemate. Ultimately, this enhanced resource productivity makes companies more competitive, not less. (Porter and van der Linde 1995a, p. 12)

They also provide an important critique of the traditional approach of environmental regulations. Models are built using the *ceteris paribus* assumption, where other variables aside from environmental policy are held constant, these representing a static scenario instead of the dynamic reality. The traditional notion that environmental policy is costly to firms is a consequence of this theoretical issue. However, the Porter and van der Lind understanding developed the idea that firms are dynamic systems which are constantly looking for innovative ways to overcome competition, satisfy customers and meet the demands of regulators (Porter and van der Linde, 1995b). The hypothesis can be summarised in the form of the following diagram:

Figure 2.1 – The Porter Hypothesis



Source: Ambec and Lanoie (2008).

According to this argument, the relationship between environmental and business performance has been framed incorrectly. Past studies wrongly focused on the static cost impacts of environmental regulation and more pertinent offsetting productivity benefits from innovation have been ignored. This line of thinking has multiplied the costs of

environmental regulation since regulations have been implemented in such a way that the promotion of innovation is stopped. Moreover, firms have tended to resist regulations instead of innovating to address them (Porter and van der Linde, 1995a).

Hart (1997) illustrates the proposal that firms should endeavour to further enhance their environmental performance, presenting a much wider perspective of sustainability:

The responsibility for ensuring a sustainable world falls largely on the shoulders of the world's enterprises, the economic engines of the future. Clearly, public policy innovations (at both the national and international levels) and changes in individual consumption patterns will be needed to move toward sustainability. But corporations can and should lead the way, helping to shape public policy and driving change in consumers' behavior. In the final analysis, it makes good business sense to pursue strategies for a sustainable world. (Hart,1997, p.75)

Critics of the hypothesis pointed to the unrealistic expectations that this could generate for firm managers and policy makers, as it could be the exception and not the rule. Walley and Whitehead (1994) assume that to comply with strict environmental regulations, firms have to incur vast sunk costs that could not be recovered. In their view, "this popular idea is also unrealistic. Responding to environmental challenges has always been a costly and complicated proposition for managers. In fact, environmental costs at most companies are skyrocketing, with little economic payback in sight" (Walley and Whitehead, 1994, p.46).

Palmer et al. (1995) have provided the basic criticism of the robustness of the case study method used by Porter and van der Linde. The argument of the static mindset where all the variables are *ceteris paribus* except for the environmental regulation is contested by the successful outcomes on the use of economic incentive instruments for environmental policy. This approach takes into account the effects of the various policy instruments on research and development and the decisions relating to technological development

(Palmer et al., 1995). Other authors have used the same argument to analyse the hypothesis from a formal point of view. However, it is important to indicate that these studies clearly suffer from the static approach of the economic models, which does not properly address the uncertainties relating to the technological innovation in a dynamic framework.

For the purposes of this work, it is relevant to cite the further refinement that Jaffe and Palmer (1997) made of the Porter and van der Linde hypothesis. This analysis presents three distinct variants of hypothesis: the weak, the narrow and the strong versions. Table 2 presents them along with their characteristics. The division is relevant as it provides a further delimitation of how the Porter and van der Linde hypothesis may be observed in real life case studies, especially with regard to the effects of regulation on the industry. The variants of the hypothesis are perhaps an indication of how unrealistic the original proposition was.

Table 2.1- Variants of the Porter and van der Linde hypothesis.

Variant of the Porter and van der Linde hypothesis	Characteristics
Weak Version	Environmental regulation will stimulate certain kinds of environmental innovations
Narrow Version	Flexible environmental policy regimes give firms greater incentive to innovate than prescriptive regulations (such as technology-based standards)
Strong Version	More stringent environmental policy may induce innovation that may compensate (or more than compensate) for the cost of complying with it.

Source: Adapted from Lanoie et al . (2007).

Several studies have aimed at testing the empirical validity of the Porter hypothesis. These studies can be divided in three categories:

1. Studies that focus on cross-selection analysis which investigate the correlation between economic and environmental performance. Klassen and McLaughlin (1996), for example, discuss this issue by looking at the market return response to investment in new and more environmentally friendly products and services. The research is based on the New York Stock Exchange – NYSE - and the American Stock Exchange - AMEX stocks. Here, a positive relationship is observed, but there is no causality. Murty and Kumar (2003) analysed the effect of water environmental regulation on 92 Indian firms. They saw indicators of the Porter and van der Linde hypothesis, as the most efficient firms were able to maintain the minimum amount of water per unit of sales. The study also considers heterogeneous firms in diverse sectors but does not look at the specific response to the environmental pressure.

2- Documentation of successful beyond compliance behaviour that resulted in economic or performance gain; Maxwell et al. (1997) report several situations where firms were able to utilise their corporate environmental strategy for economic gain. They compare the environmental management programs of Volvo, Polaroid and P&G, pointing to the importance of corporate environmental behaviour. Another important study under this category is that of Sinclair-Desgagne (1999) which looked at how strict environmental regulation can increase both social welfare and a firm's profitability, by giving the latter incentives to innovate using the empirical example of the Peugeot SA and the lean burn Engine. In his view "The hypothesis cannot be rejected on theoretical grounds, unless one sticks to a very narrow view of neoclassical economics. The regulations most likely to fit the hypothesis and yield win-win situations depend on the type of innovation that is pursued - incremental (low-hanging fruits), risk reducing or radical" Sinclair-Desgagne (1999, p.11). In this respect, he argues that

specific policies can be crafted to generate specific types of innovation cycles.

3 – International trade studies that consider the competitiveness of nations with regard to their ability to attract new firms or to influence the international competitiveness of stabilised industries. Mulatu et al. (2001) proposed the estimation of the effect of environmental regulation on international trade. Their study casts doubt on the Porter and van der Linde hypothesis, as they conclude that the environmental stringency and trade performance has a significant effect. Other important analysis has been carried out by Jaffe et al. (1995). These researchers present an econometric study of the competitiveness of the American manufacturing industry indicating that the cost related to environmental adaptation or protection had been a small part of the total amount spent by the firms, and negative effects on competitiveness could be observed.

Gabel and Sinclair-Desgagne (2001) understand that the interaction between environmental policy and the firm's allocation of resources is not straightforward and depends on the firm's organisational failures. Aside from this, they argue that the existence of low-hanging fruits may due to managerial inefficiencies, as strict environmental regulation may be able to take place in "cheap innovations is logically most likely in situations where the firm is far from the efficiency frontier, where the burden of the compliance cost is light, and where the shift to the frontier can be made cheaply" (Gabel and Sinclair-Desgagne 2001, p. 152).

For the purposes of this thesis, the first and second categories of empirical studies are more relevant as they address the economic effects of the establishment of environmental policy. The Porter hypothesis and van der Lind has been particularly relevant for this debate as have the studies that looked at the relationship between the environmental variables of the firm and the effects of economic performance. The empirical

investigation of the Porter and van der Lind's hypothesis can be criticised by the limited focus on single point in time and selected specific cases. The two first categories, can be criticised because they show a correlation between the two variables, environmental gain and economic performance, but do not show a causality between the two. The international comparison studies do not address the core aspects of the hypothesis as they are interested in the allocation of new industries and the international competition for desirable industries.

The empirical tests of the Porter and van der Linde hypothesis provide mixed views of the veracity of the premise. However, there is no question that the discussion has been profitable for environmental, managerial and policy studies. However, environmental protection is not a zero-sum game, and regardless of the fact that some environmental measures may result in economically efficient outcomes because of innovative technologies which will reduce environmental externalities, not all of them will have this effect. The importance of these empirical studies is that they indicate that the hypothesis may be true under certain circumstances, this being a relevant insight for the effects of environmental regulation to industry. In this respect, in the second generation of the 'greening of industry' literature, the debate devolved to a discussion and was not focused on whether the economic gain could be observed but rather under which circumstances wider benefits would emerge.

2.3 - The second generation of the 'greening of industry' literature on the effects of environmental regulation.

The theoretical importance of the 'greening of the industry' perspective has grown significantly as the concepts have understandably evolved towards more practical applications to firm management and strategy, with important implications for policy makers (Groenewegen and Fischer, 1996; Fuchs and Maznamian, 1998). The way the field has understood the effects of environmental regulation to industry has also changed.

The initial phase (described previously) was based on an optimistic view that presented the potential for win-win outcomes regarding the impacts of environmental regulation on industry. However, this optimistic view was not supported by the industries' behaviour toward regulation, this being questioned and challenged in court (Kagan, 1994). Lobby groups defended less stringent measures and demanded governmental aid to fully adopt standards (Fiorino, 2006). Here, successful case studies appeared to be the exception and not the norm.

The field broadened the analysis of the effects of environmental regulation to industry as studies began to analyse the market forces which could contribute to a more sustainable outcome. The effects of different policies for the development of the green industry were indicated, correlating specific policy measures with their effect on the industry. As a result, the use of policy instruments for public policy design and implementation was also linked to the discussion of 'better regulation' presented in other literatures, especially in law and economics (Fiorino, 2006). Certain studies contrasted 'command-and-control' measures to the more flexible economic incentive instruments. Others were centred on the role that large multinational corporations could play in pushing the 'greening' agenda around the globe by adopting voluntary and beyond compliance behaviour (Fuchs and Maznamian, 1998).

The most recent phase of the 'greening of industry' provides a more complete and detailed analysis of the effects of environmental regulation on industry. The general understanding of the field is that environmental performance developed another dimension for industrial development; the industry shifted the focus from pollution prevention and environmental management to a broader and more complete approach that discussed active sustainability and environmental stewardship as ways of proactively seeking better market positioning (Fiorino, 2006). The literature reports efforts by leading firms to incorporate the environmental variable as a strategic and essential aspect of their business; a position that incorporates long-term sustainability, focusing on more complex causal relationships, has been proactively highlighted (Roomie, 1998). More mechanistic

approaches which confirm the usefulness of specific management tools and systems are also defended, such as the codes of environmental management practice (Nash and Ehrenfeld, 1997) and of environmental management systems (Coglianese and Nash, 2001).

Schot and Fisher (1993) indicate that the discussion on the effects of environmental policy on industry has followed the historical development of policy making and the industries' responses. In this sense, the connection between the industries' responses and the sort of regulatory pressures that have been placed on industry is a relevant aspect of the discussion. In the first generation of environmental policy, regulations were characterised by strict 'command-and-control' measures and firms tended to resist regulation, and complied only when coerced. After this, firms started to embrace the environment without innovating, as this began to be linked to profitability; use of the environment became a strategic and important dimension in business strategy. The environment began to be perceived as another issue that had to be managed to enhance profitability, to gain more market share and to show business success (Porter and van der Linde, 1995a).

In this respect, the contemporary perception for firm managers regarding the 'greening of industry' is that industry must be committed to a steady and demonstrable endeavour to do better than mere environmental law compliance. Here firms search for ways to do far better than the requirements of regulation, as they perceive this as an important element in their business strategy (Fiorino, 2006). Moreover, a focus on the role of corporate environmental strategy has emerged with the development of particular organisational capabilities, which directly influence the firm's competitiveness (Sharma and Vredenburg, 1998). For their part, Buysse and Verbeke (2003) indicate that several improvements in organisational capacities and resource use are necessary for firms to become more proactive in environmental terms.

One of the more sophisticated levels of analysis on this matter is presented by Reinhardt

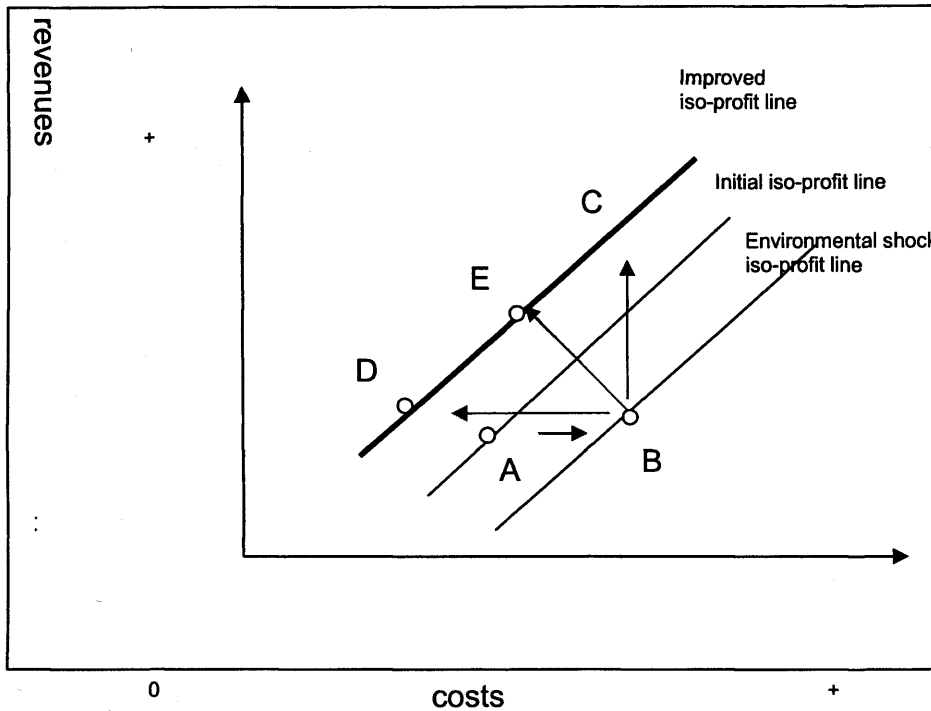
(2000) who indicates that the firms that take the best strategic approach are the ones that can comply with the necessary environmental regulations while delivering superior value to their shareholders. In his analysis, those in industry should not perceive the environmental dimension as an outside element in their business strategy but as an indispensable part of the entire business strategy. The modern firm should then put environmental management on the same level as other principles, such as strategy, finance and marketing.

Reinhardt (2000) indicates five strategic areas where the competitive advantage from the proactive use of environmental strategy can be gained. Figure 2.2 shows the basic environmental management approaches. The initial situation of the firm is displayed in point A in the first iso-profit line. At this point the firm has defined costs and revenues, which dictate its profitability. The second iso-profit line (displayed to the right) represents an environmental shock, such as environmental regulation where the firm has to implement costly technological procedures. In this case, the firm moves from point A to point B, where the revenues remain unchanged but costs increase.

However, Reinhardt's analysis shows how the environmental shock can be surpassed. Point C refers to the environmental product differentiation strategy where the firm can operate in the improved iso-profit line. Firms tend to gain monopolistic gains by supplying environmentally friendly products. Hence, they try to persuade the consumers that their products are unique so they would have no real competitors. Rodriguez-Ibeas (2007) indicates that the net result of the environmental product differentiation strategy depends on the extent of product differentiation and the cost to achieve it, so that it can be compared to non-environmental differentiated products.

Figure 2.2 – Basic approaches to environmental management

costs



Source: Adapted from Reinhardt (2000).

Under this strategy the firm is able to increase its price since the rivals' costs are also increased. Reinhardt (2000) notes that:

To make environmental product differentiation succeed, a business must satisfy the following three requirements: 1- it must find, or create, a willingness among customers to pay for environmental quality; 2 - it must establish credible information about the environment and other attributes of its products; 3 - its innovation must be defensible against imitation by competitors. (Reinhardt, 2000, p. 18)

These conditions are able to raise the business costs, and are also able to grasp a price premium in the market or gain a further market share. Point D represents the reduction of costs within the firm. According to this, the firm would be able not only to improve its environmental quality but also to reduce overall costs. This scenario is in direct accordance with the Porter and van der Linde hypothesis (Porter and van der Linde, 1995a), as the revenue would remain constant while the cost decrease would generate larger profit margins. Since environmental regulation is able to increase the cost of pollution, firms have the incentive to utilise more cost effective technologies. Here, several types of tools have been successfully used to minimise costs, such as life cycle assessments and environmental management systems (Nielsen and Wenzel, 2002).

The last case represented by point E shows the market redefinition strategy, where the firm would be able not only to increase revenue but also to reduce costs. In this example, shareholders, customers and the environment gain from the innovations adopted. Several traditional industrial sectors have tried to adopt alternative business models to gain additional profits from complementary products and services. The Blue Ocean Strategy framework, for instance, provides important insights into this discussion (Kim and Mauborgne, 2000). Alternative business models for established industries are a relevant theme in this case. One example is the micro-factory retailing system which is particularly important in this discussion (Nieuwenhuis and Wells, 2003). The micro factory retailing system is a business model in a distributed economy, based on the use of several smaller vehicle manufacturing plants instead of a larger traditional one.

Reinhardt (2000) also notes that the firm should be able to directly manage risk and uncertainty. The intention is to minimise future environmental risks that may be established by the regulatory systems. The environmental strategies are important for firms that have been traditionally targeted by regulation, such as the automobile industry. In order to diminish the risk they have implemented formal and informal environmental management systems and product substitution (Ashford, 2000). In this respect, it is relevant to note that several firms may seek to capture regulatory rules ahead of their

enactment by helping to define what is possible in a regulatory sense. They do this in part via their efforts in environmental management systems and controls.

Other more recent strategists have indicated that the industry must identify the relevance of the 'green wave' that has been sweeping the modern corporate world (Esty and Winston, 2006). They emphasise the importance of a strategic approach to this issue since a firm or industry must be seek strategic advantages from the environmental pressures. Others authors have also defended this, including Laszlo (2008), who perceives that the global industry is recasting the role of business in society. Industry has shifted away from negative environmental externalities' minimisation to innovative solutions to global problems that have not properly been addressed by governments. Esty and Winston (2006) indicate several successful case studies of firms that have provided a wider benefit to society and reaped profits thereby, such as General Electric, Toyota and Dow. These firms have tried to make the transition from being part of the problem to being part of the solution.

A more practical perspective is offered by Hoffman (2007) and shows how multinational companies have incorporated carbon reduction initiatives into their business plans for reasons of both environmental risk and opportunity.

Porter, one of the most influential authors of the first phase, has refined and extended his analysis and provides a more detailed perception of the effects of environmental policy to industry. There is emphasis on intangible gains, such as a better reputation, higher employee morale and competitive advantage in attracting human resource attraction. He also criticises the fragmented approach to environmental management in firms, as it should be part of the intrinsic business model of the industry (Porter and Kramer, 2006, p. 78). Methodical tools are presented by Holliday, Schmidheiny and Watts (2002) for 'eco-efficiency' in industry. This might be achieved by dematerialisation, with a minimisation of waste leading to production loop closure. They also present argument for changes in business models that will provide service extension, with leasing instead of selling, and

functional extension, with the extended value of the product for the consumer.

Notwithstanding that the second generation of the 'greening of industry', the literature on the impact of environmental regulation on industry is more refined and nuanced than the initial studies suggest, and there is restricted empirical support for the generalisation. These authors understand that the successful case studies serve as a benchmark for mainstream business and other industries to follow the same path (Laszio, 2008; Holliday et al., 2002). Without doubt, the second generation of the studies in the 'greening of industry' are more empirically informed than the earlier, largely anecdotal accounts of successful case studies. However, the literature has not addressed the wider issue of greater gains from beyond compliance measures, and why some industrial sectors have been able to gain tangible and intangible benefits, while others have not.

Nevertheless, this literature on corporate environmental strategy adopts the assumption of a competitive market where firms are openly willing to compete with each other to gain a larger market share. However, in markets with imperfect competitive structures like the automobile industry, these models have a limited application as there has been a tendency for the industry to operate as a collective action to pursue a corporate political strategy. In the next section, the reduction of risks and uncertainty is discussed according to the strategic use of governmental regulation.

2.4 - The strategic use of government regulation

Traditionally, industry has taken up a reactive and confronting position. In general terms, industry has asked for more flexible standards or the delay the implementation of regulatory measures. The asymmetry of information between regulators and industry in regards to the costs of technological development has been the key element in this dispute. However, several studies have indicated how industry has consistently overestimated the cost of compliance and neglected several secondary positive effects.

The strategic use of environmental regulation goes against this reactive and argumentative behaviour (Maloney and McCormick, 1982). Baron (1995) points out that non-market environmental strategies are social, political, and legal arrangements that construct the interactions amongst companies and their public. In this sense, industry can actively influence policy makers to make regulation more suitable for the present business model or to impose additional costs to competitors (Hillman and Hitt, 1999).

Reinhardt (2000) proposes that political debates over environmental policy are opportunities for firms to capture value; the 'greening of industry' literature perceives the proactive role of firms as a natural step in the development towards a sustainable society. In this respect, the positive industry position towards environmental regulation can induce the adoption of a specific technology that is at the same time more sustainable and secures the established business model. For this to take place, it is necessary that regulators perceive the necessity to regulate the specific market, and to force the technological development in this area. The industry or the firm must also have the ability to convince other stakeholders that technological innovation is technically feasible, and can provide better end results for society (Reinhardt, 2000). It should also be noted that this is implicitly pluralist, and assumes that a consensus can be arrived at.

Following a more optimistic perception of the use of regulation, industry may also have a rational interest to promote more stringent regulations; they can perceive that environmentally responsible products can be launched and the improved iso-profit line can be reached, as in Reinhardt's analysis. Regulations can increase the aggregate costs of an entire industry, but the firm can still extract a competitive advantage if there is a perception that a superior product can be offered to the market. Both early mover and first mover firms can be in a better position, or even create their own industrial standard that would eliminate potential market entrants (Klassen and McLaughlin, 1996).

The technological choice taken up by regulators to address an environmental externality

has wider implications for the future business and the environmental performance of the industry. Regulators can adopt a specific technology which favours the present business model of the industry (Salop and Scheffman, 1987), creates barriers to the entry of new competitors in their market (Demsetz, 1982), or directs the industry to a novel business model (Reinhardt, 2000). Another measure that impacts on the competitiveness of the industry or the firm and is worthy of mention includes environmental information disclosure, where the industry could indirectly raise the costs of the potential competitors or enhance its image to the consumer (Yoffie, 1988). Hillman and Hitt (1999) present a comprehensive taxonomy for types of corporate political strategies that include these kinds of non-market strategies.

Reinhardt (2000) also warns that industry must look beyond the domestic market, as international competitors that are out of reach of national legislators must be taken into consideration. This specific issue seems particularly important for industries that have limited competition in the domestic market and can be threatened by overseas new entrants. The role of multinational firms in this context is also relevant. These global firms may have the intent of pushing the harmonisation of environmental standards to regional markets so that production flexibility is enhanced by the economies of scale of designs and processes. In this respect, larger companies possess a significant competitive advantage in terms of size compared to smaller firms that may have difficulties in meeting the standards (Vogel, 1995).

A further commonly used approach is to utilise supporter groups, which is a more complex procedure than a straightforward lobby. The most polluting firms would have the greatest incentive to form and contribute to like-minded lobby groups (Damania and Fredriksson, 2000).

However, the literature of non-market strategies goes beyond intra-market competition, and there are also studies that propose aggregate sector lobbying for research and development funds, which have a crucial area of discussion in the automobile industry.

Innes and Bial (2002) noted that the government can provide incentives for research and development (R&D) based on the firm's incentive to raise rival's costs. A firm that is a technology winner will have the incentive to precisely report the nature of their new innovation to the government so that the standards can be tightened, which can lead to the persuasion of regulators to push more stringent standards, or in some cases, firms can adopt voluntary over compliance behaviour. The government can also invest in research and development as the problem of asymmetry of information may be overtaken.

Gersbarch (2002) provides a useful self-financing policy system where governments can design environmental policy to avoid hold-ups that may emerge in environmental policy when technological innovations are particularly costly. The Innes and Bial (2002) article also presents similar conclusions and another important duopoly model is presented by Salop and Scheffman (1987).

Despite the theoretical importance and mechanistic approach, duopoly models fail to provide a complete picture of the process. Not only is the focus on success stories, but these models do not allow for the influence of other stakeholders who are a determinant in the regulatory process. In this sense, the application of the models to real life markets is rather limited, as few sectors reflect the theoretical assumptions.

2.5 - The beyond compliance behaviour

The first theoretical developments on firm behaviour were based on the traditional 'command-and-control' measures, where strict legal compliance has been the key indicator of a firm's environmental performance (Gunningham et al., 2003). However, the literature has developed to present a much more complex and nuanced understanding of the potential consequences and actions that can be taken up by industry to address environmental regulation. In this sense, the field has been indicative of the rational beyond-compliance measures. Gunningham et al. (2003) provide four reasons that would

be conducive for firms to take beyond-compliance environmental protection measures.

- 'win-win' measures; these environmental measures are introduced because they are able to impact positively on the profits of the industry. This can be seen as a stronger version of the Porter and van der Lind hypothesis (Lanoie et al., 2007). Aside from direct economic profit, other less quantifiable gains are also included in this category and the enhancement of the image of the industry is an important example. Industry actively seeks to improve its reputation with relevant stakeholders, including consumers, non-governmental organisations (NGOs), social activists, local communities and even regulators.
- Margin of safety measures; the firm decides to over-comply with current regulations to ensure that the minimum environmental standards will be met. This minimises the risks of potential mistakes or accidents in normal production systems.
- Anticipatory compliance measures; the industry anticipates that a more stringent regulation will be established. In terms of economies of scale and production flexibility, it is more profitable to adopt a stricter standard in the beginning of investment cycles. This could be particularly relevant for large industries that rely on economies of scale for business success and important examples are the automotive, chemical and mining industries.
- Good citizenship measures; these are based on the fact that the management of the firm feels that more stringent environmental measures should be established on moral grounds. Good environmental citizenship also positively affects the public image of the firm. Authors such as Mehta and Hawkins (1998) believe in the emergence of a strong sense of moral and legal obligation, with supporting compliance behaviour from the majority of managers in several sectors of the British economy. Managerial responsiveness to environmental values is another

motive and workers sometimes feel that some actions are just the right thing to do. This has been analysed by new institutionalism (Edelman and Suchman, 1996).

According to a dominant understanding in the 'greening of the industry', business leaders will eventually evolve to a position of over-compliance as the management realises the importance of the greening for business success and the role that industry has in the search for sustainable development. Several authors, such as Winsemius and Gumtram (1992), Roome (1992) and Hunt and Auster (1990) support this idea. In contrast, Schaefer and Harvey (1998) criticise this hopefulness, arguing that the classification system used in identifying beyond-compliance behaviour can be disputed, as some of the categorisation is hard to be translated into practical managerial measures. Prakash and Kollman (2004) also highlight that several of the case studies selected are the success stories of large corporations, where the simplest win-win measures were identified and more core business-related measures are not addressed.

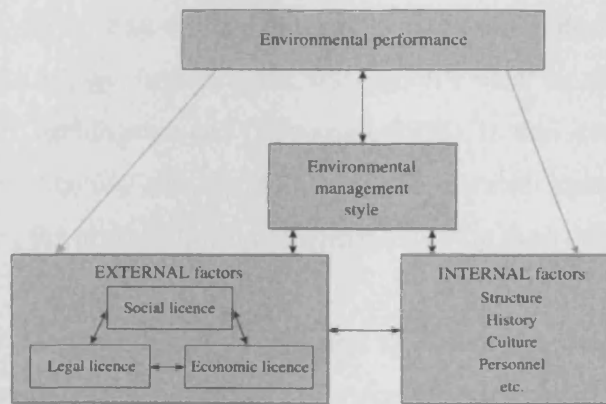
Steger (1993) concludes that the factors that determine if an industry has a proactive attitude towards environmental protection are dictated by external factors. These include the environmental risks related to the firm's operation and the market opportunities the firm can foresee in environmental innovation. In this sense, risk-free business operations for those who cannot identify an economic gain from the environmental investment and development will result in a lack of investment in new environmentally friendly technologies. However, this is a limited perception of how industry behaves, as other important elements are not considered.

The 'license to operate' framework provides a more complete perception of industry behaviour giving a more detailed analysis of the importance of several stakeholders on the environmental performance of the industry; it offers a relevant basis from which to analyse the actions that motivate firms to respond to environmental regulation (Gunningham et al., 2003). From this perspective, the environmental performance is a

direct result of a combination of internal and external factors that are calibrated by the environmental management style of a firm. The external factors are a combination of 'licenses to operate' that represent the legal, social and economic facets of business. Of particular interest for this thesis is the complex relationship between the three types of licenses, and how they are shaped and enforced.

Internal drives are shaped by several elements, such as the industry structure, history, culture, type of internal culture and the personnel. This includes, amongst others, how environmental codes of practice and environmental management systems are adopted by the industry (Hirschhorn and Oldenburg, 1991). Figure 2.3 provides a graphical representation of this framework.

Figure 2.3 – License to operate framework



Source: Gunningham (2007)

The external image that the firm wants to depict is also a significant factor shaping the managerial style. Gunningham and Grabosky (1998) and Prakash (2000) note the relevance that local communities may also have, when managers and employees live in the area. In this case, they may be interested in minimising the environmental negative externalities in the local area. Hartman et al. (1997) also point to community

involvement; environmentally friendly firms or those that display good citizenship tend to be well perceived by consumers (Foster, 1998). Environmental NGOs have also played a significant role in informing the public of the environmental impact of the firm's activities (Prakash, 2000). The reputation of the firm is also important for regulators, as this may have an impact on how strictly legislation will be imposed, or on how future legislation can be adopted.

There is also the aspect of 'institutional isomorphism'. If successful firms in one sector are the one that adopt environmental beyond-compliance behaviour in their operations or administrative control systems, other competitors in the market are bound to follow (Cashores and Vertisky 2000; Hoffman 1997). Delmas (2001) indicates the wide adoption of the International Organization for Standardization - ISO 14000 Environmental management standards constitutes an empirical example that demonstrates how corporate isomorphism has been spread over several sectors around the globe.

In certain markets, firms may still be forced by powerful industrial organisations to follow a specific technology, imposing the association's view on all firms competing in the relevant market (Gunningham and Grabousky, 1998). In this sense, even if a specific competitor has the intention and the ability to use a more modern technology with alternative materials, the organisational consensus may stop their efforts.

External factors are fundamental but insufficient to explain the corporate environmental behaviour and intra-organisational factors are crucial in determining attitudes towards the environment. The resource-based view of the firm, for instance, argues that an environmentally competitive strategy depends upon the specific organisational resources and capabilities of the firm, which are more likely to emerge in periods of crisis (Wernerfelt, 1984).

The extent of the firm's commitment to beyond-compliance measures will be influenced by a combination of external pressures and internal variables. Regulatory demands, the

perception of the market and other stakeholder pressures are also relevant elements to consider (Gunningham and Sinclair, 2002) and the firm will model the external factors depending on the internal capabilities it possesses (Roome, 1992).

2.6 - Conclusions

The industry's perspective on the environment has significantly changed over the past decades. The environment has shifted from being an irrelevant and unusual preoccupation into a mainstream and essential aspect of modern business management (Rugman and Verbeke, 1998). The theoretical development on the effects of environmental regulation on industrial performance has been significant since major advances in the literature regarding the subject have been observed.

Initially there was a belief that regulations would hinder the development of the industry. The general perception as shared by the industry and researchers was that regulation was costly and had a negative effect on the competitiveness of the industry. Nevertheless, the 'command and control' based regulation provided several environmental benefits, creating several undesirable effects to industry.

Following this, the first generation of writers of the 'greening of industry' emerged, questioning the traditional vision. The Porter and van der Linde hypothesis brought an optimistic view of the potential effects of environmental regulation to industry. From this point of view, well designed regulation would spark innovation and create benefits for the industry. This optimistic view was shared by several authors who were influenced by this idea, and supported the notion that industry would be able to find reasonable solutions for sustainable development without radical change. However, empirical and theoretical studies have failed to identify the veracity of the premise. Despite this, the first phase was a significant period for the advancement of the literature in the field, not merely because

of the documentation of the positive case studies but also for the development of environmental management tools and pollution prevention systems.

The modern understanding of the issue is based on a more inclusive perspective which is concerned with sustainability and stewardship (Schot and Fisher, 1993). Here, the effects of environmental policy on industry are perceived in a more nuanced manner. The discussion has shifted from the debate between the 'win-win' defenders and the 'win-lose' supporters to an analysis of the conditions under which different outcomes can emerge (Reinhardt, 2000). According to this vision, industry can reap benefits and adopt particular strategies to cope with the environmental dimension. One of these strategies refers to the positive use of governmental regulation, which is a much more complex process than a simple lobby and involves a wider engagement of the industry with key societal stakeholders.

The framework of the 'Licence to operate', presented by Gunnigham (2007), is rather illustrative of the elements that influence firms in an industry to take proactive steps towards environmental management. The framework provides better knowledge about the causes behind industry environmental behaviour and the complexity of the relationships between the commercial imperatives, technological development and the environmental performance of the industry. Within the framework the difference is noted between the internal drives, the external environment, intra-organisational factors and the interaction of internal and external factors as separated elements that need to be accounted for to understand industrial environmental performance. (Gunningham et al , 2003).

The framework also provides important insights into the discussion on the 'greening of industry' which understands the more complex process relating to environmental policy making. The design, implementation and monitoring of environmental policy has to take into account other stakeholders aside from the firm and the regulators. Industry can actively seek to influence regulators, as the costs can be better estimated and potential

competitive advantages assessed. However, the important query that has not been properly responded to by the field is that if the positive effects of regulation can be generated to industry why have the majority of firms not adopted beyond-compliance behaviour?

In a wider criticism of the field, it is understood that there is trust in incremental rather than radical change. The belief that sustainable development can be achieved is based on the fact that industry can find the necessary solutions for negative externalities within its own boundaries and external pressures may not be necessary. Despite a more nuanced and informed phase of analysis, the field is still characterised by the documentation of successful case studies and the trust on industry decisions to steer society to a sustainable path.

Chapter 3 - Researchable Propositions

3.1 - Introduction

This chapter provides the initial answers and researchable propositions to the central question proposed in this thesis. As indicated in the previous chapter, the body of knowledge termed as the 'greening of industry' has evolved to a more inclusive and nuanced understanding of the effects of environmental regulation on industry. The debate has shifted from the 'win-win' believers (Hart, 1996), who dominated the first phase of the field, to a more balanced intuition under which positive outcomes can emerge following certain conditions and specific arrangements (Reinhardt, 2000).

The 'greening of industry' body of knowledge, therefore sees the effects of environmental policy on industrial firms as a multifaceted phenomenon involving several stakeholders. Here, the specific and particular conditions of each industry shape internal and external factors which determine the industries' environmental performance (Kagan et al. 2003). Therefore, in order to better comprehend how the relationships between environmental policy, firm economic imperatives and environmental industrial performance come about, the 'license to operate' framework has been selected as the main framework of analysis in this chapter (Gunningham, 2007).

The framework can incorporate the influence of several stakeholders and has been widely used to discuss the formation of legal standards (Hoffman, 1999). The choice of this framework is based upon the possibility of considering the influence of multiple stakeholders and the potential contribution that this research can provide to the 'greening of industry' body of knowledge. The license to operate framework is therefore able to capture the ample influence of several groups which influence the environmental performance of the firm. Moreover, it does not focus on single point relationships such as

the regulators-industry, as other frameworks do (an example of this is the game theory (Pearce et al., 1995). Rather, the 'licence to operate' framework is more suitable for the more general perspective adopted in the field that tends to look at a diversity of stakeholders and how they interact with each other. Following the discussion of the 'licence to operate' framework, the potential contribution this thesis makes to the development of the framework is discussed alongside the researchable propositions. Initially, this chapter provides a short description of the license to operate framework, since important elements of the framework are later used. The chapter then briefly discusses the proactive role of the industry, and the environmental management style. After this, the relevant aspects of the license to operate are contextualised to the automobile industry and presented so that researchable propositions can be introduced at the end of the chapter.

3.2 - The 'license to operate' framework¹

The license to operate framework understands that multi-faceted licenses simultaneously motivate and constrain the actions of industry as regards the environmental dimension (Gunningham et al. 2003, 2004; Hoffman, 1999). The framework is flexible as it can be applied to an entire industry or to individual firms. The flexibility of the framework possesses particular strengths for researchers as it can be applied to a wide range of industries in several situations. However, it is necessary to provide a rich contextualisation since elements may emerge that restrict the discussion. The terminology used in the framework is based upon the original notion of the legal license under the 'command-and-control' regulatory regime (Kagan, 2005). The legitimacy of any industry is constructed by regulatory permits and legal obligations that the industry must comply with in order to operate. Policy makers can modify environmental requirements for industry in specific markets, and this includes not only the necessary permits but, most

¹ - The license to operate has been termed as a model in other studies. However, in this thesis the license to operate is seen as a framework of analysis as it has a wider understanding of the relationships between variables and does not have the power of prediction that a model would possess.

importantly, the impacts on the business model of the firm, including the legal requisites of certain technologies. Aside from the legal license, the 'license to operate' framework also perceives the pressure of other informal and less quantifiable external influences captured by the concepts of the social and the legal licenses (Gunnigham et al. 2003). The three licenses can be defined as follows:

- **The legal license** refers to the combination of several legal requirements and the necessary permits that are issued by environmental, health and safety officials. In general terms, firms need to comply with the minimal legal standards, respecting mandatory technology. Legal requirements applied to industry can be said to be concerned with safety or environmental matters in their discourses and there is a conceptual link between two theoretical preoccupations (Kagan, 2005). In sum, the legal license constitutes the formal regulation with which the industry must comply.

- **The economic license** represents the demands of the economic stakeholders and is defined by the lenders and stockholders who require a reasonable rate of return for their investment. The economic license frames how firms can respond to environmental necessities, adopt new technologies, invest in Research and Development (R&D) and implement wider modifications to the business model of the industry. In this sense, the economic license can be tightened or loosened depending on the market conditions of the industry and, more specifically, on the economic performance of each firm (Gunnigham et al. 2003). The economic license is part of informal regulation.

- **The social license** relates to the requirements of the social actors involved in the production and their use of the industry. Social actors belong to a wide range of interest groups, including: local communities, national environmental groups, workers, media, consumers and society in general. Each one of these groups perceives the actions of industry and the negative environmental externalities

produced differently, and each has a variable influence over the industry. The recipients of environmental and social externalities are also included as key social groups in the process. The social license is also part of the informal regulation alongside the economic license (Kagan et. al, 2005).

The 'license to operate' framework shows that the final outcome of the interaction between the terms of the three licenses is larger than the actions of each one individually, because stakeholders are able to influence multiple licenses simultaneously. According to Gunningham (2002), 'these regulatory, economic and social license requirements are monitored and enforced by the stakeholders who generate them, and who commonly seek leverage by exploiting a variety of license terms' (Gunningham, 2002, p. 19).

The conditions of some of the legal license requirements expand the reach and impact of the social license by directly empowering social interest groups in a number of ways (Gunningham et al., 2003). Social stakeholders can have a direct impact on the permit-granting process, the negotiation of standards, or access to environmental information regarding the negative externalities produced by the industry. Consequently, an industry that is not able to deal properly with the obligations imposed by the social license risks having its legal license constricted. Social stakeholders can directly pressure policy makers and regulators to impose stricter regulations. In this case, the future liabilities imposed may further constrain the economic license. Another interest group that may influence several licenses is the workforce of the industry. Workers help to shape the social license, and may have a significant influence on the way the industry addresses environmental concerns. Hence, employees can shape not only the social license but also the internal management style of each firm of the industry.

The terms of each of the licenses to operate are subject to interpretation (Gunningham et al. 2003). Different stakeholders have diverse opinions with regards to what is tolerable, not only in relation to the market conditions, but also in terms of the historical development and the environmental impact of industry. The complexity of the interactions between the stakeholders and the perception of the externalities of industry is

highly dependent upon the type of industry and the interplay between the three licenses with the internal management of the firm. The framework is then highly context specific and needs to be detailed so that it is adapted to particular industries.

Figure 3.1 shows a graphical representation of the license to operate framework. According to this, the economic, social and legal licenses simultaneously shape the industry's environmental performance. Here, the management style is indicated in the middle of the graph as it is influenced by the three different types of licenses and has a direct impact on the environmental performance of the industry. The graphical representation in Figure 3.1 shows the same shape for one of the three types of licences but solely for the purposes of graphical display.

Figure 3.1 – The License to operate

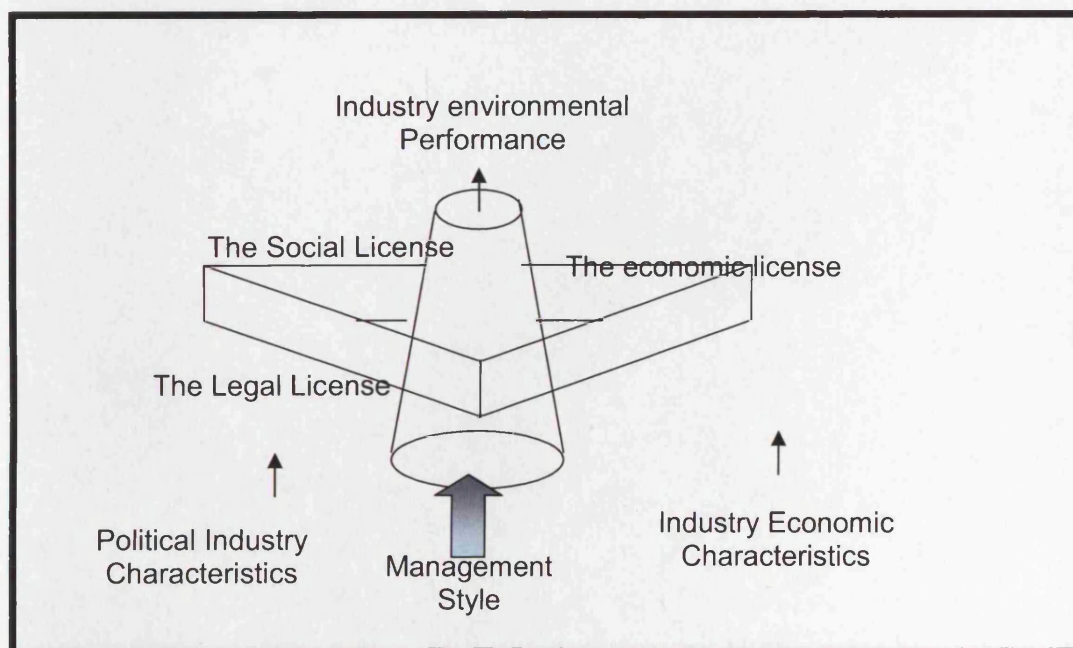


Figure 3.1 indicates that the three different licences are intertwined, providing a joint effect on the environmental performance of the industry. The initial studies that used the framework were concerned with understanding the differences between the leaders and laggards within the same industry, and how firms have been able to display different environmental performance within the same licenses (Gunnigham et al., 2003). This work, however, takes the aggregate framework and applies it to the auto industry at context-specific points in time to understand how the legal license was able to influence the environmental performance of firms within that industry. The differences observed between firms are indicated as important demonstrations of the diverse interpretation of the macro-level licences in the internal management style of the firms.

The environmental dimension is an important aspect that needs to be discussed in the context of the 'license to operate'. The environment has a wide impact on the formation of the licenses, as it possesses profound social, economic and regulatory implications; this is because a greater range of stakeholders monitor and pressure the industry to adopt specific behaviour and responses towards the negative environmental externalities produced or the natural resources used. Environmental groups can influence the regulatory license by demanding more stringent standards. The economic license can also be influenced by consumers who can switch the demand towards products or producers which are perceived to be more sustainable. Workers of the firm can also be influenced by the social perception of tightening the social license. Moreover, stakeholders and stockholders might perceive the rate of return of the investment as being directly related to the environmental performance of the firm and the terms of the social license.

3.3 - The proactive role of industry and the license to operate

The framework is helpful to understand the role that a proactive industry can play in shaping the licenses (Kagan et al., 2005); a wider understanding of the effects of industry on the environment and the role that a proactive firm engages in is also more far-reaching than a submissive position. The strategic use of governmental regulation is well defined as an active business strategy. Following the analysis presented by Reinhardt (2000) and other strategists, such as Hart (2003), it has been argued that industry can find profitable outcomes from addressing environmental shocks, including: the reduction of costs, environmental product differentiation and market redefinition strategy, where industry would be able not only to increase revenue but also to reduce costs by offering superior products in environmental terms (Reinhardt, 2000). In this context, it is also relevant to mention the industry's political activity that constitutes its attempts to shape government policy to favour the firm (Baysinger, 1984). However, despite the initial focus of the field on a firm-level political engagement, a wide range of scholars have indicated the importance of industry-wide political activity (Shaffer, 1995). For the purposes of this work, the industry-wide focus on the broader analysis is more relevant.

The pro-active role of the industry in forming the legal license is supported by greater information about costs, business cycles and the incremental limits of the business model. In this sense, industry has a better grasp of what is possible in technological terms and the consequences of pressures from the economic license to the established business model. Therefore, although the problem of the asymmetry of information has negative consequences for policy makers, it can serve as a positive element for pro-active industries willing to engage in a political strategy (Salop and Scheffman, 1987).

The characteristics of the market are crucial to comprehend the interaction between the licenses. It includes the relationship that industry has with regulators, as well as the level of cohesion that the firms operating in this market have. Consequently, more specific characteristics of the market such as the number of firms, barriers to entry and historical

relationship with regulators and consumers are also relevant to contextualise case specific responses to environmental demands. The 'collective action problem' addresses the connection between the industry level structure and the ability to organise political action (Getz, 1997). The industry level analysis follows an older interest in firm-level engagement, where issues such as firm size, dependency on government, the diversification level, foreign ownership, the age of the firm, formalised firm structures and managerial influence are relevant levels of analysis.

Industry-wide analysis indicates that the industry structure is considered as a determinant antecedent of active political activity. Here, concentrated industries are more likely to engage in lobbying and campaign contributions in the US than fragmented ones (Schuler et al., 2002). The same conclusion has been reached concerning firms operating in other parts of the world (Coen, 1997); there is therefore a causal relationship between the level of the firm, the industry and wider impacts on the firm level corporate political activity (Gray and Lowery, 1998).

The characteristics of the market impact on the formation of the legal and economic licenses to operate are the key to appreciate how an industry may be able to influence regulators. Industry can pressure for the use of a specific technology that is aligned with the prevailing businesses model, lobby for subsidies for R&D, or force the creation of specific rules and regulations to form larger barriers to the entry of new competitors in their market (Demsetz, 1988).

The influence of policy salience is also relevant to indicate industry engagement and how the issues that are being regulated by policy makers are perceived by the industry. Moreover, firms estimate the potential impact on the firms' competitive advantage and strategy (Schuler and Redhein, 1997). The environmental dimension has been indicated as being of prominent political salience for several industries, including the automobile industry. The present business model of the automobile industry is particularly vulnerable to future regulations as the automobile was not initially designed with environmental concerns in mind (Nieuwenhuis and Wells, 2003).

Another important aspect that has been highlighted in the literature has been the potential development of greening success stories that would lead to a beyond-compliance behaviour. This can be interpreted as a non-market strategy to influence the social license and to anticipate the formation of the legal license. Beyond-compliance behaviour can be the result of cooperative efforts across the industry; it may also be a result of influence over governmental policy to develop and implement new technologies that will enhance the environmental performance of the industry, and will encourage policy makers to adopt the more advanced standards that are already met by the industry.

3.4 - The environmental management style²

Corporate behaviour has been addressed by organisational theory literature. Most of the work in this field is concerned with the differences between firms seeking to establish a competitive advantage with regard to environmental regulations through voluntary corporate behaviour. Other authors have indicated that individual firms interact with each other in order to jointly shape diverse licenses, including the legal licence and standards (Elderman et al., 1999; Hoffman, 1999).

The relevance of the internal factors of the firm need to be accounted for when dealing with the effects of environmental regulation, including:

- Managerial perceptions (Bansal, 2003);
- Organisational cultures (Forbes and Jermier, 2002; Vanderbergh, 2003);
- Organisational structures (Delmas and Toffel, 2005);
- Managerial commitment (Coglianese and Nash, 2001).

² Note - Under the banner of corporate environmental responsibility - industry understands that its role is part of the solution to the environmental problem and not as part of the problem. - For the present purposes, CER (a sub-category of the broader concept of corporate social responsibility – CSR), will be defined as *practices that benefit the environment (or mitigate the adverse impact of business on the environment) that go beyond those that companies are legally obliged to carry out*. This definition is broadly consistent with that put forward by the World Business Council for Sustainable Development!

These firm level aspects help to translate the different terms of each licence in a wide range of practical actions. The literature is silent on examples of empirical studies that control external factors to provide a clear comparison of internal factors across firms (Howard-Greenville, 2006). Despite this, several attempts have been brought forward based upon organisational theory to provide a theoretical delimitation of the types of management style that influence the firm in translating the terms of the three licenses in order to operate in practical actions.

In the 'license to operate' framework the managerial style serves as a filter through which the management of each one of the firms composing the industry interprets the three types of licenses. The license to operate can be translated differently by the diverse firms operating in the market. The management style is able to translate stakeholders' demands into practical actions for industry as several other aspects need to be accounted for, including, the history of the firm, the specific characteristics of the market, general corporate culture, history, network relationships and individual membership to industry associations. These variables are important in determining if the industry can adopt a collective action strategy towards regulation or have individual responses if specific firms perceive the potential to gain competitive advantage.

A pro-active environmental management style is described very well in the model presented by Orsato (2006), where firms are divided into broad categories of environmental action in regards to regulation. Based on Reinhardt (2000), Orsato (2006) argues that competitive advantage can be gained using lower costs or differentiation, which in turn should be the focus of organisation processes or in the products or services of the firm. These variables can lead to four different types of environmental proactive management style strategies: eco-efficiency, beyond-compliance leadership, eco-branding and environmental cost-leadership.

Table 3.1 provides a graphical representation of the pro-active management style strategies presented by Orsato (2006). The structure of the industry in which a firm

operates, its position within that industry, the types of markets the company serves, and its capabilities will suggest the appropriate competitive focus (organisational processes or products/services) and the potential source of competitive advantage (cost or differentiation) of a firm.

The distinction between organisational processes and products and services is possible only because the four strategies can work independently. For instance, by being the first to certify its environmental management system, a firm may differentiate itself from competitors, while its products or services do not present any environmental features. Conversely, a firm may decide to sell products with eco-labels but not explore the green features of its organisational processes. A criticism of this model is the difficulty of spotting clear cut differences between these four types of strategies. In this sense, it may become hard to understand empirically how a firm can typify wider environmental friendly managerial strategies that will affect the four typologies described. However, the classification of pro-active management styles is relevant to the discussion of the license to operate framework.

Table 3.1 - Environmental regulation and corporate strategy

Competitive Advantage	Lower costs	1.Eco-efficiency	4.Environmental Cost Leadership
	Differentiation	2.Beyond-compliance Leadership	3. Eco-branding
		Organization processes	Products and Services
Competitive Advantage			

Source: Orsato (2006).

3.5 - Proposed extensions of the 'license to operate' framework to the problem in question

The general conceptual framework presented in the previous section indicates that the license to operate framework is context specific. The framework has been applied to sectors that have very particular characteristics, including the pulp and paper industry (Gunningham et al., 2003), mixed industrial facilities (Howard-Greenville et al. 2007) and extractive industries (Parker et al., 2008). Each of the studies has looked at industries in certain periods of time and centralised on specific negative environmental externalities. One of the extensions that this work proposes to explore is to appreciate the suitability of the framework to problems in the automobile industry. This has specific and important characteristics that shape the licenses to operate and may lead to a diverse set of conclusions.

Most of the work in this area has given wider emphasis to the formation of the legal license as a more prominent issue in distinguishing leaders and laggards in environmental performance (Gunningham et al., 2003). The researchers generally possess a policy-making background, and provide conclusions focused on the regulatory aspect of the issue. Central has been the concern of further developing the literature on the environmental management style.

This work has a different focus. The aspiration is to investigate the relationships between the corporate commercial requirements, the legal license and environmental pressures. The relationship between environmental regulation and automotive industry technological development is dependent upon the necessity to satisfy the different set of licenses taking into account the particular characteristics of the industry and the market at the time. The business characteristics of the automotive industry require discussion as they not only shape the market structure of the firms operating in the market, but also have a wider impact upon the sorts of measures that can be adopted in order to cope with environmental pressures (Requate, 2005).

Based upon the theoretical discussion presented in Chapter 2, and on the discussion of the 'license to operate' presented in this chapter, it is imperative to recognise the specific characteristics of the automobile industry to better understand the formation of the three licenses to operate. In this sense, the next section discusses the main business and economic characteristics of the industry that may affect how the industry can be influenced by the licenses to operate and how industry can adopt a pro-active role, so influencing the formation of the licenses.

3.6 - The 'license to operate' and the automobile industry

The business of the mass-produced vehicle is based on two important technical concepts: the internal combustion engine and the all-steel body structure (Nieuwenhuis and Wells, 2007). These two elements were able to make the automobile a mainstream product and they are still the pillars of the modern business of building cars on a large scale. Consequently, they directly impact on the relationship that the industry has with the natural environment (Orsato, 2007) and shape the economic license. Since the economic feasibility of the industry is based upon large-scale production, the initial investment in machinery, design and industrial structures is significant, forming high barriers to entry for new competitors. In this sense, large firms have operated throughout recent years with financial losses in several of the most important markets, including the United States (Vlasic and Bunkley, 2008), Europe (Deutsche Welle, 2010) and Asia (Frakler, 2008).

The cost structures of the automobile industry are a fundamental factor in understanding the formation of the economic license. The Samsung experience of entering the Korean automobile market in 1994 provides a relevant indication as regards the present costs of entering the market which are very different to the initial firms. It is estimated that the Samsung Group spent more than US\$5 billion from 1994 to 2001 in order to build

production and research facilities, and the distribution network (Ravenhill, 2001). After the Asian financial crises of 1998, the new firm in the Asian market had close to 2.33 trillion Won in debt in 2000. Renault acquired the firm for US\$100 thousand, and took on \$250 millions of Samsung's debt ³.

According to Gerosky (1995), entry rates in general markets diverge over time. The entry rates are often higher in the early life of any market. This phenomenon was observed in the case of the automotive industry, both in the United States and in Europe. O'Connell (1998) notes that in early days of the British motor industry, more than 400 different vehicle brands were available for purchase. Clark (1983) reached similar conclusions for the North American market and Nieuwenhuis and Wells (1997) also note the rapid rise in the number of car firms in France between 1894 and 1904.

At the beginning of the twentieth century, the number of firms involved in the production of vehicles was relatively large in comparison to the size of the market, as the barriers to entry were less significant. Many small-scale manufacturers were involved in the supply of vehicles. However, as the industry matured, new industrial groups emerged as central players with concentrated and larger markets shares (Chandler, 1964). Nowadays, the modern automotive industry is composed of a limited number of groups that possess a wide number of brands⁴. Here, vehicle manufacturers are the most important firms in the automotive supply chain. Not only are they the ones responsible for the construction of the automobile, but they are the ones who command the suppliers and provide the necessary products for the consumers. Nieuwenhuis and Wells (2003) provide three general categories of automotive manufacturers:

1 – High volume producers; these firms produce large volumes of vehicles that dominate the market as the greater part of the demand is supplied by them. The models offered by

³ - <http://www.korealaw.com/node/109>

⁴ - It is important to note that the automobile industry is composed of more than just vehicle manufacturers. There are suppliers of OEM and aftermarket equipment, distributors, retailers, and all of the wider network of activities including insurance, policies, emergency repair and others.

these firms range in size and capabilities, and are destined for the lower section of the market. In a simplistic analysis, the major source of profit for these firms lies in the economies-of-scale as they strive to maximise their initial investments by selling a large volume of cars at low cost. Examples of these include: Ford, General Motors, Honda, Toyota, Nissan, Fiat, Peugeot, Renault, Chrysler and Volkswagen; the business models of these firms are based on cost reduction (Williams et al., 1994).

2 – Specialist producers; these firms are characterised by more sophisticated products that rely on technical sophistication, offering larger and higher performance vehicles. The source of profit for these companies is differentiation, and a combination of exclusivity and quality. Examples here include: BMW, Mercedes-Benz, AUDI, Alfa Romeo, Saab and Volvo. Cost recovery is the central element in the business model (Williams et al., 1994).

3 – Niche producers; these companies are typified by extreme performance and exclusivity. The products offered are unique, with variable durability and quality. Most of them are exotic high performance sports cars or extremely luxurious models with a vast amount of craftsmanship. Examples include: Ferrari, Maserati, Lamborghini, Pagani, Bugatti, Bentley, Rolls Royce, Aston Martin and Noble. These firms also based their businesses models on cost recovery strategies (Williams et al., 1994). Another important feature of these firms is the use of advanced materials. The body follows a non-Budd pattern.

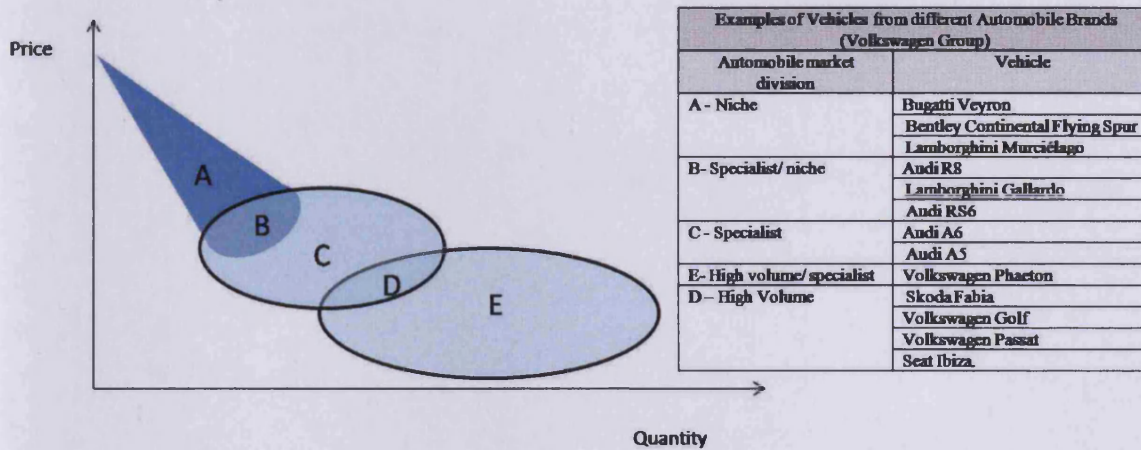
In addition to this, these types of producers distinguish their products in several areas. The number of units produced is relevant, such as the more exclusive the vehicle, the higher its market value. The engine size and general performance of the vehicle are also very important, as vehicles with higher performance utilise more powerful engines and are built with more expensive materials. Brand image also plays a relevant role in the definition of price. Certain brands possess a heritage linked to sports cars, which is valued by the consumer, such as Fiat's Abarth. Amongst several studies that model the

demand function for new automobiles, Arguea et al. (1994) indicate that the demand for horsepower is elastic in relation to income, while capacity is unitary and is negatively correlated to fuel efficiency. This indicates that as consumers get richer, they care more for comfort and performance and less about the miles per gallon.

Despite the instructive importance of the general categories of automobile manufacturers, this categorisation is not without problems. The world automotive industry is dominated by a restricted number of industrial groups which absorb several car brands within these different categories. Some of the larger ones try to compete in every market, offering a vast number of brands to the consumers, which include high volume brands, specialist and niche brands. The Volkswagen Group, for example, is a public-listed automotive producer, which holds the ownership of several important vehicle brands, including: Volkswagen vehicles, Volkswagen commercial, Audi AG, Bentley Motors Ltd, Bugatti Automobile SA, Lamborghini S.p.A, SEAT S.A, Porsche AG, Skoda Auto, various joint ventures links and other truck brands (Scania AB and 29% in MAN AG).

Figure 3.2 shows a graphical representation of the automobile market with the division of three different types of suppliers: high volume producers, specialist producers and niche producers. The areas represent the distribution of vehicle models. The graph has two important elements to discuss. The first is the inverse relationship between price and the quantity of vehicles offered. This relationship is clearer for the niche market, where the exclusivity factor is an important attribute for the consumer who is willing to pay a premium for a limited product. This relationship may not be so clear for the high volume producers, where sometimes the best sold vehicles are not the cheapest, but provide the best value in combination with what is demanded by the consumer.

Figure 3.2 Automobile market divisions



The second feature of this graph is the intersection between the areas. In the intersections the suppliers often contain products from one group or another. In the high volume and specialist intersection, high volume producers may introduce more sophisticated versions of their products or specialist producers may introduce simpler and smaller versions of their standard models.^D There are several cases of high volume producers who produce vehicles aimed at specialist vehicle consumers, such as the Volkswagen Phaeton. Certain models from specialist vehicle manufacturers are also aimed at supplying high specification, high volume vehicles, such as the Audi A2. The same rational is valid for niche vehicles and speciality vehicles. The table provides six examples of vehicle models that can be found in each of the areas. The entire vehicle brands selected in Figure 1 belongs to the Volkswagen AG. This representation illustrates how one single automobile group possesses brands that are competitors to other brands of the same group. The competition can even occur between models and brands of the same group, which, in this case, would be in the high volume, brands of the Volkswagen Group: Volkswagen, Skoda, Seat and some Audi Models. Another automobile group that would present a wide display in the graph is the FIAT S.p.A. because the group would have examples in each of the three large areas and in the intersections with Fiat, Alfa Romeo, Maserati and Ferrari.

Williams et al. (2004) note that it is important to differentiate cost reductions from cost recovery strategies. Within the cost reduction strategy, firms rely on the economies of scale to lower the unit cost of each single product. Costs can be distributed between each single unit of produced product. In this sense, the larger the quantity of vehicles produced and sold, the higher the profit of the firm. These firms try to compete on the general market where they have very little negotiation margins. However, the market cannot be classified as a perfectly competitive market as there is not an infinite number of suppliers, the products offered are not perfectly substitutable and the barriers to entry are significant (Varian, 1992).

The other sort of economic strategy of firms is cost recovery (Williams, 2004). Here, the most important elements of the business model of the firm are exclusivity and product differentiation. Since these firms try to perceive themselves as specialist or niche producers, they can capture profit, so providing a distinctive product with a higher market value. Consumers take into account a large number of issues when selecting these vehicles, including power, performance, brand image and durability. In this sense, the business model for these firms is essentially different from the large scale manufacturers and they do not solely rely on economies of scale, but on other less quantitative elements related to brand reputation and image. According to Fisher et al. (1995) manufacturing flexibility is an important attribute for firms that seek to supply niche markets, and can be achieved by not relying on Budd technology. The environmental cost differentiation proposed by Orsato (2006) and Reinhardt (2000) would therefore be classed as cost recovery.

The modern automotive industry is composed of a restricted number of industrial groups that possess ownership of several brands of high volume manufactures, specialist producers and niche products. Table 3.2 presents a summary of the leading automotive groups, along with owned Brands, the brands that are partially owned and the joint ventures or collaboration agreements with others.

Table 3.2– Global Automobile Groups (2007)

Group	Owned Brands	Partial ownership	Joint Venture
General Motors Corporation	Buick; Cadillac; Chevrolet; GMC; Holden; Hummer; Opel; Pontiac; Saab; Saturn; Vauxhall	Fiat (10%) Daewoo (50,9%) Suzuki (3%)	Toyota – NUMMI; Lada; BMW (co-develop Hybrid) Manufacturing ventures with several automakers around the world, including Toyota, Suzuki, Shanghai Automotive Industry Corp. of China, AVTOVAZ of Russia and Renault SA of France.
Ford Motor Company	Ford; Lincoln; Mercury; Volvo;	Aston Martin (8,32%) Mazda (33,4%)	PSA Peugeot Citroen – Joint venture diesel engines; Fiat.
Fiat Group Fiat S.p.A. – Fabbrica italiana de automobili Torino)	Fiat group automobiles (Fiat, Fiat Professional, Lancia, Alfa Romeo, Abarth); Maserati, IVECO	Ferrari (85%);	Fiat; Ford (co development and production) PSA Peugeot Citroen (collaboration agreement – Sevel).
BMW AG	Rolls Royce, BMW, MINI		Toyota (diesel engine for the mini); PSA (Prince engine). GM and Chrysler (co-develop hybrid).
Toyota Motor Corporation	Scion, Lexus, Toyota	Daihatsu (51,2%); Hino (50,1%); Fuji Heavy Industries Ltd. – Subaru (8,7%) Isuzu (5,9%)	GM – NUMMI; PSA (TPCA); Porsche (hybrid technology); BMW Mini – diesel Engine.
PSA Peugeot Citroen	Peugeot; Citroen		BMW (Mini engines), FIAT (Sevel), Ford joint venture (diesel engines), Mitsubishi (alliance), Dongfeng Motors, Toyota.
PSA Renault	Renault; Renault Samsung motors; Dacia.	Nissan (44.4%)alliance -Volvo trucks 20% – who owns 100% of Renault Trucks and Mack.	
Nissan	Nissan , Infiniti	Renault (15%) alliance	Dongfeng motor corporation
Shanghai automotive Industry corporation – group.	Shanghai; Nanjing automobile group (Soyat (licensed Seat and Isuzu), Chinese Fiat, MG, Rover.	SsangYong motor (50,1%) ;Chery (20%);	Volkswagen Shanghai GM. Fiat China – FIAT.
Hyundai, Kia Automotive Group	Hyundai, Kia		Mitsubishi motors (joint manufacture and technology license); Kia with Dongfeng
Honda Motor Co., Ltd	Honda, Acura		Dongfeng motor corporation
Daimler AG	Merced Benz cars (Maybach, Mercedes-Benz, AMG, Smart)		Mitsubishi motors
Chrysler LLC (80,1% owned by Cerberus capital management L.P.)	Chrysler, Dodge, Jeep, Global Electric Motor cars		Mitsubishi motors (joint venture platform); GM and BMW (co-developed hybrid))
Volkswagen AG (owned 30,9 % by Porsche)	Audi AG, automobile Lamborghini, Seat, Volkswagen, Bentley, Skoda, Bugatti.	Commercial Vehicles (Man 29,9% and 52% by Scania), Scania (20,03%)	Proton (strategic partnership) Shanghai (joint venture).
Proton	Proton Cars	Lotus cars (63,75%)	VW (strategic partnership)

Tata Motors	Jaguar, Daimler (owned by Jaguar) Land Rover, Tata		
Suzuki Motor Corporation	Suzuki	Maruti	General motors, Subaru, Mazda, Nissan, Maruti Suzuki.

Source: various sources (2007).

This shows two important characteristics of the modern automobile industry. First, globally there are a relatively small number of industrial groups dedicated to automotive production. The data demonstrates that a limited number of firms operate in all the most important markets and most of them concentrate their operations on home or specific markets. Vehicle line ups are set up taking into account several factors, such as local consumer preferences, and the price of fuel, local safety regulations, local and environmental regulations. Vehicle manufacturers also account for factory location, currency exchange rates and international trade agreements. In fact, each geographical market is supplied with different vehicles that are more suitable to the test and specific local characteristics of that regional market. Firms select the most appropriate vehicle line up to be offered to the specific market. The variety of products has to be taken into consideration when providing a market definition of the relevant market.

Imported vehicles are relevant elements in the characterisation of levels of competitiveness in the geographical markets. The current North American market provides a rich empirical example. American, Japanese and European brands have assembly-plants operating in the country, but the market also has many imports. The small import duty tax (6%), which enhances the competition in the internal market, is one of the reasons for the strong presence of imported units. On the other spectrum, the Brazilian market can be considered a closed market for imports. The government has set up rules to foster the development of the local production to the detriment of imported competition. In this sense, the country has one of the highest import taxes in the world (35%). Only new vehicles can be imported and private parties cannot complete the import requirements. Additionally, all independently imported vehicles must comply with local safety regulations which enhance the bureaucratic process. In real terms, Brazil has one

of the most expensive vehicles in the world, where analysts calculate that the direct taxes for the consumer are 30% (Pineiro, 2007).

The automotive industry can be characterised as an oligopoly with product differentiation, and not as a perfectly competitive market. The levels of competitiveness must be assessed in geographical terms as certain countries and regions have more suppliers operating in the market, making it more competitive. This holds important lessons for policy makers, and since the industry operates as an oligopoly, there are significant barriers to entry with each competitor in the market having a limited market power. It is also relevant to contextualise the analysis of the license to operate.

Economic literature has conventionally modelled the automotive market as an imperfectly competitive market (Goldberg, 1995). The main aim has been to classify the industry as an oligopoly with product differentiation (Berry et al. 1995). Krugman (1987) provides a significant discussion on the new developments in international trade theory, looking at the impacts of free trade in imperfect competition industries, which are directly linked to the automotive industry. For this study, the importance of the market characterisation of the industry is that it holds crucial lessons for implementation of environmental policy and assumptions that can be constructed for the sustainability of the industry.

Additionally, another relevant aspect of a global industry is the fact that global groups have a tendency to incorporate similar parameters throughout their car production plants. Sturgeon and Florida (1999) indicate that the modern automobile industry has transitioned from an old model of competition, characterised by the focus on the domestic market, to a global model, where the production function of the firm is organised on a regional and global basis. This distinction also has implications for emerging markets that have evolved from simple adopters of old models and production equipment to builders of leading-edge productive capacity. The industry has also changed from an export-lead industry to a networked led industry, where each major firm produces with the focus of

supplying major markets. The prime reasons for this change in the model of competition are considered to have been the advent of modularisation and supplier outsourcing (Sturgeon and Florida, 1999).

Under this new 'global' model, high volume manufacturers can maximise investments (if they can spread the 'sunk costs' in the research and development of new products) in several operational plants around the world (Nieuwenhuis and Wells, 2003). The ideal situation is for firms to offer similar models around the world. This gives the firm a larger flexibility to steer production from one market to another, as there is a surplus or deficit of a specific product. Firms like Toyota, for example, produce the same model in three continents – the Toyota Corolla, has minor differences in the three markets. This strategy makes the firm dilute sunk cost in design and auto part production, through a larger number of units.

The relationship of the global and cohesive oligopolistic firm is relevant for the study of the pro-active role of the industry. The structure of the market in business and competitive terms can directly impact on the manner in which the industry can organise itself in order to interact with environmental regulators. This is not only in terms of regulatory compliance but also with regard to the direction of future regulations (Requate, 2005). The global size and scale of the industry therefore enhances the influence of new standards.

In the context of the license to operate, as previously discussed, the main business and economic characteristics help to shape not only the economic license but also the potential political pro-active strategy to influence the formation of the legal license. Thus, the automobile industry as an oligopoly with product differentiation has a considerable interest in engaging in industry-wide corporate political activity.

The political salience that the environmental dimension has gained in recent years indicates that the present business model of the firm is highly vulnerable to further

regulatory measures. In this sense, it is in the interests of the industry to adopt a proactive role in influencing the formation of the legal license, through direct lobby and the social license, so influencing the public and society in general regarding active environmental measures to control the formation of the social license.

3.7 - The fundamental drivers for change in the automobile industry and the 'license to operate'

Following the characteristics of the automobile industry presented in the previous section, the most relevant issues and the consequences of the present business model of the industry along with the respective influence for the licence to operate framework are introduced in Table 3.3.

The issues identified here are as follows: environmental and safety regulation, market fragmentation, design limits for general purpose all-steel cars and the capital intensity of production technology. These are key issues that pressure the present business model of the firm and have significant influence on the license to operate the automobile industry. According to Nieuwenhuis and Wells (2003), the present strategy of reliance on incremental innovations has reached certain technical limits, and the market could be ready to see the emergence of a disruptive environmental technology.

Following the discussion of corporate political activity, the pressures caused by environmental, health and safety regulation need to be accounted for. The increasing scope and severity of regulation has placed important constraints on the basic characteristics of the automobile industry: the internal combustion engine and the all-steel body structure. The existing technologies have also been challenged for their ability to deliver profitable and sustainable outcomes, so tightening the economic and social licenses. In the same sense, market fragmentation, with the growing market divisions,

undermines the concept of long product life cycles and mass-production economies of scale and enhances the pressure on the design limits of the all-steel body structures. The capital intensity of the production produces high risks on the investments decision which results in conservative product design. The combination of these elements then enhances the constraints posed by the interplay of the social and economic licenses.

The drivers of change can be perceived under the license to operate framework as potential liabilities for the present business of the industry regarding how these areas constrain the environmental performance of the industry. As indicated in Table 3.3, in the context of the license to operate, these drivers significantly stress the formation of the three licenses. The economic license is therefore heavily constrained by the environmental and safety regulation, since incremental limits of existing technologies are being reached. Further strain is therefore placed on the formation of the economic license which is already heavily constrained. The economic license is also influenced by the consumer's demands for a greater variety of products, this contrasting with the design limits of the all-steel body vehicles. The capital intensity of production technology has a dual effect. On the one side it helps with the formation of barriers to entry for new competitors but on the other also enhances the potential political action of industry. The automotive industry also has a discontinuity between the cost-reduction benefits of an increasingly global production and market structure against a less than uniform regulatory framework; national regulations still vary widely, as do national market conditions and requirements. The industry lobbies for cohesive regulation, but this of course also makes the transition process slower, and hence old technologies can be retained for longer.

Table 3.3 - The fundamental drivers for change in the automobile industry

Issue	Manifestation	Consequences for the present business model	Influence on the license to operate framework
Environmental and safety regulation	Increasing scope and severity of regulation of the car on safety, toxic emissions and CO2 emissions and waste	Reaches limits of incremental improvement to existing technologies	Pressures over the social, economic and legal licenses.
Market fragmentation	Consumers demanding greater variety of products	Undermines the economies of scale; reduced product cycle	Pressure over the economic license
Design limits for general purpose all-steel cars	General purpose all-steel cars too heavy to meet CO2 reduction targets, not ideally suited to the task, wider use of plastics – ELV issue	Could lead to dramatic change in dosing concepts and materials use, resulting in radical shift in production technology.	Pressure over the economic license and the social license as consumers may demand better products with environmental aspect.
Capital intensity of production technology	Capacity expanded in large increments at high cost	Results in high risk, hence conservative product design	Legal licenses may force the industry to adopt more advanced products. The economic license is constrained by the main characteristics of the industry.

Source: adapted from Nieuwenhuis and Wells (2002)

3.8 - Researchable propositions

One of the gaps identified in the review of the '*greening of industry*' literature has been the belief that industry, by itself, is able to find long-term profitable solutions for environmental issues. The intrinsic perception has been that a pro-active management style combined with the benchmark of success stories would be able to take the industry from a largely unsustainable position to a sustainable arrangement. The model of corporate environmental strategy presented by Orsato (2000) highlights this point, as firms would be able to adopt pro-active green strategies to find market gain in the products or services offered. They could also search for competitive modifying organizational processes and not introducing any changes to their products or services. The strategic model presented by Reinhardt (2000) also discusses the condition under which industry could profit from environmental regulation by perceiving opportunities to gain competitiveness. Regulation could, in this sense, constitute an additional source of information whereby firms could address environmental issues for industries that had an advanced perception of adopting beyond compliance behaviour. The regulatory pressures would, in this case, formalise pro-active industrial behaviour that had already been in the process of implementation (Reinhardt, 2000).

Notwithstanding this, it can be argued here that the relationships are more complex; the specific case of the automobile industry presents a different and more multifaceted picture. In the present economic state of the industry, and not coping with economic demands has placed additional pressure on the industry to provide solutions which are at the same time sustainable and profitable. Questions can also be raised as to whether the present direction and pace of technological development following a pattern of incremental innovation is sufficient. Little weight has been placed on a scenario of economic constraints and whether, under these conditions, the automobile industry would have the ability to translate an abstract willingness to change into an effective transformation towards sustainable development. Therefore, the '*greening of industry*' analysis needs to consider the relevance of the market forces shaping the economic

licence which also impact on the legal license to operate. The cases will investigate this proposition.

The 'licence to operate' framework also indicates another aspect that the field has not articulated: the interplay between the social and the economic licenses. The cases will also examine this proposition. According to the framework, this joint effect is relevant to the environmental performance of the firm in the specific case of the automobile industry. The combined action of the two is a crucial element of change that needs to be further investigated. As previously indicated, a wide range of interest groups constitute the social license, including local communities, national environmental groups, workers, the media, non-governmental organizations, academia, consumers and society in general. Social stakeholders can also influence the social license as well as the legal license because policy makers and regulators can be pressured into imposing stricter regulations.

In the case of the automobile industry, the investigation of the interaction between the three licenses to operate can provide an indication of how the response to environmental regulation may be shaped. It has been documented that the growth in environmental preoccupations in society in general has changed as major corporations are dealing with the environmental dimension within the scope of their business model (Fiorino, 2006).

Aware of the need and possibility of change, industry has become more conscious of potential non-market strategies and the social licence has become more important (Gunnigham, 2006). Shaping the social license is a industry pro-active behaviour and can generate private profit.

The importance of the social license has become more prominent at the same time that the 'greening of industry' literature has emerged. This follows the rapid expansion in the environmental corporate strategy field and the dissemination of environmental ideas into society in general. The case studies will therefore investigate if the economic and social licenses have become more significant along with the growth of the 'greening of

industry' field.

3.9 - Conclusions

The analysis provided in this chapter suggests that the environmental performance of an industry is shaped by a socially constructed license to operate. The 'license to operate' framework indicates that industry must comply with the tacit expectations of social actors, the formal impositions of regulators and the economic constraints imposed by stockholders. The interpretation of these socially constructed licenses depends on the management style that determines the industries' environmental performance (Gunningham et al., 2003, 2004; Howard-Greenville, 2005; Howard-Greenville et al. 2007).

The framework also indicates that the licences to operate are not simply imposed on the industry. The industry has, at least, partial influence over some of the licence terms, including not only the social license but also the legal one (Elderman et al, 1999) and (Hoffman, 1999). This presents important lessons for industry. The industry's political activity is supported by the fact that industry has more information with regard to what is technically possible and to what extent the present business model of the firm can be extended with incremental innovation. Environmental issues have been identified as being of crucial political salience as the present business model of the automobile industry is particularly vulnerable to future environmental regulations. As a result, it is rational to assume that the automobile industry has a considerable interest in shaping both the legal and the social licenses to operate.

Since the fundamental query in this thesis is the relationship between environmental regulation, the technological development of the auto industry, commercial imperatives and wider social benefits, it is important to comprehend the central characteristics of the automobile industry so that linkages can be established between these variables in the

context of the 'license to operate' framework. The contextualisation of the problem has provided important insights into what can potentially be developed in the 'greening of industry' literature. Certain characteristics give the business model of the firm a low profitable reality, including the reliance on the internal combustion engine and the all-steel-body structure, in addition to the growing pressure from environmental and safety regulations and the market fragmentation that has been observed in more recent years. These important features help to build the fundamental drivers of change and modify the licenses to operate. However, the industry is well positioned to actively seek to influence regulators and pressure the formation of the legal license. The industry has large barriers to entry due to high sunk-costs, and possesses few international groups that are operating in the market. This has important consequences for the potential pro-active political action over regulators and corporate political strategy. Moreover, a more detailed understanding of the business of the industry enriches the debate regarding the influence of environmental regulation, this being a key area for the development of the industry. This issue indicates the high political salience of the industry as the increasing scope and severity of environmental and safety mandates enhance the pressure over the limits of incremental improvement in the existing technologies, and as a consequence limit the social, economic and legal licenses.

The researchable propositions of this research indicate two aspects which have been overlooked by the 'greening of industry' body of literature. Firstly, there has been a systematic absence of factoring for the economic license in the discussions about regulation. Most of the discussion has been concerned about what is possible in relation to the technology and not to what is possible for the industry under a constrained economic state, where large sunk costs exist for the production of the internal combustion engine and the all- steel-body structure. Secondly, the interplay between the economic and social licenses may pose significant limitations for the environmental performance of the firm. It may therefore be more relevant for the industry to deal with the aspects of the license to operate, since they could drive the formation of the legal license.

The next chapter will present the methodology adopted to investigate the central researchable positions that have been contextualised in the automobile industry and the selection of case studies taken to investigate these issues.

Chapter 4 - Methodology

4.1 - Introduction

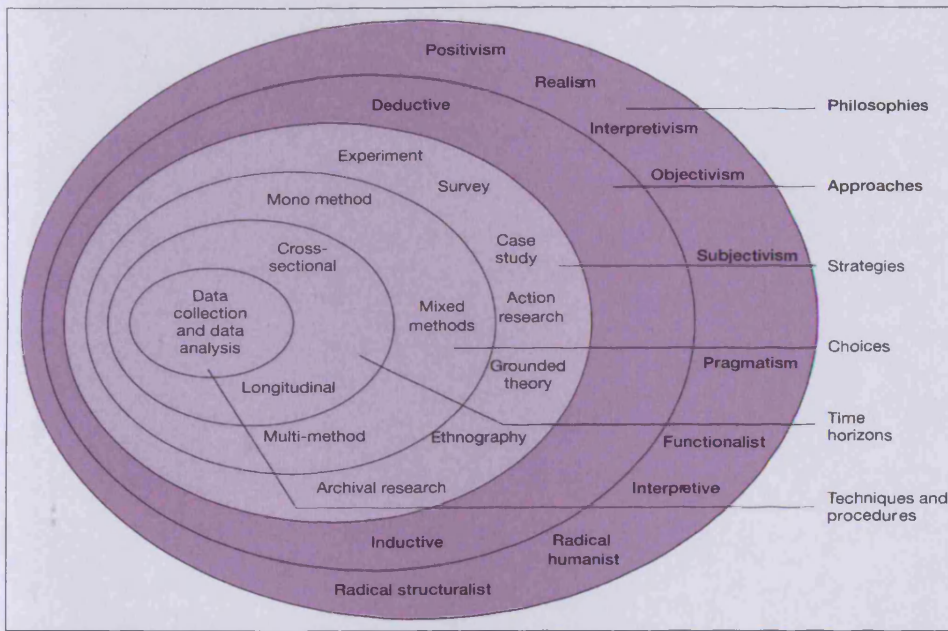
This chapter provides a description of the methodology that has been used to conduct this investigation. The research design, alongside the justification for the selection of the case study method as the central research strategy, is discussed. The chapter also addresses the selection of the case studies and presents a case study protocol.

4.2 - Research Design

An open systems approach, followed in this research, has been widely applied in the environmental policy arena. Positivistic research that isolates variables thought directly to be the manifestation of cause and effect relationships is considered inappropriate for a case-study research project, while a more qualitative approach may be able to provide a wider set of assumptions more grounded in real life problems (Saunders et al., 2000). In this sense, the epistemological position of this research design can be classed conceptually in between empiricism and rationalism, following philosophical traditions close to Kant (1781) and Popper (1935). The intent of this thesis is to use empirical research to enhance understanding of the 'greening of industry' and contribute to the body of knowledge in this area (Bryman and Bell, 2003).

In order to illustrate the various alternatives available to a researcher Saunders et al. (2004) devised the 'research onion'. This diagram, presented in figure 4.1 below, displays the various philosophies, approaches, strategies, choices and techniques that can be followed when researching social sciences. It is important to notice that there are large overlaps between each of these different social research strategies, despite the didactic separation between them.

Figure 4.1 – The research onion



Source: Saunders et al. (2004).

In terms of the research onion framework, the research philosophy that underpins this work is critical realism. The selection of critical realism is a fundamental step in the process of methodological arrangement, as it orientates the selection of strategies and research procedures. The case study method has been selected as the main research strategy, along with the deductive approach and the critical realist perspective. The critical realism allows for usual language that can be used to describe the world, and therefore, philosophical positions can be judged in pragmatic terms, in terms of beliefs. According to Easton (2010):

“Critical realism is particularly well suited as a companion to case research. It justifies the study of any situation, regardless of the numbers of research units involved, but only if the process involves thoughtful in depth research with the objective of

understanding why things are as they are.” (Easton, 2010, pp119).

According to the critical realist tradition, important aspects of research are reflexivity and the dynamic nature of the world. The rationale behind the causal relationships is central stage. It is a dynamic way of conducting research that looks at the world and rethinks researchable propositions built not by a tested hypothesis per se, but as a consequence of the way that the approach used leans towards the deductive approach.

Following the language of critical realism, the cases have been conducted under specific external contingencies (Sayer, 2000)⁵. The use of case studies in critical realism demands an explanation of the cause of events; this is particularly relevant for this research as it aims to understand relationships. Critical realism alongside a case study strategy is conducted with mixed methods and cross-sectional time horizons. The next section of this chapter presents a more detailed examination of the case study research strategy. The characteristics with respect to behavioural events and their chronological dimension as commented by Yin (2003) are also highlighted.

Yin (2003) focuses on the importance of the central research questions, as they guide the selection of the most appropriate research modes. The broad-spectrum research question, presented and discussed in Chapter 1, is as follows:

- **What is the relationship between environmental regulation and auto industry technological development, commercial imperatives and wider social benefits?**

⁵ Critical realism distinguishes context and contingency: context is a very general concept. In the case of critical realism the entity should focus not only be defined but to form causal relationships. Therefore, it is understood as contingency.

4.3 - The case study

The case study has been selected as the central research strategy to investigate the appropriateness of the research propositions presented in Chapter 3. According to Easton (2010, pp.119) case research can be defined as a "...a research method that involves investigating one or a small number of social entities or situations about which data are collected using multiple sources of data and developing a holistic description through an iterative research process."

As the question is concerned with the relationships between environmental regulation, technological development, commercial imperatives and wider social benefits in the context of the automobile industry, operational links in time are important. According to Yin, case study research is more suitable when "...questions deal with operational links need to be traced over time, rather than a mere frequency or incidence."(Yin 2003, pp.18).

Case study research can provide the opportunity for the researcher to disentangle a wide range of complex causal factors and relationships. It also provides the flexibility to adapt the researched issues to specific researchable propositions. Case study research strategies can be combined with other research strategies, such as archival analysis, to maximize the potential explanatory power of the research. Bryman and Bell (2003) suggest that for the qualitative approach, a combination of methods is the best strategy. Other authors such as Yin (2003) and Saunders et al. (2000) also present this as a common practice in qualitative research. In this respect, this study has made use of a multitude of data collection methods to strengthen the analysis, and maximize the research results on the cases selected, which has been broadly termed triangulation.

The case study method and historical analysis allow a broader understanding of the relationships between environmental regulation, technological development, commercial imperatives and wider social benefits in relation to the automobile industry. The case

study is more appropriate to uncover the meaningful characteristics of ongoing events, while the historical approach, combined with archival analysis, seems more adequate for past events. History and case studies can overlap, and a combination of the two is a feasible arrangement. Historical studies are the preferred strategy when there is no access or control. The historical method, in this sense, deals with the past (Yin, 2003). The case study provides a richer source of evidence, as there is direct observation of the events being studied and the use of interviews of individuals that have been involved in the process (Yin, 2003). In conclusion:

“...the essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented and with what result.” (Yin, 2003:pp.12).

4.4 - The case study design

The research strategy of this work has been framed under the methodological structure presented by Eisenhardt (1989), with elements from Bryman et al. (2003) and Saunders et al. (2000). The work of Saunders et al. (2000) is orientated towards business studies, while Bryman et al. (2003) is more generally applied to other fields of social science. This structure has been a fundamental part in the research process. It was designed with the intent of providing the necessary framework for robust research with internal and external validity (Ghauri et al., 1995).

The methodological approach taken in this research has followed a four-step process. The steps have been defined as: the initial phase, the case studies (which include historical analysis and case study), the data analysis and the conclusion (Eisenhardt, 1989).

4.5 - The methodological tools

The case study combined with historical analysis is the core methodological tool used in this research. Understanding the different types of licenses and how they were shaped in each of the selected cases, along with the outcomes, is necessary to answer the central research questions and to draw trends for future research in the field. Having the ability to identify operational links over time is crucial. Therefore, the case studies together with historical analysis constitute the best method to understand these relations (Yin, 2003).

Cases with historical analysis are the preferred method to examine contemporary and past events such as the effects of legislation. A case study often involves data collection through a multitude of information sources, which include: documents, objects, interviews and observations (Yin, 2003; Ghauri et al., 1995). This research strategy was built around flexible data collection methods that enrich each single case study. In order to construct validity, the internal validity is crucial for this research, as it will be concerned with the causal relationship between events. The actual data collection methods have varied across the three case studies, as the intent was to find the most relevant information related to each one of the cases.

Fuchs and Mazmanian (1998) categorise the studies on the 'Greening of Industry' under the following general themes:

- Determinants of greening;
- Technology as a driving force behind greening;
- Cooperation, product changes as a method to achieve greening;
- Greening in specific industrial sectors;
- Greening programmes, and their impact on economics; and
- Financial performance.

Of these selected themes the greening in specific industrial sectors is most relevant for this work, as the automobile industry was one of the first key industrial sectors studied because of its economic importance and large environmental externalities. Fuchs and Mazmanian (1998) point to three major works identified at the time of their review: Geffen and Rothenberg (1997), Maxwell et al, (1997) and Orsato et al. (2002) that discuss the incorporation of greening ideas in the automobile industry. Other important developments in this area are discussed in Nieuwenhuis and Wells (2006). This thesis has the intent to aid the discussion of greening in the automobile industry in the context of the license to operate.

However, Gladwin (1993) has criticised the available research on the ‘greening of the industry’ pointing out the inconsistent methodological structures in most studies and consequent lack of robust findings. The greening of the industry perspective has also suffered from an implicitly optimistic view that firms will naturally evolve to a beyond-compliance state where proactive environmental measures are part of an evolved business model adopted by the firm.

The over-selection of successful case studies in the initial development of the field has not yet been overcome. The sampling of successful case studies is still a problem that needs to be taken into account. This optimistic weighting of the field needs to be counterbalanced with empirical evidence that is based not only on the most successful cases of proactive firms but on general trends in specific industries. This has been indicated by Press (2007) who advocates that research based on empirical studies take a look at the industry as a whole instead of selected firms. Fuchs and Mazmanian (1998) also indicate the need for wider sector-specific research in the field. The present study aims to help in filling this gap, providing an empirical investigation that takes a look at the entire industry.

Another criticism of the “greening of industry” body of literature is that it tends to lack longer observational periods where the short and long terms of certain policies are

already known (Press, 2007). Most of the work initially conducted focused on the willingness of managers to tackle narrowly defined environmental issues, generally end-of-pipe issues, which could be solved with creative thinking and diverse sorts of technological arrangement. However the field could benefit from a more complete analysis that understands how regulatory policy has been able (or not) to influence the process of greening, focusing not only on environmental impact but also on the business implications for firms operating in this market. This research also addresses these issues, as the long observation is necessary as the primary and secondary effects are highlighted. It is worth noting the ex-post analysis has only been possible recently (Press, 2007).

Fuchs and Mazmanian (1998) whilst providing the research necessities for the development of the field indicate the literature on the economic consequences of environmental regulation requires further development. They argue that further systematic empirical evidence is needed to support arguments on environmental regulation and economic growth. Their analysis also highlights the failure to differentiate the types of growth of greening, and the factors that would lead a firm to take up greening. In this respect, they indicate the path that should be followed by the research agenda in the field; their understanding is that new research should focus on variables that have been undervalued, including political influence and cooperation between regulators and industry.

The next section shows the development of the field in regards to the effects of environmental policy on industry behaviour. Initially the first range of studies of the 'greening of industry' coupled economic with environmental development. The following research presents a more detailed and nuanced version of the debate that emerged in this area and the most up-to-date discussions available in relevant literature.

4.5.1 - The selection of cases

A fundamental step in the process of building theory refers to the selection of cases (Eisenhardt, 1989). The intent of theoretical sampling is to opt for cases that have the potential to provide further theoretical understandings, which would contribute to the external validity of the research (Yin, 2003). The selected cases are not intended to provide a replication of observational data, as in statistical simplifying, but to give a sense of the diversity of regulation in the context of the automobile industry. The selection process of the cases has followed the preoccupations underlying this research.

The cases that have been selected constitute significant stepping-stones in the social-environmental regulation of the automotive industry. Their selection follows the rationale that these categories could be extended to a broad range of industries that have been subjected to similar social legislation. Eisenhardt (1989), following a positivistic tradition, suggests that there should be between 4 and 10 case studies to provide meaningful and convincing empirical data to generalize into theoretical development, which is a crucial element of closure success. However, other authors point out that there should not be a limit on the number of cases to be included in a study (Ghauri et al., 1995). Another important element is the trade-off between depth and the generalisability of the research analysis, taking into account temporal and structural limitations. As such this research has accommodated the need to reconcile depth with generalisability by selecting three major cases.

The focus of this research is on social regulation that has environmental implications. This broad definition of regulation is relevant when discussing historical regulation development as the terminology and discourse can be modified with changes in political salience of issues. The environmental preoccupation is nowadays a very important issue especially in developed nations. This research is concerned with regulation that has significant positive environmental impacts, even if the regulators at the time of were not focusing exclusively on the environment. The wider definition of environmental

regulation is important as regulatory measures that have been established in the past to deal with certain issues could be nowadays used to deal with environmental issues. A number of regulatory instruments, including regulation, have been initially established with other preoccupations aside from the environment. The taxation on petrol for instance was initially established as an economic instrument and nowadays could be defined as an environmental tax to reduce the aggregate demand of climate change emitting gases. The criteria for case study selection has been designed to limit the choice of cases:

- 1- Regulation must deal with a significant environmental impact generated by the automobile industry. The 'greening of industry' is concerned with efforts by industry to deal with wider sustainability concerns and the generation of negative environmental externalities by industry in general;
- 2- Ex-post implementation is also relevant to understand the impact of the legal license in the context of the 'license to operate' framework. In this sense, the cases must refer to regulation that has already been implemented so that the social, legal and economic licenses related to the implementation of the license can be identified. Ex-ante or ongoing policy implementations such as the European CO2 agreement would not respect this criterion and hence would suffer from the problems presented by Press (2007);
- 3- Policies must have required a novel response from the industry in terms of significant technological development. Technology development is a central element in the research question as it has significant impacts on the economic license to operate of the firm. In this respect, there will be identified novel issues dealt with by regulators. The case should be the first time that the industry faced the issue under those circumstances, so generally regulations that were internationally new constitute the central focus. The technological solution adopted also provided positive effects for other markets.

4 -The regulation needs to be officially established by a legal license and automakers must be forced to comply with the regulation. As a result voluntary agreements are not considered.

5 - The technological advancement concerned is relevant to a more sustainable future for the automobile industry. The criteria for sustainability are taken from the concept of greening of industry, where every effort incorporated by firms is accounted for.

The following potential cases have been considered:

- Current CO₂ European emissions regulations;
- Brazilian biodiesel program;
- United States Corporate Average Fuel Economy (CAFE) regulations;
- The European New Car Assessment Programme (EuroNCAP);
- The United Nations Commission for Europe (UNECE) Vehicle Regulations;
- The United States Clean Air Act;
- Early California air emissions regulations;
- The United States ZEV mandate;
- Brazilian ethanol program;
- European Union End-of-Life Vehicle Directive.

Out of these, three that best fit the specific criteria presented in the previous section have been selected:

1. California air emissions regulations (including the early California Emissions regulations and the ZEV mandate);
2. Brazil ethanol program - PROALCOOL;
3. European Union End-of-life Vehicle Directive.

4.6 - The case study protocol

A case study protocol has been devised to provide a better fit for the case study and the proposed theoretical contribution to the 'greening of industry' body of knowledge, as discussed in Chapters 2 and 3; it also enhances the comparability of the case studies and facilitate their combination. In this respect, the case study protocol serves as a device to enhance the reliability of multi-case study research. Following Yin (2003), the case study protocol should have the following sections:

- Overview of the case study project: outlining central issues in the case study.
- Field procedures: how the research will be conducted.
- Case study questions: specific questions that the researcher must keep in mind, providing table shells for specific arrays of data and the identification of the potential sources of information.
- A guide for the case study report: a proposed outline of the case study.
- The next sections of the chapter follow this division of case study protocol.

4.6.1 - Overview of the case study project

The first case study selected is the State of California air quality emissions regulations. The idea was to analyze the historical process of regulation from the pioneering regulations of the 1950s to the present day in order to gain an understanding of the evolution of these sets of rules. The initial group of mandates was strict command-and-control laws that forced the industry to take environmental-related measures that directly affected the way vehicles were designed. Another important measure that was established was the ZEV mandate that required the increase in Zero-Emission Vehicles (ZEVs) to be

offered by automobile manufacturers in the State of California. The mandate was eventually reviewed but it constituted an important signal to the industry of what sort of products would ideally suit future regulation. This case also provides very rich material in illustrating the dispute between the seven big automakers operating in California and the regulatory body – the California Air Resources Board. The emissions standards pioneered in California during this case became the basis for similar legal regulatory mandates in the United States and the rest of the world.

The second case study selected is the Brazilian programme to foster the use of ethanol – the Proalcool. In 1978, after the second world oil embargo, the Brazilian government decided to explicitly foster the use of sugar-derived ethanol fuel (ethyl alcohol) as a substitute for imported oil. Sugarcane-derived ethanol had always been produced in Brazil as a secondary product from the sugar industry. As Brazil had been the world's largest producer of sugar for centuries it had a large supply of this by-product. In technical terms, the ethanol programme displayed an incremental innovation from the petrol-fuelled internal combustion engine. The impact on the emerging automotive industry in Brazil was important both from a market and technological point of view. The Brazilian market had been closed to imports as the government tried to encourage the establishment of the automotive industry in the country by substituting imported vehicles with locally produced ones. This was part of a larger strategy to industrialize the country. The automakers were faced with the difficult task of developing ethanol-only vehicles based on petrol-fuelled internal combustion engines. In theory, not much had to be changed in the engines, aside from the nylon derived fuel lines. However, in practical terms, the first experiments with E100 (100% ethanol) proved to be problematic in terms of cold start, vehicle performance levels and component maintenance. These new market conditions were important factors in the emergence of a new product that provided significant market shares for the first movers that were able to gain a competitive advantage.

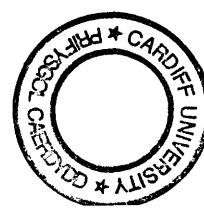
The Proalcool – the Brazilian national programme to establish the use of ethanol is not

per se an environmental regulation⁶. It was part of a larger strategy aimed at tackling a series of issues simultaneously by encouraging the use of a locally produced crop instead of imported petrol. However, for the research purposes of this study, the program will be looked as a technology-inducing mandate that focused on the adoption of an alternative locally produced fuel in contrast to the traditional imported petrol fuel. The social regulatory nature of the program is important, especially in regard to the policy instruments utilized. Moreover, the environmental impacts of the use of ethanol were significant and very positive for the populated cities of Sao Paulo and Rio de Janeiro that had historically suffered the effects of automotive emissions. The Brazilian experiment also provided important insights for the debate that emerged in the 2000s, in Europe and the United States, around the use of ethanol as an environmentally friendly fuel.

The last case that will be analyzed in this research is the European Union End-of-Life Vehicle directive. This piece of legislation is not only novel in its focus on the last part of a vehicles' life cycle but is also fundamentally innovative in the way it has introduced the 'producers extended responsibility principle' to the automotive industry. According to the European mandate, vehicle manufacturers are legally and financially liable for vehicles till the end of their lives. As a result free collection and treatment of the vehicles must be offered to the last owner. The ELV directive also provides important elements for the incorporation of sustainable development concepts into its policy making. This holistic perspective found in the EU ELV directive expands the relationship between firms and consumers beyond sales and delivery and incorporates into the cost function of firms the final destination of the product once it is no longer usable by the consumer.

The ELV directive has a wider preoccupation with material use that incorporates more complex thinking around the relationship between industry and the environment. It can still be argued that the final preoccupation is with human health; however the reasoning behind the legislation derives from a deeper environmentalist rationale. The ELV

⁶ - One aspect of the ZEV mandate was also not environmental. The idea would be to out competition the Japanese competition as they seemed to be behind in terms of EV technology.



regulation has the potential to incorporate in the regulatory system a deeper understanding of sustainability. The mandate impacts directly the design and production stages, as the vehicles need to be appropriately dismantled and treated in the ELV phase. The implications for automakers are profound, as they have to control the materials used and how the vehicles are assembled.

The cases are in this respect complementary, as they are able to provide a historical account of the evolution of the regulatory process for a specific industry and for the stakeholders involved in the process. Additionally, the case studies are illustrative of the flexibility of regulation, especially how environmental regulations can be adopted differently in specific political and local environments. They are also representative of three different regions of the world at continuous time frames where the use of the automobile has constituted an environmental and socially relevant issue. In all cases a set of regulations has been applied to correct what regulators and society perceived as market failures at that time.

From the business point of view, this is a very important issue. The global market for automobiles is run by multinational firms who tailor their products to specific regional markets (Nieuwenhuis and Wells, 2003). The selection of vehicles offered in every national market diverges depending on several variables including: the regulatory regime, international trade agreements, taxation issues, consumer tastes, road settings, climate conditions, prices, types of fuels and local cultural aspects (Williams et al., 1994). Global companies with factories distributed in a wide variety of regions are able to select which is the most appropriate and potentially profitable group of cars for each local market. The vehicles offered vary according to size, engine, options and body colours. There is a considerable difference between vehicles in Europe, United States and Latin America, which are the key markets for this research. American cars are generally larger with more powerful engines, automatic transmission and softer suspension systems, which are perceived by the American public to be more adequate for the characteristics of American roads and traffic. European cars, on the contrary, are generally smaller and

more agile; and are more likely to be diesel, and carry manual transmission. These are more suitable for European cities with narrower roads and limited parking space. In Latin America, vehicles are generally an older generation of those offered in Europe. However, several firms have designed and produced specific models that are sold only in the region, such as the Volkswagen Gol, which for several years has been one of the top selling vehicles in South America (Anfavea, 2007).

Figure 4.2 – Case Studies Selected

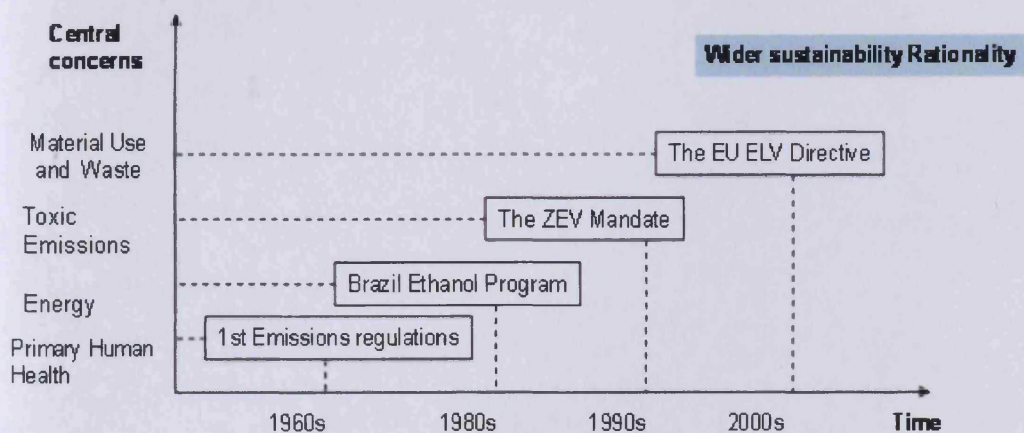


Figure 4.2 presents a schematic view of the case studies selected and their principal focus. These three regulatory mandates are all concerned with the different environmental effects of the automobile. Despite the fact that they originated in different parts of the world, there is a tendency for countries to benchmark successful regulatory experiments and incorporate foreign achievements in their own environmental regulatory systems. The historical notion that can be gained from the analysis of these regulations is important from a strategic point of view for regulators and the industry. For regulators, each different piece of legislation is put together to tackle a market failure that can presumably be corrected. Regulators can reference the most advanced legislation in order

to learn from past experience. For the multinational firms, this issue seems most relevant as firms that have successfully thrived in one market could influence regulators to adopt similar regulations in other parts of the world. Also, ideally firms may search for similar standards, which could provide economic and competitive advantages in market fluctuations and sunk cost distribution related to design, development and machinery.

The historical development of the selected cases also reflects the broader sustainable development concerns regarding the environmental impact of the automobile. It is a reflection of the change in environmental policy making that started with basic end-of-pipe measures, based on simple command-and-control measures and evolved towards a larger systems perspective (Gunningham and Grabosky, 1998).

A historical perspective on the development of automobile regulation can be gathered from the case studies selected. The development from the early command-and-control measures established in California, USA to the broader environmental preoccupations that look into a wider life cycle perspective of the product, such as the European end-of-life vehicle directive, are an important element of this research. On the left side of Figure 4.2 the central concerns of these regulations are presented; these have evolved from direct human health preoccupations to wider sustainability concerns that include concern for human health, energy use, toxic emissions and material use.

4.6.2 - Field procedures

The data collection strategy has been developed to facilitate a response to the central research question. The theoretical and practical features of each of the selected methods are presented along with a brief statement on the rationale behind the choice, along with the strengths and weaknesses of each one of them (Bailey, 1994). Aside from the critical literature on the greening of industry, a collection of data relating to each one of the case studies was carried out.

Marshall and Rossman (1989) point out a vast list of potential information sources for the case study which include amongst others: documents, interviews, direct observations, participant-observations, physical objects, films, photographs, videotapes, histories and others. Table 4.1 presents the summary of Yin's (2003) suggestions on data collection instruments.

Table 4.1 - Six sources of evidence: strengths and weaknesses

Source of evidence	Strengths	Weaknesses
Documentation	Stable, unobtrusive, exact. Can provide broad coverage, span long periods of time, many events, and many settings.	Issues with retrievability; open to reporting bias.
Archival records	Same as documentation. Precise and quantitative.	Same as documentation. Issues with accessibility due to privacy reasons.
Interviews	Focuses directly on case study topic. Insightful, provides perceived causal influences.	Response bias. Inaccuracies due to poor recall. Reflexivity, interviewee gives what interviewer wants to hear.
Direct observations	Reality, covers events in real time, contextual, covers context of event.	Time consuming. Selective, reflexivity, costly.
Participant Observations	Same as direct observations. Can provide insight into interpersonal behaviour and motives.	Same as direct observations. Bias due to investigator's manipulation of events.
Physical Artefacts	Can provide insight into cultural features and technical operations.	Selective, and issues around availability.

Source: Yin (2003).

The data collection strategy has been divided into three parts following the separation that was prepared in each of the selected case studies. Table 4.2 presents a summary of the cases and the major instruments and protocols that were used in each of the cases. The first case study conducted was the EU End-of-Life Vehicle Directive. The data collection for this case began in January 2005, with a visit to a recently established ELV facility in the Basque Country, Spain. The purpose was to gain a broader understanding of the functionality of the end-of-life vehicle sector. Therefore, using personal contacts, an open-ended interview with the facility manager was conducted. The firm called Car Recycling S.A. is the second largest ELV facility in Spain and, according to the managers, was at the time the most efficient one in terms of dismantling speed. This first visit was important to understand the mechanics of car recycling, including the process of dismantling, decontamination and shredding. Since this was a recently established facility several issues regarding the system were still being discussed with local governments and the automakers.

Table 4.2 – The data collection strategy

Data collection strategy	
Case 1 – the EU ELV directive	ELV facilities (Spain) Ford/ Cartakeback. EU Government Key Stakeholders: European government, automakers and recyclers
Case 2 – The Brazilian Ethanol Program	Visit to Ethanol Facility (Ethanol process) Brazilian Government Ethanol Producers Key stakeholders: Central government and ethanol producers, automakers
Case 3 – the CA Emissions Regulations	CAL EPA UC Davis ITS Key stakeholders: Automakers and CAL EPA.

After this prospective visit to an important ELV facility, the rest of the research in this case was conducted in the United Kingdom. A strategy was formulated following an interview with the ELV European Manager of Ford Motor Company and the company that had been contracted to take care of the Ford ELVs in this country – Cartakeback. This firm is of particular interest to the research as it signed an agreement with Ford Motor Company to collect and treat Ford brand vehicles in the United Kingdom, which included Ford, Volvo, Mazda, Land Rover, Jaguar and Aston Martin. Ford Motor Company is one of the most important vehicle manufacturers in the UK market. Another important point that could be observed during the visits is the similarity between the issues that seemed relevant for the recyclers in Spain and Britain. Interviews with managers at the Ford Motor Company and Nissan Europe were also conducted. In order to gain a further understanding of the regulatory process behind the formation of the European legislation in this area, interviews were also conducted with European officials that were involved in the creation of the ELV law.

The second case study is the Brazilian experience with ethanol. A visit to Brazil was undertaken with the intent to collect data for this case study. Using a personal contact in the Brazilian government, interviews were scheduled with technicians and policy makers that were able to provide an in depth and authoritative analysis of the development of ethanol fuel in the country. A prospective visit was also scheduled to a Petrobras biofuels refinery in the state of Bahia, Brazil in order to understand the process of refining the fuel. Open-ended interviews with policy makers were conducted in Brasilia, where the central government of Brazil is located.

The third case study was carried out in 2007 at the Institute of Transportation Studies (ITS) at the University of California, Davis. During this time, information was gathered with UC Davis and UC Berkeley academic and research staff. At the ITS, open-ended interviews were conducted with professors and researchers that had conducted consultancy work for the California government on air emissions regulation and those

who had significant publications in the area. The Director of the ITS, Professor Daniel Sperling, was the main contact, and provided valuable information on the relationships between policy makers and the automobile industry. He is presently a member of the California Air Resources Board. Other important sources of data included the California Environmental Protection Agency in Sacramento and the archival records of the California Air Resources Board.

4.6.2.1 - Open-ended Interviews

One of the tools used in each case study has been the open-ended interview. Specialists, industry representatives, governmental representatives, academics and other stakeholders have been targeted. After key individuals had been selected they were invited to take part in the research. A short list of specific questions was tailored to each case study and a pre-structured questionnaire was used to foster discussion of the specific topic. However, the interviewees were prompted to provide further information or add new aspects they felt were important for the research. In this sense, the interviews provided understanding from the perspective of that stakeholder and how they are able to comprehend the process in which they have expertise (Saunders et al., 2000).

The research has not been mainly concerned with the epistemological position of the interviewee - that is the analysis of the use of language and construction of discourse. It is relevant to note how environmental language or jargon has been incorporated into the vocabulary. The ontological position, in this sense, is more important to comprehend the understanding and interpretation that the interviewees make of environmental regulation.

It is important to be aware of the limitations of the semi-structured interview method. The characteristics of the interviewer has an impact on the responses of the interviewee. Also, the response sets play a very important role in the interviews especially in regard to the social desirability effect of each one of the stakeholders involved. For instance, managers

may portray their company as environmentally responsible and investing in cutting-edge pollution prevention and recyclables, which could seriously affect the validity of the responses. Therefore, it is important to be aware of this fact while analyzing and crosschecking the information (Bryman et al., 2003).

The list of interviews is displayed in the appendix tables at the end of the thesis. The intent was to cover a range of stakeholders. An important aspect regarding the research ethics of the interview process has been the privacy of the subjects interviewed. The principle of informed consent was respected. Guarantees of confidentiality and anonymity have been offered (Frey and Oishi, 1995). However, some of the respondents have waived this privilege and agreed to have their names displayed for the academic purposes of this study.

4.6.2.2 - Quantitative data

In order to gain further understanding of the processes taking place in each case study, quantitative data will be utilized. Quantitative data can function as an additional source of data to enhance the information provided by the qualitative analysis (Saunders et al., 2000). Industry data, car fleet data, environmental quality data will be collected in order to give a more detailed picture. Despite the fact that it constitutes a challenge to collect new data from past events, the intent was to search for records and information available in environmental agencies, government records, automotive associations and libraries in general.

4.6.2.3 - Document analysis

The analysis of documents is a fundamental factor for a researcher utilizing a historical approach to business research. Since two of the selected case studies took place in the

1960s and mid 1970s finding individuals that took part in the implementation of these regulations was not possible. The initial discussions regarding Californian air quality emissions are somewhat conserved in the Air Resources Board Library, in the California Environmental Protection Agency in Sacramento, CA. Library archives have been used as well as some of the documents of the time that described the smog problem in the Los Angeles Metropolitan Area and the initial response from the authorities. The library also has the records of the Air Resources Boards Meetings and the regulatory events that led to the constitution of the air quality emissions regulations. The most relevant documents have been recently available on line: www.arb.gov.ca/library/. Other important sources of documents for the research were the Transportation libraries of the University of California, Davis and the University of California, Berkeley. Since this issue has caused tremendous impact on local research on the air quality standards.

With regard to the Brazilian ethanol case, several libraries in Brazil were consulted: the University of Brasilia Library, the Livraria do Congresso, Biblioteca do UniCeUB, and IPEA library. Some of the earliest documents that talked about the use of ethanol for vehicles were uncovered along with the initial studies proposed by the commission that originally suggested the plan to subsidize the fuel on a large scale. These documents have been taken from the ANFAVEA Association, which is the Brazilian association of automotive producers. The ELV directive case study has mainly been researched using material available online and from the Cardiff University library on European sources, which has a wide variety of materials regarding environmental policy in the European Union.

4.6.2.4 - Validity and reliability

Following Yin's (2003) work, business management research can make use of four kinds of validity tests: construct validity, internal validity, external validity and reliability. These tests are presented in Table 4.3 that presents the case study tactics of the design

tests.

Construct validity refers to the response to the initial questions presented in the thesis. This type of comparison has been popularized by the explanation of what has been measured was actually what was initially intended in the beginning of the research (Collis and Hussey 2003). The research questions displayed in Chapter 1 are at centre stage in this research methodology and the theoretical development proposed in this study seeks to find plausible answers to them. Some authors describe this as being ‘face validity’ (Collis and Hussey, 2003) others as internal validity (Bryman and Bell, 2003), yet others as measurement validity (Saunders et al., 2000).

Table 4.3 - Case study Tactics for four Design Tests

Tests	Case study Tactic	Phase of research it will occur
Construct validity	Use of multiple sources of evidence Establish chain of evidence Have key informants review draft of the case study report	Data collection Composition
Internal validity	Do pattern –matching Do explanation building Address rival explanations Use logic models	Data analysis
External validity	Use replication logic for multiple-case studies	Research design
Reliability	Use case study protocol Develop case study database.	Data collection

Source: Yin (2003).

Bryman and Bell (2003) point out that the internal validity of a piece of research can be verified by the explanatory power of the dependent variable regarding the exogenous variables. The internal validity refers to answering the initial questions with the data that has been collected and treated. External validity is also a crucial element in business research since the investigation will be applied to other contexts and situations. In this respect, this research has been tailored to analyze the historical evolution of environmental policy design and implementation applied to the automotive industry. The conclusions have a much broader application to other regulations applied to specific industries and generalize the implementation and design of environmental regulations to other industry. Reliability ensures that the steps undertaken in this thesis could be potentially replicated by other researchers, following the same research strategy. Reliability, in this sense, minimizes mistakes and personal bias that could have been inflicted in the research collection processes and analysis by the researcher.

4.6.3 - Case study questions

The following questions have been used to guide each one of the cases:

- How important is the legal license to steer the industry towards sustainability?
- What have been the social and political factors that have led to the implementation of this policy measure?
- What technology was necessary to be applied to achieve technical advancement?
- How has the economic license been affected by the implementation of the legal license?

4.6.4 - Case study report guide

As part of the discussion of the relationship between environmental regulation, auto industry technological development, commercial imperatives and wider social benefits, in the context of the license to operate framework, it is important to contextualize the formation of the legal license. In the context of the 'license to operate', the formation of

the legal license is directly influenced by the social license and, in certain cases, may be influenced by changes in the economic license. In this sense, it is argued that it is important to clearly define the terms of each 'licence to operate' that the industry has faced in the implementation of a specific environmental policy. Therefore, the historical background is crucial to give a rich contingency.

- **Relevance of the selected legal license:**
- **The legal license:** the investigation of the legal license in itself is also important and the legal aspects that have been established may impact on the relationship between environmental regulation, automobile industry technological development, commercial imperatives and wider social benefits.
- **The economic license:** elements that have influenced the behaviour of industry towards the implementation of the regulatory mandate, including relevant aspects related to costs of research and development and impacts on the business model of the firm.
- **Social license:** aspects that have influenced regulators to establish regulation are significant. The main stakeholders will be identified, along side their position in relation to the implementation of the legal license. It is expected that different cases will have diverse stakeholders as the central ones in the discussion.
- **The effects of legal license:** the effects of the legal license are important to understand how corporate environmental performance has been modified by the changes in the legal license to operate. The effects of the legal license can take the form of social, environmental, economic or innovation effects.

4.7 - Conclusion

This chapter has presented the methodological approach that was used in this research. It points out how a combination of data collection methods was selected as the most appropriate strategy to gather information regarding the relationship between corporate

firm strategy and environmental regulation. It also justifies the use of case studies, within the framework of critical realism. The selected cases- to be discussed in the following chapters- have been the California emissions regulations, the Brazilian experience with the ethanol industry and the European Union legislation on end-of-life vehicles.

This research has the intent to understand more fully the relationships between environmental regulation, auto industry technological development, commercial imperatives and wider social benefits. As a result automotive environmental regulation is the focal point of the research and has been identified as the central element and unit of analysis.

The four underlying principles of good social research have been respected. Firstly, the analysis during the case study conduction has tried to gather as information in the selected cases. Secondly, the analysis has taken into consideration alternative approaches. Thirdly, the research looks at the most significant aspect of the cases selected and uses that information to feed into the theoretical testing process. The multiple case studies will have to show relevant information for the most relevant issue. In this sense, keeping the focus on the main important issues is fundamental to avoid going into less important aspects of the research (Yin, 2003). Fourthly, and most importantly, expert knowledge has been used to design and implement the case research methodology presented in this study. Awareness of the most up-to-date theories and the intent to build bridges between different social disciplines to create a holistic and encompassing multidisciplinary study has been used. Therefore, previous knowledge regarding the structure and the mechanics of the design and implementation of environmental policy has been very important. Additionally, the peculiar characteristics of the automotive industry and the product itself have also been relevant for this research.

Chapter 5 - US Emissions

5.1 - Introduction

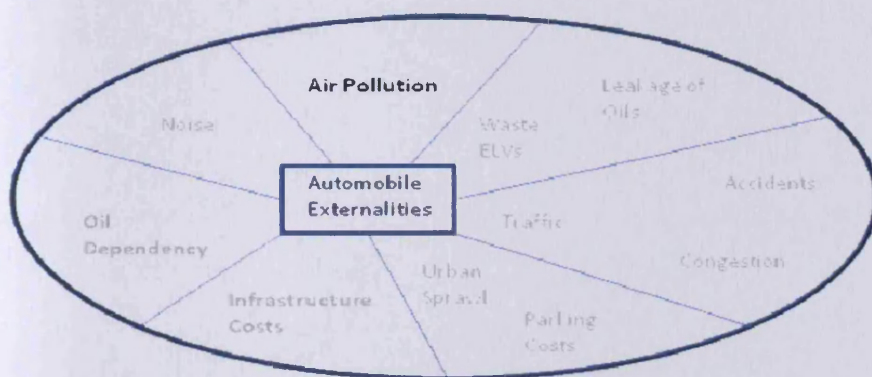
This chapter provides a historical account of the emissions regulations in the United States. Two major legal licenses are discussed: the initial air emissions regulations in California from 1950 to 1990 and the Zero Emissions Vehicles (ZEV) mandate. Both were pioneering regulations at the time that forced the adoption of novel technologies for the automobile industry and hold relevant lessons for the discussion provided in this work. The chapter follows the basic structure of the case study report as presented in the methodology; it is also divided in two major parts which refer to of the regulatory periods. The first one has a larger time frame and refers to several legal regulations imposed on the industry; it will also be analysed under a single license to operate for the period. The second part of the chapter discusses the ZEV mandate and the implications of this regulatory mandate in the context of the license to operate framework. The chapter finishes with implications for the central research question and the development of the 'greening of industry' body of knowledge.

5.2 - The relevance of this case study

The California approach to dealing with air emissions from motor vehicles is central to this research. California was the birthplace of air emissions regulations due to a combination of geographical characteristics, rapid motorisation and the enormous interest of the public authorities in solving the significant pollution episodes observed in the region (Grant, 1995). It was also the first place where motorisation started to be questioned on environmental grounds (Brilliant, 1989). The large metropolitan areas of Los Angeles and San Francisco have historically suffered greatly with smog problems,

and this is still a current environmental concern in the state because of its health implications (Brunekreef and Holgate, 2002). However, the modern air emissions problem has been improved with wider sustainability concerns being aligned with local air pollution strategies (Steiner et al., 2006). Figure 5.1 portrays the automobile environmental externalities directly addressed by the literature. The California emissions regulations have focused on local and regional air emissions from vehicles, including exhaust pipe and other emission sources, and some of the regulations that addressed more advanced engine management systems also had a significant impact on noise.

Figure 5.1 - Automobile externalities tackled by the Emission Regulation in California.



Source: Adapted from Delucchi (2003).

The pioneering action taken by Californian regulators has had important consequences for automobile firms and regulators from the United States and other countries. The original set of measures implemented in the state constitutes the foundation of automobile environmental regulation since the 1940s as it was benchmarked by not only American federal regulators but also by other countries. This leading role continues to the present day with the ZEV regulation and the low-carbon fuel standards (Farrell and Sperling, 2007). Vogel (1997) named this phenomenon of importing higher environmental quality standards and specific regulatory measures the 'California effect'.

The regulatory model adopted in California is also illustrative of the government's role in dealing with negative environmental externalities from motor vehicles, having an important effect on both firms and consumers. Aside from the environmental leadership *locus*, California also constitutes a significant market for automobile firms operating in the United States. The combination of advanced environmental requirements, economy size and highly demanding consumer preferences has made the state the testing ground for product development and consumer acceptance of new products (Professor Daniel Sperling, personal communication, 24 March, 2007). In more recent years, environmental awareness has also become an important factor shaping consumer demand, as this behaviour may stimulate a significant spill-over to other markets (Heffner et al., 2007).

5.3 - The legal license to operate in California (1950 – 1990)

In 1947, the Air Pollution Control Act was established authorising the creation of an Air Pollution Control District in every county of the state (Grant, 1995). This was based on the Los Angeles' Bureau of Smoke Control that had been established two years earlier by the Health Department. After the first smoke attack, initial assessments indicated that the source was a large Butadiene plant. The Air Districts tackled the smog problem by using measures to limit the sources of large visible air emissions. The main targets were the petrochemical refineries, coal power plants and the burning of waste. Following this, less visible sources were targeted, including paint shops, gasoline stations, boilers and incinerators (California Air Resources Board, 2008a).

Despite these measures, the smog problem persisted and the automobile became the next target of regulation. In 1950, the first legal license directly aimed at the automobile industry was established. Rule 50A was introduced which limited smoke based on the

Ringelmann System⁷ and in 1959 pollution was legally typified as a health hazard (Killion and Ferrier, 2004). California's Department of Public Health was able to institute acceptable air quality levels for humans and in the following year, the Motor Vehicle Pollution Control Board was established, with the objective of establishing air emissions standards for automobiles (Krier and Ursin, 1977).

The legal license became tighter with the implementation of the Positive Crankcase Ventilation⁸ requirement of 1961 that came into effect on domestic passenger vehicles for sale in the state (Killion and Ferrier, 2004). The first automotive emissions control technology in the nation, Positive Crankcase Ventilation⁹, was brought in by mandate by the California Motor Vehicle State Bureau of Air Sanitation to control hydrocarbon crankcase emissions. This was established for domestic vehicles sold in California in 1963 (California Air Resources Board, 2008a). In 1964, the Chrysler exhaust control system was approved by the Motor Vehicle Pollution Control Board and four other independent companies also received approval. On the federal level, the 1963 Clean Air Act provided enforcement power over interstate pollution (California Air Resources Board, 2008b).

In 1966, tailpipe exhaust emission standards for Hydrocarbons - HC and Carbon Monoxide - CO were adopted by the California Motor Vehicle Pollution Control Board and exhaust control devices on all new cars were required. A year later, the California Motor Vehicle Pollution Control Board and the Bureau of Air Sanitation and its Laboratory were merged, creating the California Air Resources Board - CARB. Professor A. J. Haagen-Smit, after his pioneering academic work on air emissions (Haagen-Smit, 1950; Haagen-Smit et al. 1952a, 1952b), was appointed Chairman of this Board by

⁷ - The Ringelmann system was developed by the French Professor Maximilian Ringelmann. It consists of a scheme where shades of grey are presented in five phases that can be reproduced by means of a rectangular grill of black lines of definite width and spacing on a white background (US Bureau of Mines, 1967).

⁸ - Positive Crankcase Ventilation : relates to a means for ventilating the crankcase of an internal combustion engine, and more particularly, to a system connected between the crankcase and inlet manifold of an internal combustion engine whereby fumes and vapors within the crankcase are drawn into the system, filtered by the system, drawn into the inlet manifold and ultimately passed into the combustion chambers of the engine where the fumes and vapors are oxidised (Roper, 1965).

⁹ Positive Crankcase Ventilation withdraws blow-by gases from the crankcase and returns them with fresh air and fuel mixture in the cylinders (crankcase blow-by produced 25 percent of the engine's hydrocarbon emissions at this time).

Governor Ronald Reagan and the first meeting of the State Board was held in Sacramento on February 8, 1968 (California Air Resources Board, 2008a).

Table 5.1: California and Federal Exhaust Emission Standards for Passenger Cars (g/mi)

Year	HC		CO		NOx	
	Fed	Cal	Fed	Cal	Fed	Cal
uncontrolled	8.7	8.7	90	90	3.4	
1966		4.3		44		
1967		4.3		44		
1968	4.1	4.3	34	44		
1969	4.1	4.3	34	44		
1970	4.1	2.2	34	23		
1971	4.1	2.2	34	23		
1972	3.0	1.5	28	23		3.0
1973	3.0	1.5	28	23	3.1	3.0
1974	3.0	1.5	28	23	3.1	2.0
1975	1.5	0.9	15	9	3.1	2.0
1976	1.5	0.9	15	9	3.1	2.0
1977	1.5	0.41	15	9	2.0	1.5
1978	1.5	0.41	15	9	2.0	1.5
1979	1.5	0.41	15	9	2.0	1.5
1980	0.41	0.41	7.0	9	2.0	1.0
1981	0.41	0.41	3.4	7	1.0	1.0
1982	0.41	0.41	3.4	7	1.0	0.4
1983	0.41	0.41	3.4	7	1.0	0.4
1984	0.41	0.41	3.4	7	1.0	0.4
1985	0.41	0.41	3.4	7	1.0	0.4
1986	0.41	0.41	3.4	7	1.0	0.4
1987	0.41	0.41	3.4	7	1.0	0.4
1988	0.41	0.41	3.4	7	1.0	0.4
1989	0.41	0.41	3.4	7	1.0	0.4
1990	0.41	0.41	3.4	7	1.0	0.4
1991	0.41	0.41	3.4	7	1.0	0.4
1992	0.41	0.41	3.4	7	1.0	0.4
1993	0.41	0.41	3.4	7	1.0	0.4
1994	0.41	0.25*	3.4	1.7-3.4*	0.4	0.2-0.4*
1995	0.41	0.231*	3.4	1.7-3.4*	0.4	0.2-0.4*
1996	0.41	0.225*	3.4	1.7-3.4*	0.4	0.2-0.4*
1997	0.41	0.202*	3.4	1.7-3.4*	0.4	0.2-0.4*
1998	0.41	0.157*	3.4	1.7-3.4*	0.4	0.2-0.4*
1999	0.41	0.113*	3.4	1.7-3.4*	0.4	0.2-0.4*
2000	0.41	0.073*	3.4	1.7-3.4*	0.4	0.2-0.4*
2001	0.075*	0.07*	1.7-3.4**	1.7-3.4*	0.2-0.4**	0.2-0.4*
2002	0.075*	0.068*	1.7-3.4**	1.7-3.4*	0.2-0.4**	0.2-0.4*
2003	0.075*	0.062*	1.7-3.4**	1.7-3.4*	0.2-0.4**	0.2-0.4*

*- Fleet average of non-methane organic gases (not total hydrocarbons)

** - Emissions standard varies depending on certification levels TLEV, LEV or ULEV.

Source: Chen *et al.* (2004).

The Federal Air Quality Act of 1967 was then enacted which established a framework for defining 'air quality control regions' based on meteorological and topographical factors. California, being at the forefront of the regulatory pressure, was allowed by the federal government to enforce its own standards (California Air Resources Board, 2008a) and in 1969, the first state Ambient Air Quality Standard was promulgated by California for total suspended particulates, photochemical oxidants, sulphur dioxide, nitrogen dioxide and carbon monoxide.

According to Crandall et al. (1986), the federal legislators established a 95% reduction goal for hydrocarbons, compared to the pre-1968 model and a 90% decrease for nitrogen oxide emissions from the 1970 model by the time of the 1976 model year. An amendment to the 1970 Clean Air Act allowed for further reductions and enabled the Environmental Protection Agency (EPA) to set standards for new automobiles and other motor vehicles concerning pollutants. However, the automobile industry went against the implementation of the legal license, and requested several delays (Gerard and Lave, 2003). These are discussed in the next section. Table 5.1 provides a comparison between the federal and the Californian standards, showing the stricter standards of the latter.

The introduction of the oxidation catalytic converter in 1975 helped to improve fuel economy as well as to reduce emissions, and electronic engine control later added another layer of technology (California Air Resources Board, 2008a). Additionally, the first two-way catalytic converters came into use as part of the Motor Vehicle Emission Control Program of the California Air Resources Board (CARB) and in the following year, ARB limited the amount of lead that was present in gasoline which was highly pollutant.

The 1980/81 standards required a minimisation in the nitrogen oxide, which made a drastic difference to the automotive manufacturers' costs. The converter had to operate using a more complex system to keep the composition of the exhaust gases within the close range of the efficiency levels. Designing new pollution prevention features for a new engine is more efficient than adapting existing ones; the addition of extra features to

an old engine creates cost increases, but by incorporating the equipment as part of the entire cost, such costs can be diluted (Crandall et al., 1986).

Crandall et al. (1986) also indicated that the ARB rapidly realised that the strategy of regulating only new vehicles was flawed as there was a lack of a proper assessment systems to control emissions, there being no compulsory inspection or maintenance measures that the owner of the vehicle had to comply with. In this sense, the regulatory system made the manufacturers focus on the improvement of the new vehicle and not on its long-term reliability. Hence, in 1984, California instigated the Smog Check Program, which was designed to spot on-going vehicles with emissions problems by establishing regulatory control. However, the smog check program was called a failure as it failed to reduce the expected emissions (Glazer et al., 1995). Lawson (1993) indicates that part of the failure of the overall reduction in air pollution caused by the smog check programs was because of the oversights regarding human behaviour; motorists have taken steps to pass the test and high-emitting vehicles idle-emissions performance and tampering rates in the roadside surveys are unaffected by the Smog Check test (Lawson, 1993).

The Phase I California exhaust standards were also followed at federal level. However, the federal government (under the administration of George W. Bush) explicitly opposed the California Phase II exhaust standards for 1996. Therefore, the regulatory focal point switched from cars to fuel so that alternatives including reformulated gasoline, methanol, ethanol and natural gas started to be discussed. The industry along with the federal government also proposed specific vehicles that could be offered for transportation in larger cities (Professor Daniel Sperling, personal communication, 08 March, 2007).

5.3.1 - The economic license to operate (1950-1990)

Automobile firms have taken a general non-cooperative stance towards air emissions' regulation in the State of California and on the federal level. The 1972 and 1975

regulations were fiercely challenged by the three large American automobile firms, General Motors, Ford and Chrysler. The main argument presented by the industry to oppose the implementation of air emissions was the recession caused by the first oil crisis, and the regulations would impose a prohibitive cost on the automobile firms. The new regulations would also require large investments and the loss of already existing assets. The firms further argued that the increase in manufacturing costs would have little impact on the quality of the vehicles produced, and would not positively influence the demand for new vehicles (Chen et al., 2004). The explicit opposition of the industry alongside the lobby on the state and federal levels led to a number of delays in the implementation of the proposed emissions requirements. Gerard and Lave (2003) provide a description of the timetable of delays (see Table 5.2).

In 1975, The Environmental Protection Agency was able to add a one-year delay to the standards under the understanding that car firms provided evidence that they had attempted to meet the standards. The requested delay, however, was not given as the EPA considered that firms could have met the standards by this time. In response, four car firms sued the EPA and the Court of Appeal ruled in their favour, with the result that Congress eventually extended the deadline for a further three years in 1977 (Doyle, 2000).

Table 5.2 - Timetable of delays

December 31, 1970	Clean Air Act Amendments direct EPA to set standards and federal test procedures
June 23, 1971	EPA sets standards for the 1975 Model Year
January 1, 1972	NAS issues report suggesting technology to meet standards is not yet available
March 13, 1972	Volvo requests delay of standards. Other automakers follow suit, including the Big Three on April 5
May 12, 1972	EPA denies extension
December 18–19, 1972	D.C. Court of Appeals hears automakers appeal and remands the case back to EPA for further investigation (<i>International Harvester v. Ruckelshaus</i>)
December 30, 1972	EPA issues supplement to Decision of the Administrator
February, 1973	D.C. Court of Appeals again remands (<i>I.H. v. Ruckelshaus</i>)
April, 1973	EPA delays in HC, CO standards
June, 1973	EPA delays NOx standards
June, 1974	Congress extends interim HC, CO standards to 1977 and NOx to 1978
February, March 1975	EPA extends interim HC, CO standards to 1978 in response to concerns about sulphate levels
August, 1977	Clean Air Act Amendments push interim HC to 1980 and CO, NOx standards to 1981

Source: Gerard and Lave, 2003.

The opposition of the car firms was also due to the fact that they had been able to operate in a free market for many years and were suddenly faced with environmental pressures

from regulators to adapt their product to a reality that the vehicles were not originally designed for. For the car firms, regulators did not take into account the product planning cycle, which ranged from five to seven years at this time (Chen et al., 2004). Chrysler, the smallest of the American firms, was the most outspoken about the negative economic effects of environmental regulation on their business model. Several public releases were sponsored by the firm, which considered that the adoption of identical standards for all firms was unfair as they would have to pay a larger proportion of the costs (Chen et al., 2004).

Despite the opposition and relative gain with the delays, the industry was not able to stop the implementation of the requirements. In order to meet the new standards, car manufacturers chose to add mechanical complexity to the already existing engines¹⁰ and the catalytic converter was the chosen solution, as it could be used with the existing engine technology. This also contributed to the fuel economy, which was an important issue at the time, and by 1975, 85% of new vehicles were fitted with the equipment¹¹; when the NOx requirement was introduced in 1981, the three-way catalytic converter was also introduced (California Air Resources Board, 2008a).

At this time, the American automobile fleet suffered an important transformation since the dominance of the American firms started to be threatened by foreign competition. The Big Three (General Motors, Ford, and Chrysler) had traditionally focused on larger and heavier vehicles and their business model was based on low compression engines and automatic transmissions. However, this product line-up only made sense where there were cheap oil prices and, significantly, the environmental effects of these vehicles were largely ignored, as the industry mainly opposed any limits on exhaust emissions. In addition to this, foreign competitors (mainly from Japan and Europe) began to offer smaller, lighter and more economical vehicles. These problems, along with the

¹⁰ - Other strategies could have been the use of lightweight materials to reduce the overall weight of the vehicles or to incorporate other elements. An exhaust pipe measure was perceived as the most appropriate technical solution at the time.

¹¹ - The rest used rotary – Mazda, or stratified charge engine - Honda (Chen et al., 2004).

consequences of rising of oil prices in the 1973 and in 1978, had a drastic economic effect on American car firms and brought about a huge reduction in demand in US-made vehicles which provided additional pressures over the economic license to operate (Mondt, 2000).

5.3.2 - The social license to operate (1950-1990)

The first smog incidents in the Los Angeles metropolitan area were registered in 1940. Smog is characterised by yellow and grey polluted air that causes eye irritation and has a negative visual effect¹². In the summer of 1943, the city of Los Angeles experienced the first harsh incidents, the “gas attack”. This episode constituted a major event in the state that directly influenced the formation of the social and the legal licenses. Here, public authorities were pressured by the population and media to remedy the situation.

A large percentage of people that lived in LA had moved from other parts of the country after the World War II searching for favourable labour opportunities and living conditions. The weather was part of the Californian Dream. The reality, however, presented itself in a very different picture. (Professor Robert Kagan, personal communication, 12 April 2007).

Kagan understood that the public pressure to have clear air alongside the visible health effects for the population of California provided the necessary social pressure for policy makers to initiate the constitution of legal licenses. The social pressure to have clean air also generated academic research which eventually identified the automobile as one of the main sources of air emissions (Kagan, 2001).

Professor John Middleton showed that the damage to plants was not caused by exposure to SO² and the atmospheric processes occurring involved oxidation not reduction

¹²

- The term ‘smog’ was originally defined in 1905 by Dr. H.A. Des Voeux of London’s Coal Smoke Abatement Society as a combination of Smoke and Fog.

(Middleton et al., 1950; Middleton et al., 1961). This was a feature that was specific to California, making this type of smoke different from other studies on London smog (Gaffney and Marley, 2009). Dr. Arie Haagen-Smit along with colleagues from Caltech, pioneered academic investigation into the problem, and defined the chemical composition of smog. According to their conclusions, nitrogen oxides and hydrocarbons exposed to sunlight produce the photochemical smog, which was measured by the damage to vegetables. They exposed plants to photochemical products of nitrogen dioxide (NO₂) and gasoline exhaust containing hydrocarbons in laboratory reproducing the causes of the smog problem (Haagen-Smit, 1950; Haagen-Smit et al., 1952a, 1952b). The main feature of the Los Angeles smog is that it is a 'photochemical smog' such as the solar photolysis (Stephens, 1987). This investigation was central to the development of various emissions-control technologies and was used to back up the ARB rule making.

The general public gradually became more concerned with wider sustainability preoccupations. Initially, the concern with environmental degradation was linked to direct human health and aesthetic issues. (Brillant, 1989; Mondt, 2000). However, this preoccupation did not challenge the rise of the automobile as a modern icon and California has been very influential in forming the modern culture of automobility. The automobile therefore represented part of the modern cultural identity that influenced other American states and regions of the world (Sacks, 1992). However, with the development of the environmental movement in the States, the public became more concerned with wider environmental issues and more prone to supporters of stricter measures on the automobile industry. In the 1960s, the social license was shaped by books of critical journalism that informed the public of the dangers of the automobile, including safety preoccupations (Nader, 1966) and pollution issues (Edelson and Warshofsky, 1966). These books on the negative externalities of the automobile followed the same line of criticism pioneered by Carson (1962).

5.3.3 - The effects on the environmental performance of the industry from the early emissions regulations.

The emissions regulations, from 1940 to 1990 produced significant positive environmental benefits. In the State's most populous area, Los Angeles's South Coast Air Basin, carbon monoxide, NOx emissions, volatile organic compounds, alongside ozone levels, declined sharply. The positive effect had been noticed by the amount of smog alerts observed. In 1977, the South Coast Air Basin had 121 Stage 1 smog alerts¹³. The number of Stage 1 alerts dropped to 66 in 1987, one in 1997 and there have been no Stage 1 alerts since 1997. There have also been no Stage 2 alerts (.35 PPM ozone) in the South Coast Basin since 1988, when there was just one. Most other areas of California have also made significant progress in reducing smog. However, smog is still a problem that has not been completely tackled (U.S. Environmental Protection Agency, 2008).

Table 5.3 – Reduction in air pollutants in California highways

Source category	1970	1980	1990
Highway vehicles Carbon Monoxide - (million short tons)	163.23	143.83	110.26
NOx Emissions from Highway Vehicles (million short tons)	12.64	11.49	9.59
Emissions of Volatile Organic Compounds from Highway Vehicles (thousand short tons)	16,911	13,869	9,388

Source: U.S. Environmental Protection Agency (2008).

¹³ A Stage 1 smog alert is called when ozone levels reach .20 parts per million (PPM).

5.4 - The Zero Emissions Vehicles Program (ZEV) legal license.

In September 1990, the California Air Resources Board established the Zero Emissions Vehicles (ZEV) Program, also called the LEV-I legislation (California Air Resources Board, 1990). The regulations stipulated that a minimum percentage of the new vehicles sold in the State would give no air emissions. The ZEVs were identified as vehicles that would have: 'No tailpipe emissions, no evaporative emissions, no onboard emission-control systems that can deteriorate over time and no emissions from gasoline refining or sales' (California Air Resources Board, 1990).

The original ZEV program was initially intended to be applied to the 1994 model vehicles in California. In order to do this, various emissions categories were established not only for passenger cars, but also for light duty trucks¹⁴. Automobile producers had to comply with several levels of stringency that were directly proportionate to sales and the fleet average emission rates. The original mandate set up a minimum of 2% ZEVs by 1998, with growing percentages for the years of 2001 (5%) and 2003 (10%) respectively. Tradable credits were also established with a US\$5,000 fine for each vehicle not made available for sale (California Air Resources Board, 1991a).

Regulators set up legislation in such a way that reasonable flexibility was offered on how the ZEV requirements could be attained. In this respect, legislators did not pick a fuel or power-train technology since several options were available to automobile firms, including: battery-powered electric vehicles, fuel-cell vehicles, compressed air vehicles and any other technology that could be classed as ZEVs. However, the electric power-train technology was generally considered the most feasible alternative at the time. General Motors (GM) for instance, possessed a fully operational version of a battery-powered electric plug-in vehicle – the Impact. Several other models were in the initial stages of development by the US Department of Energy – DOE hybrid/ Electric program. In fact, GM announced the intention of producing the Impact before the LEV-I legislation

¹⁴ ARB defined the types of cars as: passenger cars, light duty trucks and heavy trucks. The analysis of this thesis is based on passenger cars, as the proposed studies are focused on passenger cars.

had been established in California (Shnayerson, 1996). This suggested to CARB that a ZEV was possible. However, the American automotive industry reacted negatively to the LEV-I legislation; the automobile firms claimed that the technology related to electric cars was not economically feasible and a great deal of research and technology development was still necessary to make the ZEVs a competing alternative to the internal-combustion engine (Sperling, 1995). In order to enhance the economic feasibility of electric vehicles, another business model based on car leasing instead of direct car sales was implemented. Automobile manufacturers also argued that there was not a strong demand for such products. As a consequence, the automotive industry directly opposed the LEV-I legislation and sued the California regulators (Collantes, personal communication, 13 May 2007).

Following the planned biannual review of the LEV legislation and the opposition of the automakers in 1996, the ARB eliminated the ZEV sales requirements for the model years 1998 and 2001. This had been a change in position for CARB that took a less confrontational approach (Kemp, 2005). The ZEVs requirement was retained for 2003 with an exchange of a Memorandum of Agreement between the ARB and seven big automobile firms (General Motors, Ford, Daimler-Chrysler, Honda, Mazda, Nissan and Toyota). In the agreement, the automobile firms agreed to increase the research and development of ZEV-related technologies, and to produce a minimum of 3,750 battery electric vehicles from 1998 to 2000 (California Air Resources Board, 1996).

In 1998, further modifications were set up with the introduction of a new category of ZEVs - the P-ZEV. These were defined as very low emissions vehicles powered by compressed natural gas, gas-electric hybrid and methanol fuel cells. The introduction of this category added more flexibility to the automakers' portfolio as 6% of the 10% requirement of the ZEVs could be compensated with the PZEVs (Collantes, 2006).

In 2001, greater flexibility was implemented and the minimum requirement of pure ZEVs was reduced from 4% to 2% of total sales (California Air Resources Board, 2001). Aside

from this, legislators also instituted the following modifications:

- P-ZEVs could account for one fifth of the 10% requirement;
- ZEVs credits could be given to demonstration projects (including the California Fuel Cell Partnership);
- Other types of vehicle, such as SUVs, pick-up trucks and vans, could also count for the ZEV requirement;
- The ZEV requirement would be increased to 10% in 2003 and 18% in 2018.

In 2002, the automakers filed another lawsuit against the board. The preliminary federal injunction prohibited the Board from enforcing the 2001 ZEV amendments with respect to the sale of new motor vehicles for the model years 2003 and 2004. In response, the board offered to introduce a new set of modifications to the regulations and the minimum technical requirements, and the automobile firms agreed to end the litigation (California Air Resources Board, 2003).

As a result, the CAL Environmental Protection Agency staff proposed additional modifications. Following the data gathered in a major technology symposium with all the stakeholders involved and a report of an independent expert review on the status of ZEV technologies, changes were recommended for the 2009 model years (California Air Resources Board, 2010).

The new set of modifications was approved by the board at the March 2008 hearing and these affected the 2009 and 2015 model years. Table 5.4 introduces the timetable of delays.

Table 5.4 - Timetable of delays in the ZEV mandate

1990	Zero Emission Vehicle (ZEV) Program was introduced by the California Air resources board. The original requirement predicted in 1998 was that 2% of the vehicles that large manufacturers produced for sale in California had to be ZEVs, increasing to 5% in 2001 and 10% in 2003.
1996	The ZEV mandate had its first modifications as the “ramp up” was eliminated. The 10% ZEV requirement for 2003, and again in 1998 to allow partial ZEV (PZEV) credits for extremely clean vehicles that were not pure ZEVs.
2001	The 2001 modifications allowed large manufacturers to meet their ZEV requirement with 2% pure ZEVs, 2% Advanced Technology PZEVs and 6% PZEVs.
2002	Due to a lawsuit filed against the Board, a federal district judge issued a preliminary injunction that prohibited the Board from enforcing the 2001 ZEV amendments with respect to the sale of new motor vehicles in model years 2003 or 2004. Once the Board adopted the 2003 Amendments to the ZEV regulation, the parties to the lawsuits agreed to end the litigation.
2003	Modifications to the ZEV regulation were introduced to address the preliminary injunction and better align the program requirements with the status of technology development.
2006	A Technology Symposium was held at CARB. An Independent Expert Review Panel submitted their report on the status of all ZEV technologies assessing the present level and cost of technological development.
2007	The Board determined that staff should recommend changes to the regulation for the 2009 and subsequent model years, following the conclusions from the Technology Symposium and the Independent Expert Review Panel.
2008	The CARB adopted further modifications in the March 27, 2008 hearing. The Board also directed staff to redesign the ZEV Program so it would affect the 2015+ model years.
2009	The 2008 amendments to the ZEV Regulation became effective. A second ZEV

	Technology Symposium took place in September, and an informal update to the Board was conducted by the staff in December.
2010	Staff could return to the Board with regulatory changes to the ZEV Regulation.

Source: California Air Resources Board, 2010.

The 2008 amendments that became effective in 2009 are displayed in Table 5.5. The new arrangement was based on more ZEV categories, which included a new type of AT PZEV - the enhanced AT PZEV. This is a vehicle that uses hydrogen or electricity as an energy source. Examples of this category are the hydrogen internal combustion engine vehicles and plug-in hybrid electric vehicles. In addition, the board also lowered the number of required ZEV vehicles for 2012-2014 and set the Enhanced AT PZEVs to meet a portion of the ZEV requirement. Enhanced AT PZEVs can now be used to meet up to 70% of the requirement from 2012 to 2014 and up to 50% from 2015 to 2017 (California Air Resources Board, 2008b).

The categories of ZEVs have been divided into 6 types according to the powertrain technology and mile range. Table 5.6 shows the ZEV types predicted by the legislation along with the core definition and example of the vehicle.

Table 5.5 – Categories of vehicles for the ZEV Legislation (March 2008).

Category	Acronym	Technology	Number of Vehicles placed (between 1994 and 2006)
Gold	ZEV	Battery, Hydrogen Fuel cell	Fuel cell 160 ZEV Battery electric 4,400 Neighbourhood electric 26,000
Silver Plus	Enhanced AT PZEV	AT PZEV using a ZEV fuel such as electricity or hydrogen. - are hydrogen internal combustion engine vehicles and plug-in hybrid electric vehicles.	-----
Silver	AT PZEV	Hybrid, compressed natural gas, methanol fuel cell	Hybrid, or Compressed Natural Gas 109,000
Bronze	PZEV	Extremely clean conventional vehicle with extended warranty and reduced evaporative emissions	Conventional 672,000

Source: California Air Resources Board (2008b)

One of the most visible indicators of the growing flexibility that was offered to the automobile firms is the new credit system that was used to calculate the minimum requirements with which each automobile firm has to comply. The firms can opt to adopt one or a combination of types of ZEVs. The credits area - which is directly proportionate to the type of vehicles - is displayed in Table 3. The Air Resources Board (2008b) has also offered an illustrative example for the 2012-2014. According to this, the gold

requirements can be met with IV ZEV type (25,000 vehicles) or a combination of IV ZEV (7,500 vehicles) and Enhanced AT PZEVs (58,333). These projections are based on estimated sales of 1.4 million cars per year.

Table 5.6 - Categories of Zero Emission Vehicles - ZEVs.

ZEV Type	Definition	Example
Type 1	Electric Vehicle with 50-75 mile range	Limited range battery EV
Type 1.5	Electric Vehicle with 75-100 mile	City Electric vehicle
Type II	Electric Vehicle with 100-200 mile range	Full Function Battery EV
Type III	100+mile electric vehicle with fast refuelling or 200 mile battery mile battery EV	Fuel Cell or Battery EV
Type IV	200+mile electric vehicle with fast refuelling	Fuel Cell
Type V	300+ mile electric vehicle with fast refuelling	Fuel Cell

Source: California Air Resources Board (2008b)

5.6 - The economic license to operate

Since the Zero Emissions Vehicle Mandate – (ZEV mandate) was part of the larger Low Emission Vehicle Program-LEV¹⁵, the attention of the automobile industry was focused on the discussion of LEV requirements. The Zero Emissions Vehicle Mandate – ZEV requirement would only be established at a later date, in 1998, which would give the industry time to come up with a debate over the requirements of the legal license.

¹⁵ - The ARB first adopted LEV standards in 1990. These first LEV standards ran from 1994 through 2003. LEV II regulations, running from 2004 to 2010, represent continuing progress in emission reductions.

However, it is important to indicate that the general perception of the industry was to fight the regulatory intervention, but some firms in the American industry perceived that the regulation could be an opportunity (Sperling, personal communication, 10 March 2007).

The main automobile firm that understood the opportunity for a good negotiation with ARB was General Motors (GM). The latter had been involved in the development of battery electric vehicles since the first government-led initiatives that started with the Electric and Hybrid Vehicle Development and Demonstration Programme (EHVDD) and was sponsored by the Department of Energy (DOE) in 1974. This program later evolved into the U.S. Advanced Battery Consortium (USABC) and the Advanced Lead-Acid Battery Consortium (ALABC) was later formed in 1991 and 1992. The development of advanced batteries was the key technological constraint for automobile applications established by the Department of Energy (United States Department of Energy, 2006).

The management of General Motors was very optimistic about the potential developments that could be achieved in the battery technology. For them, General Motors would mass-produce electric vehicles by the time ARB established the regulatory necessity profitably (Shnayerson, 1996). At the time GM had the electric impact program, which was a development of the 1987 Sunraycer that won the first 2,000 mile solar car race in Australia. GM's Chairman, Roger B. Smith, publicly announced that GM was pushing the research and technology still needed to mass produce the electric vehicle (Risen, 1990). In January 1990, GM publicised that their prototype accelerated from zero to 60 m.p.h. in 8 seconds and was equipped with a 124-mile range between battery recharging, making the electric car comparable to the internal combustion counterparts (Los Angeles Times, 1990). In a scenario without the mandate, GM perceived that 0.5% of the market could be captured with the Impact vehicle. GM also noted a competitive advantage with other car makers that needed to reach the 2% target. This at the time was not an easy task to achieve especially because the others were behind in R&D for this niche market. However, GM realised that the figure of 2% was still high

and could be further reduced in the biennial reviews already planned in the ZEV proposal (Collantes, 2006).

General Motors also perceived that there was relative leverage with regard to opportunities to negotiate specific requirements of the legal license. Thus, GM accepted the negotiation on the regulation with the various sales-weight averages, the lead time and the biennial reviews that were part of the regulation (Johnson, 1999). The publicity gathered by GM with the Impact¹⁶ was very important and part of a strategy to gain larger market in the US. Showing technology leadership was a key attribute that GM wanted to display to consumers and to be recognised, since the GM management wanted to re-invent its business model. The new electric vehicle program brought fresh business thinking in the form of alternative ways of integrating the various parts of the company and different business models to bring about more profit (Johnson, 1999). Within General Motors, certain divisions welcomed the ZEV mandate, as the ARB requirement would justify the investments in R&D in unproven technology (General Motors USA Representative, Personal Communication, 04 May, 2007).

In 1996, GM finally launched the Impact vehicle under the name of EV1. The car was a two-seater sports compact. The performance levels were acceptable with 0–60 mph (0–97 km/h) acceleration time at less than 9 seconds and a top speed of 80 mph. In ideal conditions, the range of the electric pack was 90 miles on the motorway and 70 miles in city traffic. Despite attempts to use alternative materials and body structure design, the weight was 2,970 pounds with 1,175 pounds of battery (General Motors Corporation, 1997). Initially, the learning experience phase was launched and the vehicles were given to particular utilities firms to test drive the vehicle in real life situations (Johnson, 1999). From then on until 2000, the EV1 was leased in Saturn dealerships, but only in the states of California and Arizona and around 600 vehicles were leased.

¹⁶ - Early GM "Impact" prototype was later renamed the EV1. General Motors built about 1,100 vehicles. Nearly all have now been destroyed, with a handful held by GM for test purposes and a small number of non-functioning models donated to various universities and museums in North America.

The other two large American firms had a different position. For them, the environmental pressures with the perceived technological leadership of GM in the field of battery electric vehicles development led to their full-blown opposition to the LEV and ZEV Mandate. Some even noted that the Impact had been oversold to the ARB, who did not have any other information aside from the optimistic vision of some of the GM executives. These firms also saw that the mandate had a strong political appeal in California, which was using some of the press releases of GM indicative of the technological development achieved with the Impact. CARB gained confidence and realised that the mandate had feasible targets, and could be defended politically. Moreover, the Impact was the centre of attention of many newspapers (Collantes, 2006).

CARB had taken a unilateral move toward regulation. The approach had traditionally been based on technology forcing, but automobile makers would have preferred to build a collaborative approach where the technological information would be negotiated between them. The automakers were also not satisfied with the approach of establishing a new technology alongside the volume and schedule. The three elements were perceived as harsh (CARB, personal communication, June 2006).

The industry perceived that there could be other ways of achieving the reduction in air emissions as dictated by the ARB, with alternative measures that did not break away from the traditional business model of the firms as the cost effectiveness of the ZEV mandate was not quantified, and other options had not been assessed (Collantes, 2005). The industry therefore indicated that the resources spent on the development of battery packs could be better spent in further developing the internal combustion engine (Professor Allan Lloyd, personal communication, 15 May 2007).

California Air Resources Board followed the perception that certain General Motors managers had pushed the mandate forward. In fact, ARB did not take the time to analyse the detail of the economic feasibility of electric vehicles (CARB Staff Representative,

personal communication, 11 June 2007). Additionally, the cost of technology development and vehicles to the public, the performance limitations that the technology would impose to the consumer and other relevant issues had not been properly assessed. Furthermore, the ARB did not know whether the Californian consumer would be willing to pay a premium to have all-electric cars and accept lower levels of performance and range.

5.7 - The social license to operate

The following social stakeholders have been identified as forming the legal license: oil companies, government agencies, government, public entities/energy entities, the electric-drive industry, environmental NGOs, academia and consumers.

The oil companies had a direct influence against the implementation of the ZEV. Calef and Goble (2005) indicate that the basic strategy taken was through monetary contributions of the oil companies to legislative candidates. The oil industry lobbied several state assembly members and senate members to pressure the air resources board and presented a paper to fight the ZEV mandate. This paper was submitted by ARCO and indicated the problems of fostering electric vehicles.

In the 1996 biennial review, there was evidence of the oil industries' investment in the policy process. WSPA joined forces with the American Petroleum Institute (API) opposing the mandate, arguing for the elimination of the ZEV requirement for 2003. They opposed any subsidies for the formulation of subsidies for electric vehicles as well as subsidies for specific products or industries (Western States Petroleum Association - WSPA, 1996). The oil industry also questioned the ARB's statutory authority to regulate emissions standards, and queried the economic and technological feasibility of the measures. It was against subsidies for battery electric development, and claimed that there would be negative effects on the state-level economy. 'WSPA does not oppose the manufacture and sale of electric cars which are developed in a free market...but there is

no justification for ARB to mandate technologically unproven EVs which are neither competitive nor cost-effective, and which rely on subsidies to be marketable' (WSPA, 1996, pp. 3).

The environmental community did not have a direct influence on the initial stages of the ZEV mandate. However, in 1998 a ZEV alliance was officially constituted. This was composed of the American Lung Association, the California League of Conservation Voters, the California Public Interest Research Group, the Coalition for Clean Air, the Natural Resources Defence Council, the Union of Concerned Scientists, the Planning and Conservation League, the Kirsch Foundation and the California Electric Transportation Coalition, and had the goal of promoting the use and commercial supply of zero emissions vehicles (Collantes, 2006).

The consumer has been an important stakeholder in the social license. The Californian consumer at the time was not willing to pay a premium to have a limited range electric vehicle, with very restrictive levels of performance and a smaller vehicle. Significantly, the number of electric vehicles leased by the California and Arizona consumers was much lower than anticipated by GM management. Eventually GM decided to collect and crush the EV1 vehicles and after 2000, the consumer was also key in the success of the hybrid vehicles in the state, especially with the demand for the Toyota Prius vehicle (Byrne and Polonsky, 2001).

5.8 - The effects of the ZEV legislation

5.8.1 - Short term effects

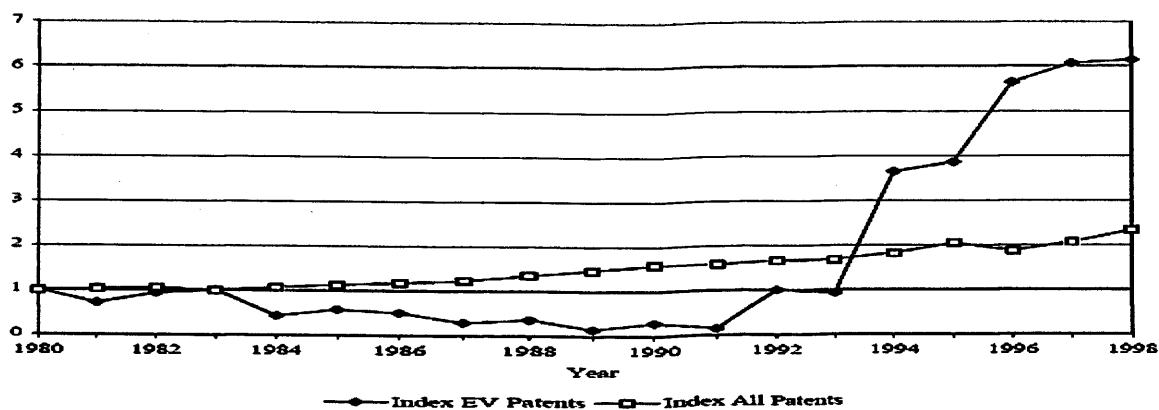
Burke *et al.* (2000) identify several secondary benefits of the ZEV Program, including:

- Growth in electric vehicle research measured by the increase in number of patents related to electric vehicles;
- The constitution of government/industry consortia to support EV development¹⁷;
- Advanced vehicle developments, which include several of the categories proposed by the ZEV legislation (internal-combustion engine vehicles, hybrid-electric vehicles, fuel-cell-powered cars and the use of lightweight materials);
- The development of low-speed electric transportation, including several types of EVs for city and neighbourhood EVs, electric bikes and scooters.

The secondary benefits include the economic benefits to California of the primary ZEV programme and new and improved technologies/products attributable to the programme. The legislation also favoured more research into other types of zero emission vehicle technologies, which included the emergence of hybrid electric vehicles. This specific issue is analyzed in section 7.

¹⁷ - Electric utilities' use of advanced energy storage technologies, industrial and consumer applications of EV advanced battery technologies (including large prismatic nickel metal hydride and lithium batteries, electrochemical capacitors (ultracapacitors), pulse power batteries, improved lead-acid batteries, zinc-air batteries, zinc-bromine batteries, battery test equipment and monitoring systems).

Figure 5.2- Annual number of EV-Related Patents and all US Patents Granted from 1980 to 1998 (indexed to 1980).



Source: Burke et al. (2000)

Burke et al. (2000) indicate the direct correlation of the ZEV legislation and the rise in the number of patents in the United States related to EV applications. This is indicated in Figure 5.2, which provides a comparison between the annual number of EV- patents in contrast to the index of all United States patents granted from 1980 to 1998 (indexed to the year 1980). The exponential growth in the EV patent index is a direct consequence of the future expectation that the automobile firms, automobile suppliers and other related firms created with the introduction of the ZEV legislation in California. However, it is not only the private sector which has researched and developed alternative technologies for the automobile industry; a large part of this was led by government-owned research centres and institutions, and some of these were in conjunction with private firms. The next section will therefore address this crucial issue.

5.8.2 - Long term effects

The introduction of hybrid models in California was directly fostered by the implementation of the ZEV legal license. These two firms were able to offer products that were more suitable for the requirements of the ZEV mandate. The first model to be

offered, in 1999, was the Honda Insight, a two-seater compact car that resembled a sports car. However, the most important vehicle that has dominated the market for hybrid vehicles in the United States has been the Toyota Prius. This was launched in 2000 as a more practical 4-door hatchback more suitable for the compact segment in California.

In 1993, the American government did not invite Toyota Motors Company and Honda Motor Company to take part in the Partnership for a New Generation of Vehicles (PNGV) program (Sperling, 2001b). As a result, the firms perceived that they would be at a competitive disadvantage if they did not increase expenditure in Research and Development in the area. Other firms also increased expenditure in advanced internal combustion engines and other alternative technologies (Professor Joan Ogden, personal communication, 10 May, 2007). The story of how the Prius was created can therefore provide valuable insights into the American policy to foster the development of fuel efficient vehicles.

The Toyota Prius represents a tremendous success for Toyota Motor Company as the first large-scale hybrid (petrol-electric) vehicle to be supplied to the global market. Regardless of the fact that the Prius only represents a very small percentage of Toyota's sales in the United States, it constitutes a great technological development in terms of fuel consumption, which directly affects CO₂ emissions and a unique marketing opportunity to showcase an innovative product. For a company which had been regarded in the past as a one which followed the market, this pioneering experience not only projected an image of an environmentally conscious firm, but also one as a technological leader in the global market (Toyota USA Representative, personal communication, 23 May, 2007).

The Toyota Prius is unquestionably an development from the single, internal gasoline combustion engine, as it is equipped with a traditional petrol-fuelled engine and an electric motor. Toyota also developed a system, called *The Hybrid Synergy Drive* system, that automatically switches between the electric motor and the internal combustion engine depending on the power needed to move the vehicle. The concept is to rely less on the petrol fuel engine at low speeds and to use its full capacity when more power is

needed. The system allows the vehicle to have very low consumption when compared to standard vehicles of the same size (Toyota Motor Corporation, 2006).

The origin of the Prius can be traced to an internal committee created by Toyota Motor Company to forecast the future perspectives in the automotive industry for the 21st century - the G21 in September 1993. This committee was set up to provide a response for Toyota not having been invited to participate in the PNGV. Sperling call this phenomenon the 'PNGV boomerang effect' (Sperling, 2001a; Sperling 2001b). The initial committee that identified the necessity to provide a market response for the advances that were being made in the United States was a key element in the developmental process. Despite previous research funds that had in the past been used to develop joint projects with the Japanese government on electric vehicles, powertrain and batteries, the research and development investment was completely taken by Toyota itself, which makes this figure different from the previous analysis of the Brazilian Proalcool programme. The committee established a project with the guidelines to develop an extremely economical mid-sized family car based on new production methods. Here, the initial goal was to have an internal combustion engine vehicle with a fuel consumption of 47.5 miles per gallon, this being less demanding than the original PNGV goals.

In the first stages of the project, engineers believed that by solely improving the internal combustion engine they would bring about the necessary fuel economy. However, in due course it became clear that additional measures would have to be taken in order to reach the proposed targets. The group therefore decided to attach an electrical motor to the petrol-fuel engine. It has been argued that Toyota benefited from joint research with the Japanese government on the battery powered Electric Vehicle, the MITI. Nevertheless, this did not meet the initial goals, but set the technological basis for the Hybrid Engine Vehicle platform (Ahman, 2004).

For the 1995 Tokyo Motor Show, Toyota prepared a concept car with the hybrid system,

presenting it as Toyota's vision of the future (Taylor, 2006). The feedback the company received at the Motor Show was critical for the decision to produce the hybrid vehicle. Regardless of the additional costs to the initiative, Toyota calculated that the car could go into production if the fuel economy was enough to compensate for the additional cost and the complexity that came with the addition of an electric engine. In addition to this, it was clear that further development could be achieved in the battery technology. The battery powered electric engines/batteries were something novel with great development potential (Taylor, 2006). Consequently, the Californian market presented the desired environment to launch this type of vehicle, since there was growing pressure from the California Air Resources Board.

The Prius was officially launched in Japan in October 1997 and sales began in December. However, during the first two years the generation I Prius was only sold in Japan. These initial years were necessary to carry out further development in the hybrid system and in the batteries. The launch of the cars in their national market therefore provided the necessary marketing feedback and consumer acceptance of the product so that it could be globally available and California eventually became a very attractive market due to the combination of legislation to enforce high efficiency in its vehicles and the environmental awareness of its population.

Global sales started in 2000, when the company developed the Generation II model. The American market started to receive the first models in 2000 and the success of the vehicle was staggering, especially in Japan and the North American market. More progress was made with the batteries, which became smaller and lighter, and the vehicle became more powerful; at the present time, the Prius is in its third generation. The vehicle has also experienced an increase in power from both the internal petrol fuelled engine and the electrical engine. It is equipped with a traditional DOHC 16 valve 1.5 litre petrol engine that produces the maximum output of 76 bhp and an electric motor that can produce 67 bhp. It also has a nickel-metal hydride battery that has a 201.6 nominal voltage. In addition to this, the vehicle has 104 g/km emissions on a combined cycle and the fuel

consumption of 65.7 litres/100km (Toyota Motor Corporation, 2006). (Table 5.7 demonstrates the developments in battery electricity in each of the four Prius generations).

The penetration of the Toyota Prius into the California market has come about as a result of the combination of the requirements of the ZEV legislation, higher oil prices and greater environmental concerns by consumers. Toyota indicates that the initial sales are in niche markets as the vehicle would appeal solely to a specific type of consumer. Consequently, the successful launch in these niche markets led to an expansion of the hybrid technology into other models. Toyota now offers the hybrid option on 6 models in the United States: Toyota Prius, Toyota Highlander, Toyota Camry, Lexus LS600hL, Lexus GS 450h and Lexus RX 400h.

Table 5.7 – The Generations of the Toyota Prius

Prius Type	Generation I	Generation II	Generation III	Generation IV
Year	1997-1999	2000- 2003	2004-2009	2009- present
Petrol Engine (Hp)	58	70	76	98
Electric motor (Hp)	40	44	67	80
Combined Power kW(hp)	58 (78)	72 (97)	82 (110)	100 (130)
Battery-Pack Weight (kg)	57	52	45	44
Operating voltage – Motor engine	288	273	500	650

Source: www.toyota.com

Lave and Maclean (2002) investigated the economic aspects for the consumer of the Prius; they considered under which conditions the purchase of the Prius would make economic sense, compared to the Toyota mid-size counterpart, the Corolla. They also found that the Prius may not be economically efficient when taking into account the price of fuel, the average distance travelled and the reasons for the market success of the Prius, which go beyond the crude economic calculations and are linked to others issues such as image and environmental perception.

When the federal government proposed the PNGV, the cooperative consortium represented an important alliance for the American automakers as they could indirectly receive a considerable amount of public resources to develop technologies that would offer them competitive gains over foreign based firms. Aside from this, since the next generation of vehicles were going to be developed as part of a government-industry cooperative effort, the firms could also influence how regulations would be shaped.

Regulators on the other hand, in proposing to invest in research and development in the area and in putting forward flexible options on how automobile firms could comply with the requirements of the ZEV mandate in California, added a considerable amount of flexibility. In Figure 6.4, the combination of the investments in Research and Development through the PNPG and the flexibility that was added to the ZEV mandate are represented by the PNGV on the regulator's side.

On the company's side, the PNGV boomerang effect shows the difference between the initial investments required by the Japanese and the American firms. Because the Japanese wanted to counterbalance the government-funded PNGV, the private investments have been larger and as a consequence the automobile industry was more cooperative towards the initial goals of the ZEV mandate. However, during the implementation process of the LEV-1 legislation, all the automakers were hostile to the level of stringency required by the original ZEV legislation, which also included the Japanese (Sperling, 2001b).

5.8.3 - Effects on industry environmental performance

The following table shows the significant reduction in emissions regulations observed in the total emissions of carbon monoxide, NOx emissions and volatile organic compounds. The reduction has been significant but regulators still consider that air pollution is a significant problem in the state (U.S. Environmental Protection Agency, 2008).

Table 5.8. Total emissions in California of CO2, NOx and EVOs

Source category	1970	1980	1990	1995	2000	2006	Percentage of 1970 reduction
Highway vehicles Carbon Monoxide - (million short tons)	163.23	143.83	110.26	83.88	68.06	54.10	53.8%
NOx Emissions from Highway Vehicles (million short tons)	12.64	11.49	9.59	8.88	8.39	6.39	50.55%
Emissions of Volatile Organic Compounds from Highway Vehicles (thousand short tons)	16,911	13,869	9,388	6,749	5,326	4,078	24.11%

Source: U.S. Environmental Protection Agency, 2008.

5.9 - Conclusions

Environmental regulation has been a very important determinant in automobile technology development in the United States. California was the birth place of air emissions regulation in the 1950s and is still in the forefront on air emissions with the ZEV mandate. The case study has indicated how the license to operate has mandated the use of specific technologies. California requirements were later followed on the federal level and influenced other parts of the world.

In the context of the license to operate framework, the history of automobile air emissions in the United States is also an account of an ongoing dispute between regulators and automobile firms that opposed the 1975 catalytic converter and the three-way catalytic converter in 1981. In this respect, all the regulations analysed in this chapter show how the legal license has been influenced by the industry, through a wide range of non-market strategies, especially direct lobby and legal disputes. In fact, automobile firms in the United States have argued about the large costs involved in adopting such technologies. Due to the resistance of the industry, less stringent standards were implemented, with many extensions of the original deadlines. The American legal system has certainly contributed to this adversarial scenario, but the approach towards regulation by corporate environmental strategy is also a determinant factor in this relationship.

The ZEV mandate however, portrays a different picture. The case is representative of how policy makers can lose sight of the social and economic licenses, and focus on the formation of the legal license. The wide process of delays and changes to the initial mandate indicated a slow and cumbersome legal process and the economic and technical feasibility of some of the ZEV requirements were not fully considered. Moreover, since the original targets were not accomplished, the California Air Resources Board has failed in its original goal of 10% ZEVs by 2003.

CARB took a unilateral move toward regulation as the board followed the vague perception of some of the General Motors' managers who believed they would have a commercially feasible full electric automobile. However, a detailed analysis of the economic license to operate electric vehicles had not been carried out. Here, several aspects of the economic analysis should have been considered, including the cost of technology development, the cost of vehicles to the public, the performance limitations that technology would impose on the consumer and other relevant issues had not been properly assessed.

The Air Resources Board also failed to include an analysis of the social license to operate that the industry would be facing. The consumer was largely excluded from the debate as regulators did not know how the Californian consumer would respond to electric vehicles that had considerable less performance and lower practicality than traditional petrol-fuelled vehicles.

The failure of the General Motors electric vehicle and the consequent review of the ZEV mandate opened the market for hybrid vehicles. Here, the Japanese firms Toyota and Honda have been the most successful in launching commercially successful hybrid cars which reviewed categories of the ZEV mandate.

The industry, in sum, perceived that that the market was not ready for the ZEVs, and the ways of achieving the reduction in air emissions as dictated by the CARB could be gained with alternative measures that did not break apart form the traditional business model of the firm. Moreover, the cost effectiveness of the ZEV mandate was not quantified since other options had not been assessed. The industry indicated that the resources spent on the development of batteries packs could be better spent in further developing the internal combustion engine. An example of this in the case of the hybrids would be to attach an electric engine with a battery pack to the traditional internal combustion engine.

The California case study brings about important lessons for the greening of industry body of literature. In the license to operate framework, three different licenses influence corporate environmental strategy and direct corporate environmental performance. The case indicates the imperative of considering the interplay between the three licenses to understand how the legal license impacts on industries' environmental performance. In the case of the ZEV mandate, the economic license to operate emerges as the most important one. Therefore, policy makers need to take into account the three licenses together in order to have a more precise influence over the industry's environmental performance.

Chapter 6 - The Brazilian Experience with Ethanol¹⁸

6.1 - Introduction

This chapter looks at the Brazilian experience with ethanol. It describes the first large-scale attempt to implement an alternative fuel as a substitute for traditional petrol. The chapter begins with a description of the importance of the case study for the empirical development presented in this thesis. The historical description of the government-led initiative to foster the wide adoption of ethanol fuel for vehicles – the Proalcool - is therefore introduced to comprehend the formation of the legal license. Hence, the analysis focuses on the establishment of the legal and economic licenses. After this, the initial research and development required for the adaptation of the ethanol-fuelled internal combustion engine are described, along with an examination of the government's role in the process. Then, the primary and secondary effects of the program are analysed, and the chapter concludes with a discussion about bio-ethanol fuel.

6.2 - The relevance of this case study

As shown in Chapter 2, the case studies in this thesis have been selected for their illustration of the impact of the license to operate on innovative technological development. They deal with novel environmental problems generated by the extensive use of the automobile that have required a new set of responses from automobile firms. The Brazilian Proalcool program case study has also demonstrated a pioneering regulatory measure and has been very important from an environmental point of view. The Proalcool was the first successful, large-scale government program intended to

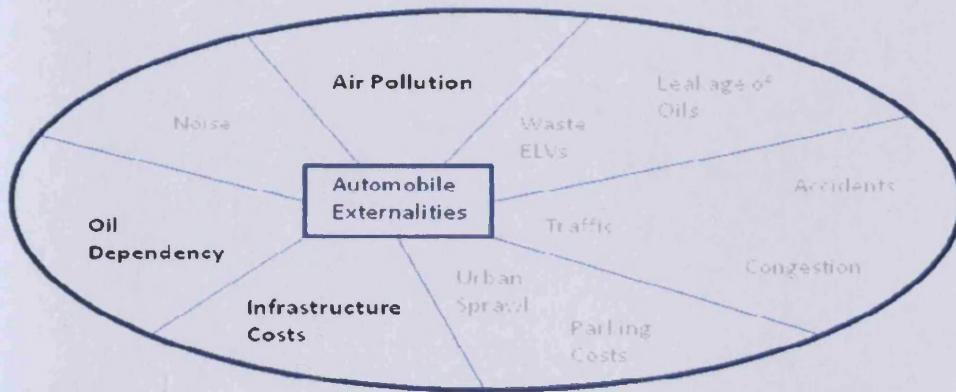
¹⁸ A modified version of this chapter has been published at the Business Strategy and the Environment Journal : Zapata, C. and P. Nieuwenhuis (2008) Driving on Liquid Sunshine - The Brazilian Biofuel Experience: A Policy Driven Analysis, Business Strategy and the Environment. Published Online: 26 Aug 2008.

substitute traditionally imported petrol fuel with a locally produced alternative source. Aside from the economic benefits, the use of ethanol has produced a significant number of positive environmental externalities vis-à-vis the use of traditional petrol fuel (Goldemberg et al., 2008).

The case study also shows the crucial role played by government, the Brazilian dictatorship of the time being the main force behind the initiative. The government played a vital role in providing support for the research and development of new ethanol-only engines, fostering the early adoption of new ethanol-only vehicles. The various instruments adopted by the policy have shaped the economic license to operate, to make the initial costs competitive with those of petrol. This case study also shows the important role of the consumer as well as the automobile firms involved in the process, both of which are analysed separately.

The use of biofuels as automobile fuel was not a novel idea in Brazil. Biofuels have always constituted a feasible fuel alternative for the automobile industry, as many early experiments with the internal combustion engine involved ethanol-derived fuels. These were relevant to even the most iconic of early automobiles - the Ford Model T. In fact, the U.S already possessed a suitable ethanol program during the 1920s and 1930s (Hunt, 1981). However, ethanol was eventually sidelined, as petrol emerged as a cheap and abundant alternative after World War II (Lincoln, 2000). In the initial development phase of the automotive industry, environmental concerns were almost non-existent or favoured the car as a clean replacement for the horse (Nieuwenhuis and Wells, 1997). Inexpensive and plentiful fossil fuels, therefore, became the reason for the growth of the automobile industry. However, the use of biofuels can, in theory, minimise several of the negative environmental externalities observed with the use of traditional petrol fuel. Figure 6.1, initially presented in Chapter 1, gives a graphic description of the major automobile environmental externalities which were the object of previous analysis in the literature. Biofuels have the potential to provide positive benefits to several areas of environmental interest, including: oil dependency, air pollution and infrastructure costs.

Figure 6.1- Automobile externalities tackled by the Proalcool.



Source: Adapted from Delucchi (2003).

The primary negative environmental externality that can be curbed with ethanol is the overall reduction in the dependency on imported petrol fuel. In the case of Brazil, the use of a locally produced crop to the detriment of imported petrol fuel was one of the main arguments used to support the large state intervention in the fuel market. The substitution of imported fuel represented an important macro-economic tool to strengthen the balance of payments of the country. The dependency on foreign petrol oil was perceived by the military government as a key national development hurdle that needed to be overcome (Rotstein, 1979).

Biofuels can also limit the local and global air pollution caused by automobile emissions, including both tail-pipe and crankcase emissions (Goldemberg et al., 2008). Because ethanol is extracted from biological sources, the plant growth absorbs CO₂. Aside from CO₂, ethanol use has also resulted in the reduction of several other pollutants.

The use of ethanol, in contrast to other alternative fuels or powertrain technologies, has a further positive economic effect as regards exploiting the investments already in place for the traditional petrol infrastructure. Therefore, the investments that have been made in

pumping stations, with logistical systems and even production distilleries and distribution centres, can be used with minor changes. Additionally, the sunk costs are already in place to develop, construct and maintain these large infrastructures. Other alternative fuels such as hydrogen, and even electric vehicles in certain areas, need large infrastructure construction or adaptation. In some cases, the necessity of building new infrastructures may render the adoption of an alternative fuel or powertrain technology uneconomical.

6.3 - The legal license to operate

In 1973, the Brazilian government initiated a programme called the National Alcohol Program - Proálcool, which constitutes the most successful large-scale biofuel initiative in the world (Leite, 1990). This demonstrated the technical and economic feasibility of bio-ethanol as a substitute for traditional petrol fuel. In order to understand how the legal license was formed, it is important to appreciate the economic and political situation of Brazil at the time. Brazil in the 1970s was a country that was marked by a severe macroeconomic crisis due in part to the drastic rise in petrol fuel. At the time, Brazil imported 77% of all the petrol used. The internal agricultural sector was also in crises due to the growth in competition from other nations (Magalhes et al., 1992).

Since the 16th century, Brazil had been the world's largest producer of sugar and this economic activity played a prominent role in the agro-industrial development of the country. In the political sphere, the rural sector had a strong political influence on the central dictatorial government which consequently favoured this sector, especially the sugar producers. In the late 1960s and early 1970s, the internal sugar sector was in clear decline, as the international price of sugar had reached a historical low, there having been a large production expansion in Asian countries. The price severely declined from US\$1,237 per ton in November 1974, to an average price of US\$172 per ton in 1978 (Mello, 1981). In addition, the sugar crisis had a severe impact on numerous other activities linked to sugar production, thereby causing high unemployment. In this

economic climate, fostering the sugar sector was very desirable politically (Magalhaes et al., 1992).

Another key factor in the implementation of the *Proalcool* programme was the oil crisis of 1973. Since a large proportion of the oil consumed in the country was imported, the macroeconomic effects of the Arab oil embargo were extremely harsh. The internal spending on oil imports rose from US\$600 million in 1973 to US\$2.5 billion in 1974 (Pamplona, 1984). The impact on the commercial balance of payments was devastating, causing rapidly rising inflation.

Since the early days of motoring in Brazil in the 1920s, ethanol had been thought of as a potential source of energy and had been a by-product of sugarcane production, this being used to manufacture other chemical materials. The first experiments with ethanol-fuelled vehicles had been carried out by 1925, with the development of the Ford Model T based prototypes. In 1935, a minimum blend of 5% ethanol to gasoline (E5) was introduced. However, it was not until the World War II period that ethanol was used on a wider basis. The north-eastern states were forced to use mixtures of up to 42% of ethanol and automobiles were only used in cases of an emergency. At that time, there were around 44 ethanol distilleries producing 76.6 million litres of ethanol a year (Pamplona, 1984). The automobile fleet was mainly concentrated in the southern states, which were richer and had larger populations.

Therefore, in 1975, the military dictatorship government of General Ernesto Geysel launched the *Proalcool* programme to aggressively increase the demand for sugarcane-derived ethanol (Moreira and Goldemberg, 2000). This would simultaneously strengthen the Brazilian economy, boosting the agricultural sector and thereby creating a new biofuels sector, whilst reducing the country's dependence on imported oil, and would reduce significant emissions in the large city centres of Rio de Janeiro and São Paulo. The programme had the ultimate goal of substituting all imported oil with locally produced ethanol, which could potentially make the country self sufficient in energy. The

Brazilian government referred to it as a programme as it incorporated a series of legal mandates alongside various changes in the economic license to operate of the automobile industry, including changes in the tax system and other sorts of subsidies to ethanol. Energy independence was a long-term ambition of the military government, who perceived the lack of this as a crucial impediment to the long-term development and national security of the country (Leite, 1990).

The role of the dictatorship was crucial in the implementation of the Proalcool project. The central government had strong control over the economy, which included price fixing, and the state-ownership of several companies, including the only national oil petrol company - Petrobras. Notwithstanding this however, the implementation was troublesome. Different stakeholders in the process tried to gain control over the programme and bargained in their own interests (Sperling, 1987). These included Petrobras, which had a monopoly in oil exploration in Brazil, the government regulator, *Instituto do Açúcar e do Alcool* – IAA, the sugarcane and ethanol producers, and the automotive industry, which had been chosen by the government of Juscelino Kubitschek to lead the industrial process of import substitution and historically had received both direct and indirect incentives. Brazil had followed a policy of promoting local automotive suppliers, while encouraging foreign automotive assemblers to build the actual cars. This process was part of the wider development strategy established by President Kubitschek – known as the ‘substitution of imports’. In this way, the country benefited from foreign vehicle design expertise, whilst promoting technology transfer to local suppliers (Nieuwenhuis, 1988).

Several studies divide the Proalcool program into three phases, including those of Goldemberg et al. (2003), Leite (1990), Moreira and Goldemberg (2000) and Magalhaes et al. (1992). In the first phase in 1975, the government established an E22 blend to utilise spare capacity in sugarcane plantations and to foster the expansion of production with new ethanol refineries. This initial stage was essential to test the mechanical capabilities of existing engines and to understand the economic short-term effects of the

initiative (Goldberg et al., 2003). This was also crucial for the government policy makers, who saw this as a take-off stage for the next, more radical phase. A crucial element of this phase was the strong support given to the Research and Development of the new ethanol-only engines. A government strategy to develop this initiative was devised at the state owned research institute *Centro Tecnológico Aeronáutico*- CTA. (Section 4 describes in more detail the government's role in the research and development of ethanol only engines.) These were a benchmark in the modern automobile industry as it was the first time that modern internal combustion engines ran solely on ethanol.

A second phase started in 1979 with the goal of launching ethanol-only vehicles, designed for using E100 (100% ethanol fuel). This was a novel approach which greatly promoted the demand for sugar-cane. As a result, there was a large expansion in production as well as in the development of other industries in the ethanol supply chain, including the internal chemical industry, agricultural machines and the research and development of new sugarcane varieties by the state-owned company Embrapa. In this period, ethanol production flourished, reaching its peak in 1986 with 96% of new vehicles sold being E100 versions (ANFAVEA, 2007).

At the end of this phase, ethanol vehicles constituted most of the vehicles sold in the country. The supply chain was mature, as producers and distributors were operating fully, while the initial technical problems of ethanol engines had been solved. These included cold starts, high consumption and the excessive corrosion of plastic components. At this point, the ethanol government initiative in Brazil was hailed as a great success.

The third and final phase of the alcohol programme started in 1987, when the subsidies were gradually reduced until the program officially came to an end. According to the governmental documents of the time, the ethanol market was mature and did not need further financial subsidies. The legal license was also changed as automakers could supply merely petrol-fuelled vehicles. The government had other priorities which required large investments. After 1987, the price of petrol had also decreased

significantly, which placed in question the economic feasibility of the ethanol production levels.

In the three phases of the program, the consumer demand for new ethanol vehicles and for ethanol was directly influenced by the economic benefits of using ethanol. The public perception of the new technology included several variables, such as the running costs, the reliability of ethanol cars, the availability of ethanol at gas stations and the resale value of ethanol-only vehicles. Another important issue that was accounted for by the consumer was the availability of conversion kits that could be used at a relatively low cost to transform gasoline vehicles into ethanol ones. During the first and second phases of the program, ethanol-only vehicles surged as the dominant automotive product sold in Brazil, following a large marketing campaign to foster the use of the fuel. However, the demand for new ethanol-only vehicles was particularly responsive to the variations in the supply of ethanol and the policies implemented to foster the use of ethanol, including the initial marketing campaign based on nationalist arguments. However, during the third phase of the programme, the demand for E100 vehicles reached a historic low.

According to a study conducted by Moreira and Goldemberg (2000), the crisis in ethanol use and production in the third phase was the result of a combination of economic factors and the consumer reaction to some of the system inefficiencies. The government gradually decreased the subsidies of ethanol production, not only reducing benefits to the producers but also removing the tax waiver for new ethanol-only vehicles. The demand for new ethanol vehicles was particularly elastic in relation to the supply and price of the fuel at the pumps, rapidly shifting from ethanol to gasoline vehicles, as the price of ethanol was approximately 80% of gasoline prices.

This change of preferences was also sparked by the large ethanol shortage in the internal market, as the international price of sugar rose significantly. Many ethanol producers decided to produce sugar instead, which forced the national oil company, Petrobras, to import ethanol. The ethanol production decline was also promoted by low petrol prices resulting from cheaper oil worldwide, which made the economic feasibility of ethanol

production uncertain. The international price of petrol plummeted from US\$72.40 a barrel in 1980 to US\$21.85 by mid-1986 (adjusted for inflation to 1999 US dollars), and remained relatively flat until the beginning of the Gulf War in the 1990s (Energy Information Administration, 2007).

The stability of petrol prices during this period directly affected the prices of gasoline sold in Brazil and consumers rapidly abandoned ethanol-powered vehicles in favour of petrol cars. Petrol began to be considered a more reliable fuel as its price had remained constant for many years and it appeared to be less susceptible to price fluctuations than ethanol. In addition to this, petrol was known to be constantly available at every fuel station, which became less true for ethanol as demand slipped and production volumes followed suit.

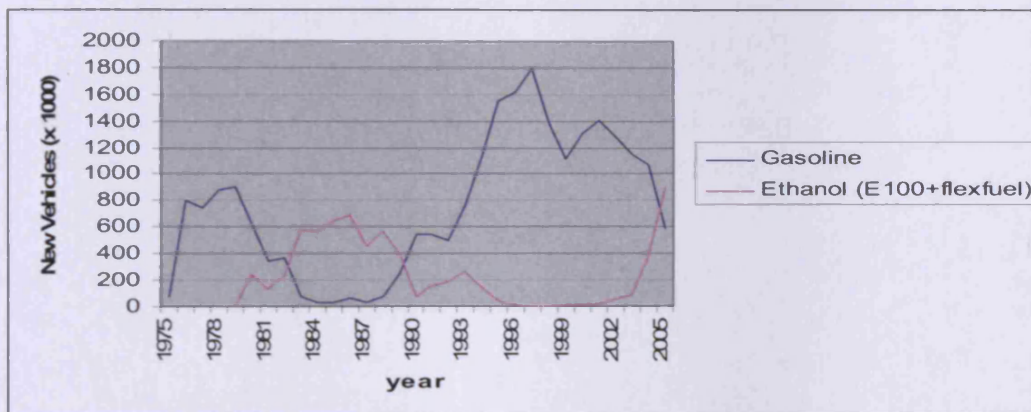
Even today, this continues to be an important issue. The cost of Brazilian ethanol is about \$35 per barrel, which means that the oil price needs to be above about \$40 per barrel for it to compete with oil (Eggar, 2007).

It was not until 2003 that ethanol demand recovered with the introduction of flex fuel engine systems. These engine management systems, developed in Brazil by Bosch and Magneti Marelli, enable a vehicle to function with ethanol, gasoline or any mixture of the two¹⁹. This also eliminates consumer risk, there no longer being the uncertainty that was previously related to the purchase of a vehicle which had to be either gasoline fuelled or ethanol fuelled. Consumer risk was dramatically reduced as the chance of running out of the right fuel and the risk of mis-fuelling were significantly reduced. Consumers now tend to opt for ethanol whenever ethanol is at least 75% of the price of petrol, as it provides enhanced performance and this is a well-known reason for its use in motor racing. The introduction of the flex engine combined with high oil prices and the rising

¹⁹ - Sperling indicates that the flex fuel engines were initially developed and offered in the American market in the early 1990s. Flex fuel engines were widely available in small trucks. However, few consumers actually used the ethanol capabilities due to the lack of infrastructure in the US. This situation changed after 2005, when there was a concentrated effort from the central government to developed ethanol fuel (Sperling, personal communication, 08 March 2007).

demand for cars in Brazil has sharply driven up domestic ethanol demand. By November 2005, flex fuel variants represented 70.9% of Brazil's total vehicle sales (ANFAVEA 2007). Figure 1 shows the evolution of gasoline, ethanol and flex-fuel vehicles sold on the Brazilian market between 1975 and 2005. After 2003, flex-fuel vehicles are included in the ethanol group. Figure 6.2 shows the fluctuations in the demand for ethanol-only vehicles for new car sales.

Figure 6.2 - New car sales according to type of fuel.



Source: ANFAVEA (2007).

6.4 - The economic license to operate

In March 1975, the first internal documents supporting a national set of measures to promote bio-ethanol for transportation purposes emerged in the Brazilian Federal government. Active groups that voiced their early support for a national plan included industry associations and sugar cane producers. In response, the Ministry of Industry and Trade established a study group to examine the benefits and costs of a national program to make ethanol a widely-used fuel in the country (Roststein, 1979).

One of the key barriers for the use of bio-ethanol as a fuel alternative was the lack of mass-produced ethanol engines which would perform as petrol counterparts. The Secretary of Industrial Technology, José Walter Bautista Vidal, invited Dr. Urbano Stumpf, who was a professor of mechanical engineering at the University of Brasilia, to lead the government research team that would ultimately develop ethanol-only engines. Professor Stumpf was given the task of putting together a research team that would be responsible for assessing the necessary technical measures required to develop internal combustion engines running on ethanol. The team was based at the Centro Tecnológico Aeroespacial - CTA in Sao Jose dos Campos, where Professor Stumpf had conducted research on engine development in the early 1950s.

The initial task of the research team was to prove that bio-ethanol could be combined with gasoline. At the time the results indicated that a mixture of up to 15% could be safely used with the existing engines. However, the goal was to establish the development of engines that would run solely on bio-ethanol.

In order to accomplish this, the Brazilian government used a mixture of command-and-control (C&C) measures and market-based instruments- MBIs to foster the increase in the demand for the new fuel. The incentives were gradually modified, taking into account the market reaction at each stage of the program, and involved the following:

- The Brazilian state-owned Petrobras was forced to purchase a minimum amount of ethanol, so that ethanol producers would have a guaranteed minimum demand for their product. Petrobras also had the legal and financial responsibility for distributing and offering ethanol in every one of the 29,000 filling stations in the country (Professor Goldemberg, personal communication, 18 December 2006);
- Subsidies in the form of low interest loans were specifically designed for and provided to companies willing to enter the ethanol production market (from 1980 to 1985);
- The common price fixing instrument used as a macroeconomic tool to curb inflation was taken as the basis for making ethanol prices competitive with gasoline.

Ethanol prices at the pump were established at 59% of the gasoline price. This was intended to make the use of ethanol more appealing to the consumer, as ethanol engines consumed an average of 30% more;

- Gasoline received an additional tax. A part of this tax was used to finance the subsidised loans that were given to the ethanol producers;
- In order to enhance the demand for ethanol-only vehicles, a differentiated tax system was established for new vehicles. Under this system, ethanol-only cars were in a smaller tax bracket, while gasoline cars paid more tax. Additionally, ethanol taxis and commercial vehicles were exempt from paying the new vehicle tax.

The country also received external aid for the initiative. The World Bank perceived the macroeconomic importance of the initiative as a tool to balance the external balance of payments and to produce positive effects on inflation. It therefore provided a conditional loan of US\$ 200 million to support the program (Goldberg et al., 2003).

The role of the automotive industry in the process should be highlighted as a fundamental factor for the successful introduction of ethanol in Brazil. In the initial stages of the ethanol program, there was some controversy among the car manufacturers, who publicly questioned the government's commitment (Roststein, 1979). Some of these regarded the initiative simply as a short-term political stunt to satisfy the sugar-cane lobby. The issue of using agricultural land for feeding cars rather than people was also questioned, Brazil being a country with many poor people. The most vocal of these manufacturers was the independent Brazilian car producer Gurgel (Nieuwenhuis, 1988).

This negative attitude towards the initiative progressively changed as the government provided extensive indirect subsidies to the industry in the form of tax credits and direct financial support for the development of the technical modifications needed to adapt the existing petrol-fuelled internal-combustion engines. Some fundamental mechanical issues had to be addressed before each car manufacturer was able to fully adapt the CTA's engine developments to their production systems, which meant that the car producers had to believe in the government's ethanol proposal and invest their own resources in

research and development for the new engines. In fact, in 1979 the large-scale manufacturer had difficulty complying with the technical targets that had been set up by the CTA for the new engines. There was an excessive increase in fuel consumption and several technical problems in relation to cold starts and the corrosion of parts.

The extraordinary relationship that the automobile firms operating in Brazil had with the government is a key factor to understanding the major instruments utilised by the government. This relationship was a reflection of the historical provision of financial privileges to automobile firms, since during the 1960s they were perceived as important instruments of economic growth. At the time the largest players in the Brazilian market were Volkswagen, Ford, General Motors (Chevrolet) and FIAT and they had a protected market because imports were limited by high import tariffs. In addition, they received significant fiscal and financial benefits for producing vehicles in Brazil.

Aside from these four large factories, other smaller automobile firms also participated in the Brazilian market. These included Gurgel and Puma, which supplied the small segment of niche and sports car components. Mechanically they were based on the Volkswagen beetle and used a carbon fibre body. However, from 1975 to 1982, the market for new vehicles sold in Brazil changed significantly. High oil prices and the introduction of ethanol-only vehicles caused the Brazilian consumer to be more interested in smaller and fuel efficient cars.

The demise of the Brazilian Chrysler was also a significant factor in the modification of the market for new vehicles and the change in the tastes of the Brazilian consumer hit manufacturers specialising in cars with V8 engines especially hard. Chrysler ceased production of the three models that were produced in Brazil – the Dodge Polara, the Dodge Dart and the Dodge Le Baron in 1981²⁰. However, the most important market

²⁰ - In 1979 Volkswagen purchased 67% of the Brazilian Chrysler. In 1980, the demand for the Dodge V8 was only 388 vehicles, and the factory had no orders for the more powerful Charger R/T. In the same year, Volkswagen purchased the remaining 33% of Chrysler. In 1981 the factory ceased production of the Dodge models as the demand was practically zero. The Old Chrysler plant was eventually used for the production

entrant in the Brazilian market was FIAT, which started to produce small and compact vehicles in the Minas Gerais factory in 1976. One employee interviewed had the following to say:

Fiat has been a pioneer in the Proalcool program. There was a clear force behind the firm strategy to help developed products that would be suitable for ethanol... the technology development in FIAT, made the 147 one of the best cars at the time in Brazil. This was quickly recognised by the consumer. (FIAT do Brasil Representative, personal communication, 19 December 2006)

Fiat was the first large-scale automobile manufacturer to produce ethanol-only vehicles, which it did in 1979. The firm had always been interested in launching ethanol-only vehicles and in 1976, when the first manufacturing plant in Brazil was opened, there was a public exhibition of the Fiat 147 ethanol prototype. However, the firm only launched mass-produced vehicles after the government provided economic guarantees (Veja, 1979). Notwithstanding the pioneering market release by FIAT, other manufacturers soon followed in their footsteps, including Volkswagen, Ford and General Motors. All of these were already strong firms in the Brazilian market and merely adjusted their product line-ups to better suit the demands of the ethanol engines (Veja, 1979).

The tradition of heavily subsidising the automobile sector continued with the Proalcool. The program was designed with a large participation of industry representatives and the government knew that the success of such a large initiative also had to involve economic benefits for the stakeholders involved in the process, especially the consumer and the automobile companies. Ford calculated an increase in the price of the new vehicles sold due to the investment in the new technology (5,000 to 10,000 Cruzeiros being around 5% of the final price of the car), which was almost all passed on to the consumer, as the elasticity of demand for new vehicles was relatively inflexible (Veja, 1980).

of Volkswagen ethanol-powered trucks that used an updated version of the Chrysler 318 V8 engine.

Automobile producers possessed a great deal of influence over the central government and effectively lobbied the federal government to set up several policy instruments, including direct subsidises for the production of ethanol and the use of research and development programs to form the economic license to operate. Consequently, the industry could move towards producing ethanol-only vehicles without changing the traditional business model of the auto industry and still rely on the internal combustion engines and the all-steel-body frame structure.

During the years of the Proalcool, the model line of Brazilian cars changed dramatically and the large American-based vehicles were replaced by smaller ones. At the end of the Proalcool programme, the Brazilian market was changed by the participation of the newly established FIAT and the demise of Dodge. The other car manufacturers also changed their product lines considerably. The vehicles were now based on smaller, European-based models, instead of the larger American vehicles. For example, in the mid 1970s, Ford was producing the Maverick, which was replaced by the Del Rey, a smaller car that had been produced under the Corcel platform.

6.5 - The social license to operate

In the context of the license to operate framework, the social license to operate is shaped by a variety of stakeholders. The requirements of the social actors which the firm must comply with belong to a wide range of interest groups, including: local communities, national environmental groups, workers, media, consumers and society in general.

In the case of the ethanol engines, the consumers and the Brazilian society in general had initially been identified as the central stakeholder which governmental policy had to focus upon. In order to gain the public support for the initiative, the ministry of trade and industry decided to market the new technology with learning demonstrations. In 1976, the CTA team possessed fully working prototypes which were ethanol-only based for the Volkswagen Fusca engine (Volkswagen Beetle). The next step was to present a working demonstration of ethanol-only engines.

The research team presented the idea of a national rally. This would demonstrate the technology that had been developed by the CTA and would provide a public display of the possibilities. This would allow for further research funds and would present to the Brazilian society the results that were visible in the labs. (Representative Ministry of Trade and Commerce, personal communication, 15 December 2006)

In 1976, a widely-marketed public demonstration was launched under the name of The First National Integration Circuit for the Integration of Alcohol Vehicles. The route was planned to take in more than 8,000 kilometres in 23 days (Veja, 1979). The vehicles that took part in the rally were as follows:

- A Volkswagen Fusca 1300: this was the most popular and cheapest vehicle available on the Brazilian market. The CTA prototypes used Fusca 1300 engines;
- A Gurgel Jipe Xavante that was on loan from João Conrado do Amaral Gurgel, the owner of the Brazilian automotive firm Gurgel; this vehicle was also powered by a Volkswagen 1300 engine:
- A Chrysler Dodge 1800: Chrysler was the first large-scale manufacturer to be interested in the ethanol project. The Dodge 1800 was a two-door version with a large engine from the British Hillman Avenger. It was launched in 1973 and its name was changed in 1976 to the Dodge Polara (Samata, 2003).

The vehicles left de São José do Campos and had scheduled stops in São Paulo, Manaus, Cuiabá, Porto Velho, Vilhena and Manaus. The last leg of the rally from Vilhena to Manaus was on more than 1000 kilometres of unpaved roads in the rough tropical conditions of the Amazon Forest (Veja, 1979). This initiative received considerable press attention at the time, and the local populations gathered to see the rally pass through the selected towns (Veja, 1979).

The successful outcome of the learning demonstration proved that the ethanol-only engines could be used in real life situations. Following this, a set of policy measures were established by the federal government to foster the use of ethanol engines. Government-

owned firms became the early adopters of the new developments, thereby giving a wider exposure to the technical feasibility of the engines in real life situations, and this helped to advertise the initiative, with several state-owned firms being given new ethanol retro-fitted gasoline vehicles. These vehicles had large logos displaying that there were fuelled with the new home grown fuel. The government at the time had several firms that could provide general services in large cities and the purchasing power of the public sector was used to enhance the initial market penetration of ethanol-only vehicles. The government became an early adopter of the technology, buying the first 750 vehicles to be retro-fitted under the CTA's supervision.

The early use of ethanol-fuelled vehicles was restricted to government owned companies or taxi firms, and only authorised drivers could fuel their vehicles with ethanol in the pump stations. The São Paulo government-owned phone company -Telesp - received the first 25 vehicles in August 1977 as part of the first CTA prototypes; after its successful initial use, a subsequent batch of 400 Volkswagen Fuscas was received in 1979. These cars were used in Sao Paulo as maintenance vehicles and were driven on a 24-hour basis (Veja, 1979). In total, the CTA supervised the ethanol conversion of 731 Fuscas, this being carried out by the private firm, Majorit; they also set the technical standards for the engines and the bio-ethanol fuel that was to be produced in the following years.

The public display of the technology development was key to gaining media attention for the new fuels, as well as providing the validity of the new fuel as a feasible alternative and making the population aware of the fact that the performance level of the cars would not be affected. The national rally was therefore a very strong market signal for automobile firms, auto-part suppliers and consumers.

This enhanced the phase of the learning demonstrations and the made the public aware that the technology would actually work. The demand by the government was also a strong signal that this initiative was not a temporary measure and that it needed to be seriously considered by the automobile firms.

6.6 - The effects of the program

6.6.1 - Short term effects

It is important to emphasise that the greatest concern about the program was the economic outcome. Several authors have applied distinctive methodologies to calculate the macroeconomic value of this program. According to Nastari et al. (2005), between 1976 and 2004, the use of ethanol for automotive fuel purposes provided savings of up to US\$60.74 billion (in constant dollars of 2005) for the Brazilian government. If the external debt interest rate is included in the calculations, the figure adds up to US\$121.26 billion. These figures support the initial economic arguments for sustaining the program. Ashford (1989) provides different figures that are less optimistic, but his outcome is still positive. According to his analysis, between 1975 and 1989 the savings were US\$10.4 billion, with government subsidies of US\$9 billion. These figures corroborate the initial idea that Proalcool was a macroeconomic tool to correct distortion in the international balance of payments, as it substituted imported oil for locally produced ethanol fuel. In addition, the generous subsidies to the sugar sector and to the distilleries reflected positively in generating aggregate national wealth, and this directly affected the national economy.

Another factor that should be considered is that the renewable nature of biofuels impacts positively on the economic rate of return in ethanol production. In fossil fuel extraction, additional investments are needed on a regular basis in order to sustain a constant extraction rate and these are dependent on the number of years each reserve can offer. With biofuels, sunk costs can be amortised over a very large number of years as the same area can provide production indefinitely, allowing for adequate crop rotation and agricultural management. However, the use of agricultural chemicals may be an issue. For example, the growing feedstock for biofuels has been linked with increased emissions of nitrous oxide as a result of the use of nitrogen fertiliser. The global warming potential of nitrous oxide is about 300 times that of carbon dioxide (Commission to the Council and the European Parliament (CEC), 2007, p.9) and is therefore a potential

problem. Nevertheless, current research suggests that on a wheel-to-wheel basis, Brazilian bio-ethanol from sugar cane has one of the best greenhouse gas saving potentials of any biofuel, which has been estimated up to 90% compared with petrol (CEC, 2007, p. 11). This compares with a more modest 50% for bio-diesel from palm oil and 30% for bio-diesel from soya bean production (CEC, 2007, 11). The ethanol production learning curve also reveals that the cost of ethanol falls sharply as experience is accumulated in ethanol production (Goldenberg et al., 2003). This provides a competitive figure for the \$ to tonne of carbon saved.

6.6.2 - Long term effects

In the initial discussions about the Proalcool programme, along with the economic value of this policy, the government put forward several socio-economic objectives which were fundamental not only to justify the program on economic grounds, but also on ethical grounds, it being a developing country with a high divergence of income levels. The social objectives included: the reduction of regional income disparities, the reduction of individual income disparities - especially between rural and urban areas- and the creation of a large number of new jobs. Whether or not these goals can be achieved, however, is questionable (Sperling, 1987).

An essential aspect of the programme was that it was able to create approximately a million jobs directly and several million indirectly, mostly in the deprived rural areas of Brazil (Magalhães et al., 1992); this was in line with the initial goals of the program. Estimates calculate that in order to produce the same amount of energy, ethanol in Brazil generated 152 times more jobs than oil production (Magalhães et al., 1992). However, this argument has to be weighed by the quality of the jobs created. Most of these were low-wage workers, the so-called '*boias-frias*'. This term signifies the lowest class of workers, who were hired to perform specific and relatively unskilled tasks on a temporary basis. The term comes from the Portuguese expression 'cold meal', as these poor workers had to bring their own food with them and had no means of heating it before eating. The working conditions of those workers could have been improved significantly, especially

in relation to working hours and pay; however, the government was only able to effectively intervene in this area after the introduction of the 1988 constitution.

6.6.3 - The effects on industry environmental performance

The Proalcool program was created based primarily on economic arguments. However, the environmental dimension had always been a preoccupation of the program. The initial working group set up at the ministry of trade and industry, indicated as one of the main arguments for the implementation of the program, the enhancement of the quality of air in major Brazilian city centres:

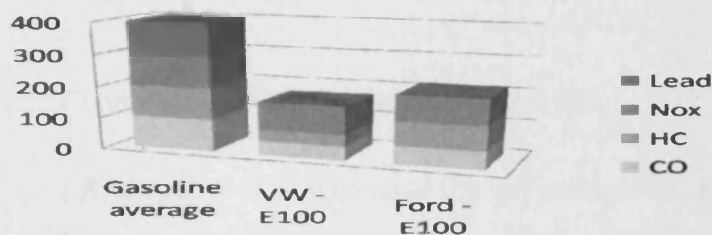
The air quality of the large city centres of Sao Paulo, Rio de Janeiro and Belo Horizonte, will significantly increase following a gradual switch to ethanol fuelled engines. This will produce a positive impact on the quality of life of the people living in these cities. (Free translation) (Brasil, 1976)

The document also indicates that without the benefits to various areas, a large program would not have been backed up by ministries and governmental agencies. Despite, this positive view of the member of the working group, Brazilian society had concerns relating to pollution that could be caused by the expansion of sugar cane plantations. At the beginning of the program, the general public perceived gasoline as a cleaner alternative to the local sugar cane production. Not only were there preoccupations relating to the waste produced by the sugar cane plantations, but also because the producers traditionally burned the sugar cane plantations after harvest (Rotstein, 1978). In 1979, there was no clear consensus in the Brazilian press about the effect of ethanol on the environment (Copersucar, 1989).

Gasoline engines release carbon monoxide which is highly pollutant but is not as visible to the population. The ethanol engine, however, does not emit this substance, but does produce a large quantity of aldehydes. This is a polluting substance that has several adverse health effects on humans, such as eye redness, sore throat and skin irritation.

However, in the second phase, the environmental agenda started to play a more prominent role since ethanol had many beneficial chemical and physical properties in contrast to the gasoline used at the time. These included: lower toxicity, better combustion and lower exhaust emissions, no sulphur emissions, lower emissions of photochemical smog precursors, biodegradability and a higher octane rating (up to 120, compared with 85-95 for most types of petrol). Figure 6.2 shows some of the first results with E100 fuel in Volkswagen and Ford engines.

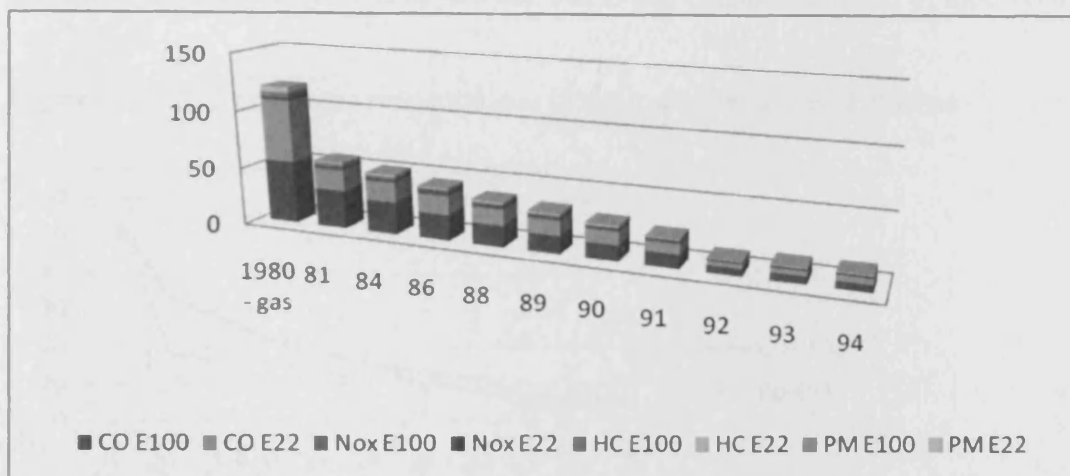
Figure 6.2 - Gasoline engine emissions compared to E100



Source: Brazilian Ethanol Producers (2005)

The city of Sao Paulo, which had a traditional problem with smog and toxic emissions from automobiles, experienced a significant improvement in air quality and after the introduction of E100 (100% ethanol fuel), emissions were drastically reduced. Figure 6.3 presents the reduction in global emissions observed in the city of Sao Paulo. The figures relate to ethanol free gasoline (pre-1980), gasoline C (E22), and ethanol (E100) and compares gas exhaust emissions for new vehicles from pre-1980 to 1994.

Figure 6.3 - Total emissions verified in the City of Sao Paulo.



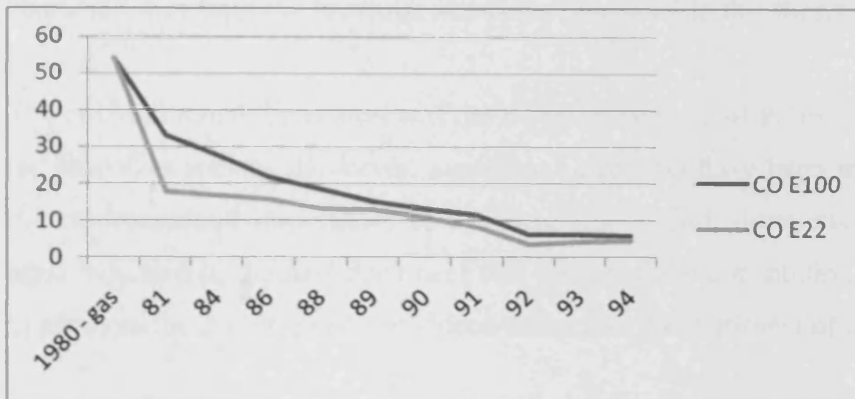
Source: Confederacao Nacional da Industria (1990).

The CNI Association also calculated the environmental impact of the ethanol in the city of Sao Paulo; according to this analysis, if the entire automobile fleet had been totally converted to E100 fuel, there would have been a total decrease of 65% in CO₂ emissions, 58% in HC emissions (although the precise mix of hydrocarbons varies e.g. higher formaldehyde levels, cf. Nieuwenhuis et al., 1992, p.96) and no significant modification in NO_x emissions. As these benefits translate into each individual vehicle running on ethanol, it highlighted the contribution ethanol-fuelled vehicles made to the city of Sao Paulo in terms of air quality improvement (Confederacao Nacional da Industria, 1990).

It is true that sugar cane monoculture over the years has had a series of negative impacts on Brazilian biodiversity. This was especially so in the establishment of the sugar cane farms in the 17th and 18th centuries as it was carried out at the expense of virgin forest (Padua, 2002). The production of sugar cane has also created a number of negative environmental consequences in the country. The most important ones are related to the monoculture nature of the plantations which need to be cultivated in very large areas. These plantations have directly impacted on local biodiversity, with the potential loss of several vegetable and animal species. However, if the period of the Proalcool is focused

on in isolation, the negative externalities of ethanol production relate to the production process of the sugar cane derived fuel and not to deforestation and loss of biodiversity.

Figure 6.4 - CO₂ emissions reduction due to the implementation of ethanol



Source: Confederacao Nacional da Industria (1990).

The most polluting sub-product of sugarcane production is *vinhoto*, which has been carelessly discarded in rivers for decades, thereby causing water contamination. This by-product must be properly treated and can be transformed into fertiliser. Nowadays, *vinhoto* is mainly used as a fertiliser and provides an extra income for sugar cane producers. In fact, in Brazil sugar cane production is considered one of the cleanest and most efficient agro-industrial production systems (Representative of the Ministry of the Environment, personal communication, 11 December 2006). Another negative environmental externality was the traditional practice of burning sugar cane plantations after the cane had been extracted. This causes polluting emissions, soil nutrient loss and erosion. According to the Brazilian Ministry of the Environment, these practices are disappearing in the country, with very few exceptions in isolated areas in the north-eastern states (Ministério do Meio Ambiente (MMA), 2003). However, it is known that these practices still occur, especially in more isolated states that do not have a well-enforced system of fire detection (*interviews*).

6.7 - Conclusions

The Brazilian ethanol program is a case of partial innovation, and has different characteristics from the previous two cases presented in this thesis.

The environmental dimension was not a central element of political salience at the time in the Brazilian society. However, significant elements have been identified that indicate the environmental importance of the program. In fact, these environmental effects had been indicated in the first document that proposed the constitution of a large scale policy to promote the use of locally produced ethanol to the detriment of imported petrol fuel.

In the context of the license to operate framework, the government had been able to shape the economic, social and legal licenses simultaneously, providing support for the modification in the industries' environmental performance. The successful adoption of mass-produced ethanol-only engines was only possible because of the right combination of shapes of licenses. The interplay between the different licenses has produced a positive environmental effect as the industry has successfully switched from gasoline-fuelled engines to ethanol, so generating significant environmental gains.

The chapter also shows that the government has been the central force steering industry to launch ethanol-only engines. The combination of the legal and the economic license have led to the commercial launch of ethanol-only engines. The automobile industry had already indicated the technical capability and willingness to make ethanol-only engines. However, the industries only embarked on the ethanol initiative after the economic license to operate had been shaped in their favour. The industry used its excellent relationship with the military government to actively shape the economic license, and obtain several advantages, including: the organisation of the supply chain of ethanol, the process of R&D and the creation of an appropriate economic environment with a

combination of market-based instruments and command-and-control measures for ethanol to become cost-competitive. The government was also able to directly influence the social license, as a large marketing campaign was conducted to convince the Brazilian consumer of the qualities of the ethanol-powered vehicles.

In this respect, the case study indicate an important area that the `greening of industry` field has not paid attention to, namely the interplay between the licenses to operate as a crucial element to understand the relationship between environmental policy, technological development, market imperatives and social benefits. Therefore, the modifications that have been observed in the industry's environmental performance have been the consequence of the joint modifications observed in the three licenses, and not in the industries corporate environmental strategy.

Chapter 7 - The European Union End-of-Life Vehicle Directive

7.1 - Introduction

The following chapter analyses the European Union End-of-Life Vehicle directive (EU ELV) directive in the context of the 'license to operate' framework. It provides the third case study presented in this thesis and addresses the negative environmental externality of waste generation which has been a significant issue in Europe. This has been driven by pressure from landfill and the expense of dumping waste, particularly in Italy, France and Germany (Institute for European Environmental Policy, 1996). These specific issues had not been systematically addressed by any other previous environmental regulation and required a novel approach.

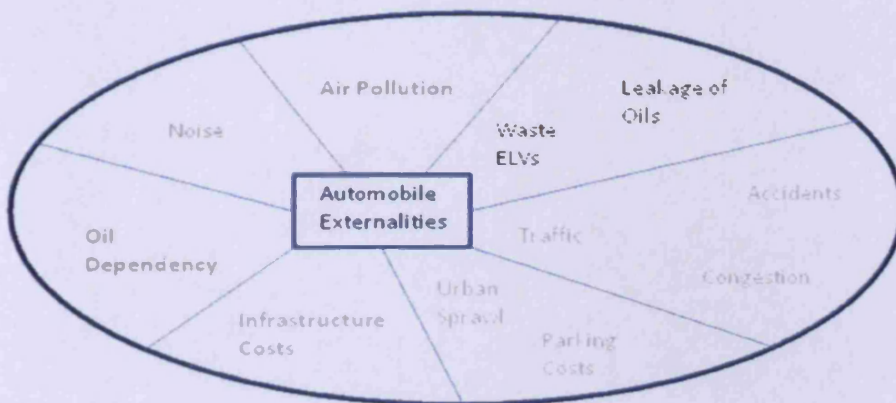
The chapter begins with the implementation of the EU ELV directive and introduces the conceptual framework of Extended Producer Responsibility, which is the core theoretical notion of the legal license. Following this, the main elements of the EU ELV directive are presented. The chapter also discusses the economic and social licenses and the short-term effects of the directive.

7.2 - The relevance of this case study

The EU ELV directive is a distinct case study from the two automobile regulations of an environmental nature previously analysed in this work. It tackles a different kind of negative externality and has been more recently implemented, which limits a more detailed *ex-post* analysis. It does not come into full force until 2015. Figure 6.1 represents the negative environmental externalities that have been addressed in the literature. The highlighted area represents waste caused by the inappropriate displacement of end-of-life vehicles, or ELVs. The leakage of oils in landfills and rivers also constitutes an important environmental issue that is tackled by the EU ELV directive. ELVs also impact

on the use of land for landfill space and produce the contamination of metals and other chemicals besides oil (Bontoux and Leone, 1997). These negative externalities are perhaps not as evident as those addressed by the air emission regulations, and their impact is more indirect. This explains why the waste generated by ELVs was not considered a relevant environmental issue in the early days of motoring. Perhaps, as with air pollution, it is a question of numbers. As the population of ELVs grew, so the disposal problem came to be one of increasing significance. Automobile Shredder Residue (ASR) is classified nowadays as hazardous waste, but perhaps also like air pollution earlier it was not sufficiently appreciated how much of a problem scrapped cars really were (Gonzalez-Fernandez et al. 2008).

Figure 7.1 – Automobile externalities tackled by the EU ELV Directive



Source: Adapted from Delucchi (2003).

By the time the ELV directive was established in Europe, the directive had helped to address the annual creation of around 9 million tonnes of waste in 15 members of the European Community (Institute for European Environmental Policy, 1996).

The EU ELV directive constitutes an important landmark in the environmental regulation

applied to the automobile industry. Not only is the directive a pioneering attempt to tackle material waste from vehicles in the last stage of their life cycle, but it also constitutes a novel legal concept, that of the Extended Producer Responsibility (EPR) principle (Lifset, 1993). The European Union has taken the leadership in dealing with this specific negative externality which has become a major problem in large cities in Europe, where space has a significant value for society (Bontoux and Leone, 1997). The next section discusses the legal license to operate according to the collection, treatment, reuse and recovering of targets.

7.2 - The legal license to operate

The European Union legislation for the treatment of end-of-life vehicles was established by the EU Directive 2000/53/EC. The main goal of the directive was to prevent the waste from vehicles in the last stage of their life cycle and to foster the reuse, recycling and other forms of recovery of end-of-life vehicles and their components. In order to do so, the directive indicated the reduction of materials that are simply disposed of and used for landfill. Economic incentive instruments support the market for ELVs that deal with the end-of-life of vehicles, which include dismantlers and recyclers of old cars²¹.

The Extended Producer Responsibility (EPR) principle is the central legal principle that permeates the EU ELV directive (Johnson and Wang, 2002). One of the first definitions of the EPR was developed by Lindhqvist (1992), this being:

²¹ The directive provides definitions of the following terms: vehicle, end-of-life vehicle, producer, prevention, treatment, reuse, recycling, recovery, disposal, economic operators, hazardous substance, shedder, dismantling operation. Following the elements presented in the directive, the main legislative points are divided into specific articles that deal with the following: prevention, collection, treatment, reuse and recovery, coding standards/dismantling operation and specific procedures, such as entry into force and other technical requirements.

[A] policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the product's life cycle, and especially to the take-back, recovery and final disposal of the product. Lindhqvist (2000, p.154)

This concept provides a systemic understanding of the various ways businesses impact on the environment, as it incorporates the theoretical basis of life cycle thinking. In this respect, there is a change in perspective of firm accountability with regard to their products (Kibert, 2004). The legal and financial responsibility that is imposed by the EU ELV directive, invites firms to widen the analysis of the business model of the firm and move towards a more sustainable production system (Toyo, 2004). The EPR principle implies that the firm should take into account the life cycle of their product, including the last stage of the life cycle of the product. This is a significant step for the automobile industry that has become legally and financially responsible for waste management (Crotty and Smith, 2006). The other major environmental policies applied to the automobile industry (presented in Chapters 5 and 6) have not addressed the end-of-life phase, as the focus has until now been on the production and use phase.

Providing an economic instrument that makes the producers legally and financially responsible to collect, dismantle, treat, recycle their product and use it for landfill in the end of the life cycle, may impose life cycle systems thinking on regulated firms (Toyo, 2004). In the case of the automobile industry, these issues have only recently been taken into consideration. Hitherto, the centre of attention has been on production, with the addition of incremental end-of-pipe measures to solve specific problems, for instance the adoption of the catalytic converter to solve air emission problems (Zapata and Nieuwenhuis, 2010).

Gerrard and Kandlikar (2007) present a time line of the ELV legislation, with the most important events concerning the establishment and implementation of the ELV directive.

Table 7.2 – The EU ELV time line.

Year	Major Facts
2000	ELV (ELVD) directive passed.
April 2002	Deadline for Member State transposition of ELV directive into national legislation (unmet by various countries).
June 2002	Amendment to ELVD Annex II.
Feb 2003	EC Decision establishing coding standards based on the ISO.
July 2003	ELVD ban on heavy metals comes into force.
March 2004	Proposal for Directive on Approval of Vehicles w.r.t. design for 2015 recovery targets – COM (2004) 162 final.
Dec, 31st, 2005	Re-examination of 2014 targets before this date.
2006	ELVD Target: 85% recoverability and 80% recyclability/re-use.
Jan 2007	Free Take-back for vehicles put on the market before July 2002.
2008	Estimated date for ‘design approval based recycling’ requirements come into effect (3yrs after directive proposed in 2004 is enacted).
2015	ELVD Target: 95% recoverability and 85% recyclability/re-use.

Source: adapted from Gerrard and Kandlikar (2007)

On the 18th of September 2000, the EU ELV Directive came into force (2000/53/EC). April, 2002 was the deadline for member state transposition of the ELV directive into the national legislation and the amendment to the ELV directive in June, 2002. In February, 2003, coding standards were established based on the ISO and in July, the important ban on hazardous materials for new vehicles on sale came into force. According to this ban,

new vehicles sold in the EU would not contain lead, mercury, hexavalent chromium or cadmium²².

The directive indicates the measures that need to be implemented by member states in order to prevent the generation of ELV waste; it takes a holistic approach as it incorporates the prevention concept into the design and production of new vehicles that should respect the principles of dismantling, reuse and recovery. In this respect, it follows the general idea that the automobile should be designed with the intention of being recycled after the use phase. The directive also addresses certain materials considered to be hazardous that should not be used in the production of new vehicles as of 1 July 2003. Some vehicle manufacturers had already carried this out (e.g. Volvo) with a list of chemicals to be avoided. There was also a list created by the chemical industry itself (Zoboli, 2000).

7.2.1 - The collection of ELVs

The directive directly addresses the collection of ELVs. It states that the collection of the vehicle shall be done in such a way that the last owner or holder of the vehicle will not be financially responsible for the delivery of the vehicle to an authorised treatment facility. However, the last owner or holder must ensure that the vehicle possesses all the essential components, especially the engine and coachwork. Atasu et al. (2009) indicate that one of the relevant issues dictating the efficiency of take-back systems is the end-user willingness to participate in take-back programs.

The deregistration system demanded by the directive includes national systems for the collection of all the end-of-life vehicles and used parts from repaired automobiles still in

²² A limited number of applications exempted from the provision of this article are listed in Annex II to the Directive as well as scope and expiry date of the exemption and labelling requirement according to Article 4(2)(b)(iv)¹

use. This includes not only the legal aspects, with the introduction of the certificate of destruction when the vehicle is transferred to a treatment facility, but also the geographical availability of collection facilities within the territory that are located at a reasonable distance.

7.2.2 - The treatment of ELVs

A minimum standard for the storage and treatment of end-of-life vehicles, with the minimum technical requirements, was set up in the directive. In order to standardise and limit the ELV operation facilities, the directive requires that each member state should be issued with a permit for operation facilities that will treat end-of-life vehicles. Inspections should be carried out by competent authorities in order to provide permits for the recovery operations for end-of-life vehicles; the authorities will therefore look at the type and the quantities of waste to be treated; the technical requirements to be complied with, and the safety precautions that will be taken in the facilities (2000/53/EC).

The technical method of treating end-of-life vehicles must include the stripping of parts before treatment in order to minimise the impact on the environment, and components and materials should be labelled, with hazardous materials and substances removed and segregated so as not to contaminate the shedding of the vehicle. These authorised facilities will be encouraged to incorporate environmental management systems into their business strategy (2000/53/EC).

6.2.3 - The reuse and recovery targets

The reuse and recovery targets of the directive have been one of the most discussed aspects of the EU ELV directive. The directive indicates that Member States should take the necessary measures to stimulate the reuse of the components when this is possible, and to recover components that cannot be reused, so placing emphasis on recycling

whenever this is possible (2000/53/EC).

Table 8.2 indicates the reuse and recovery targets proposed by the directive. Before the directive was established, car recyclers and dismantlers were already reusing and recovering up to 70 or 80% of the vehicle (Funazaki et al., 2003). The directive, however, gives a minimum percentage of 85% for ELV reuse and recovery in Member States. These limits were calculated by the average weight per vehicle with effect from January 2006, to be increased to 95% by 2015. Less stringent limits of 80% and 85% respectively were set for reuse and recycling and consideration was given to the review of the re-examination of the targets and the establishment of targets that go beyond 2015²³ (2000/53/EC).

Table 7.3 – EU ELV directive Reuse and Recovery Targets

Date	ELV reuse and recovery Limits	Reuse and recycling Limits
Before the Legislation	70 – 80 %	None – variable depending on the market
1 January 2006	Minimum of 85% by an average weight per vehicle and year.	Minimum of 80% by an average weight per vehicle and year.
1 January 2015	Minimum of 95% by an average weight per vehicle and year.	Minimum of 85% by an average weight per vehicle and year.

Source: 2000/53/EC.

Material coding standards have also been set up. Dismantlers need to identify materials,

²³ - Less stringent parameters for vehicles produced before 1980 have been set up.

which can be used for reuse and recovery. Producers have, in this sense, to provide dismantling information for each type of new vehicle that is launched on the market six months after the first units appear in the market, where different components and materials are used, and the location of all hazardous substances in the vehicle.

Another aspect of information established by the directive concerns the implementation process of the directive in each member state. A report at three-year intervals is required by the commission by each member state. In this report, there is relevant information regarding the possible changes in the structure of motor vehicle commerce, and on the collection, dismantling, shedding, recovery and recycling industries that may result from the effects of the competition between Member States. The latter should also require all the economic operators to publish information regarding the design of the vehicles and their components, the treatment of end-of-life vehicles, any innovation regarding the reuse, recycling and recovery of end-of-life vehicles, and any progress in the recovery and recycling to reduce waste.

These targets are not without criticism. 'The approach taken to establish the parameters has been legalistic and not technical' (UK Government Representative, personal communication, 22 August 2007). The establishment of future parameters have not always been technically feasible because the process that led to the implementation of the ELV directive was so complex. Lobbying by automobile firms has been an important element in this process; although the parameters have been set at 80%, 85% and 95%, the intrinsic uncertainty related to R&D and innovation remains as there is no guarantee that the targets set for 2015 will be met. Studies have also been conducted on the possibility of meeting the 2015 recycling quotas, upgrading the technologies available for processing the light and heavy fraction of the automotive shredder residue by developing the separation technologies and finding recycling possibilities for the products gained from the separation (Ferrao and Amaral, 2005). Additionally, extensive research in shredder technology requires extensive shredder residue separation and recycling technologies, as indicated by Francois (2003) and Vanherpe (2003).

7.3 - The economic license to operate

The history of how the implementation of the EU ELV came about provides relevant elements to understand the formation of the social license. In August 1990, the German Ministry of the Environment (BMU) stated their intention to adopt the Extended Producers Responsibility as policy guiding principle for the end-of-life issue which was to be applied to car makers operating in Germany. Here, the proposed legislation planned to make automobile firms financially liable to collect and treat end-of-life vehicles at their own expense.

The automobile firms immediately opposed the direct regulation that would have resulted from the command-and-control framework. The strategy of the German Association of the Automotive Industry (VDA) was to create a study group to provide further information in relation to the issue and present a substitute solution for regulators. A study group called 'Concept for the Future Processing of Old-Vehicles' was therefore set up by the VDA to investigate the recycling and dismantling issues (Orsato et al., 2002).

The complexity of automobile dismantling and recycling posed a great challenge for automakers as the vehicles had been constructed with no concern for dismantling and recycling. Therefore, the vast amount of material and number of parts made the entire operation a cumbersome activity. Pilot dismantling projects were later established and conducted for the creation of 'recycling networks' between the dismantling industry and the automobile firms (Orsato et al. 2002). These networks focused on larger plastic parts, such as bumpers, dashboards and other large homogenous plastic vehicle components; plastics were already perceived as a great challenge due to recycling technical limitations and the economic costs related to plastic recycling.

In 1991, 'Used-Car Utilization Project of the German Automobile Industry' (PRAVDA) was established and focused its efforts on the recycling of end-of-life vehicles. The VDA elaborated a common concept for the recycling of vehicles, following new proposed

targets to be established in conjunction with the industry (Orsato et al., 2002). The active members of the group were BMW, Ford, Mercedes Benz, Opel, Porsche and the Volkswagen Group. PRAVDA contributed substantially to the draft of a joint recovery plan, which included: public information in relation to car recycling, testing material cycles, and most importantly, the implementation of large-scale experiments for dismantling and material recycling (Bunderministerium für Bildung und Forschung, 1999). As expected, the PRAVDA opposed the introduction of the Extended Producer Responsibility Principle for ELVs and offered an alternative solution. PRAVDA supported shared responsibility among all the stakeholders involved in the end-of-life issue and the self-regulation of the industry in relation to the recycling targets and the economic costs of the system. In 1996, the BMU accepted the cooperative agreement.

The same cooperative agreements were followed in France - *Accord Cadre* and Italy - Fiat's FARE system. Both the Italian and the French automobile industries associations proposed voluntary agreements. In the case of the French, the *Accord Cadre* was a consequence of the ADEME 9, the French state agency for the Environment and Energy conservation to develop the policy framework for the European ELV project group. The *Accord Cadre* was an agreement between the government and the French automobile producers to reduce ELV disposal and the cooperation among the stakeholders of the ELV supply chain (Aggeri and Hatchuel, 1997).

In the case of Italy, the government followed the lead of FIAT in dealing with ELVs and a network was created that was headed by the firm. A national agreement was established following the initial operating system of 1992 (Zoboli, 1998). In all these nations, there has also been an aspect of regulatory capture, as national governments had to be willing to accept the voluntary proposals of the home-based industries. The cooperative voluntary agreements constituted a positive short-term outcome for firms to escape direct strict regulations and for governments to accept a less stringent solutions.

On the EU-level the ELV was incorporated as a priority waste stream in 1989. The

French were responsible for establishing an ELV Project group, following the experience of the Accord Cadre. The group was represented by the various representative stakeholders of the ELV process, and in 1994, a proposed strategy was produced. The ELV project Group of 1994 set up several targets, including the drainage of fluids, the recycling of at least 85% of the total car weight by 2002 and the recycling of 95% by 2015. In 1996, the European Commission (EC) perceived that the voluntary agreement model was flawed since there were substantial differences between agreements at national level and it requested parliament to present a proposal on ELVs and to make use of the Producers Extended Responsibility Principle (Zoboli, 1998). The proposal was then duly prepared and presented as a directive. The proposal was the result of the ELV project group and a wide stakeholders' consultation process that was carried out in the following years.

The use of the directive is based on the necessity to harmonise the ELV policies at EU-level. The creation of a single European market meant that products could be bought and used without regard for national boundaries within the European Union. Hence, a common approach akin to European Type approval was logical. At the time the uncoordinated national efforts would generate negative effects on international competition, but harmonisation of the standards would overcome this issue. The use of the directive also allowed for a certain flexibility of the member states in the framework of the binding. The directive was eventually set up following other waste management principles adopted by the EU directive, which included the free take-back for the final consumer or holder of the vehicle (Zoboli, 1998).

The ELV directive was identified as one of the first EU priorities on the waste stream program. Each member state has had to implement the general aspects of the directive by incorporating the directive to the national legislation. One of the most pressing aspects of the ELV directive has been the implementation of the directive at national levels. Ferguson (2007) indicates the following issues that have affected the implementation of the directive on the EU level. The majority of the problems are as follows:

Export of second-hand cars before they reach their end of life is an important (and possibly growing) feature of the European car market.

- The legitimate second-hand trade masks some illegal activities, such as the export of wrecked or stolen cars.
- A significant number of cars in some countries are being scrapped by unlicensed operators who remove the economically desirable parts.
- Some cars are still abandoned rather than properly scrapped.
- Some end-of-life vehicles are 'garaged' rather than scrapped. (Ferguson, 2007)

There is a great variety in the waste disposal arrangements between member states (European Commission, 2009). Some of these were established before the EU ELV directive was set up so they have not been structured to comply with the regulations foreseen in the Directive. The EU ELV Directive also sought to regulate the cars that were already in the market. The negotiation process was particularly divisive as the automobile firms would not support the notion that they would have to take legal and financial responsibility for vehicles already in the market (Orsato et al., 2002). In addition, the EU ELV Directive did not contemplate the funding of the 2002-2007 period.

However, when the European Commission introduced the ELV directive, the industry was forced to follow stricter standards for recycling and more stringent target recycling percentages were established for the period to 2016 (2000/53/EC). In fact, the Commission has introduced an outcome where the industry has lost in terms of flexibility of implementation as it will be forced to invest in additional research and development in order to meet the requirements of the directive for the year 2016 (Representative Nissan Europe, Personal Communication, 03 July, 2007).

It should be indicated that in the first stage the industry hired the already existing recycling industry. Here, the nature of the business is different, as there are levels that need to be divided between the dismantlers, the shredder, the extract and remelt of

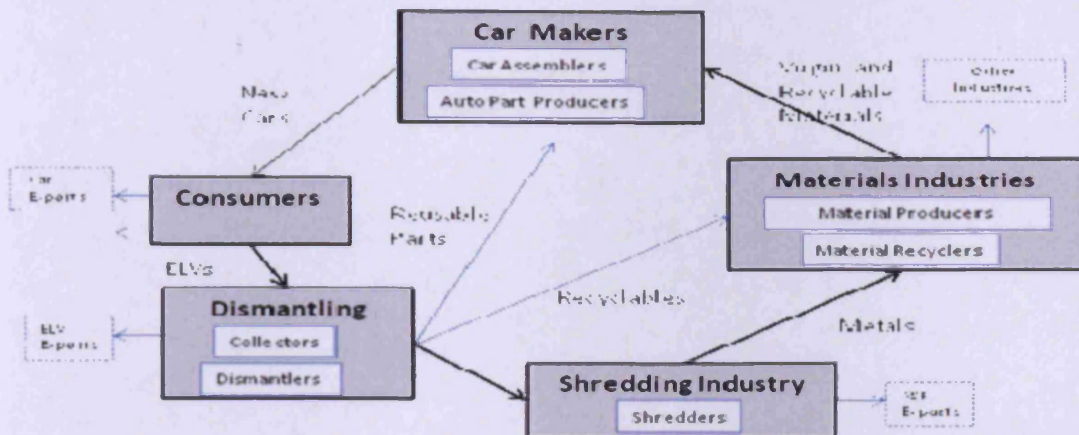
metals, as well as the metal suppliers (Mike Rivers, Personal Communication, 25 July 2007). However, the case study indicates that in order to meet the 2016 recycling requirements, automobile manufacturers will have to invest in the research and development of material and dismantling technologies so that the targets can be met.

7.4 - The social license to operate

The EU ELV directive influenced a wide range of stakeholders including automobile firms, suppliers, consumers, local authorities, national authorities and the recycling and dismantling industry. Recyclers and dismantlers have been operating in Europe for decades with a relatively low control over their operations. The dismantling and scrap metal industry is composed of a very large number of firms, with a significant part composed of small dismantling operations (Den Hond, 1998). Figure 7.2 shows the stakeholders involved in the ELV market alongside the material flows among the stakeholder groups. The life cycle notion that can be gained from the schematic representation is important as the EPR principle adopted in the EU ELV directive provides a legal framework with the intention of enhancing the material flows between these stakeholder groups, and particularly to enhance remanufacturing and reuse.

The implementation of the EU ELV directive was intended to organise the end-of-life phase of the automobile by setting standards for the dismantling and shredding industry. Here, minimum environmental standards and technical specifications have been established on relevant issues, such as dismantling, residue treatment and facility operation. For example, the Authorized Treatment Facilities (ATFs) must possess concrete floors to prevent the leakage of fluids into the ground (Environment Agency, 2010). However, the monitoring of the facilities is still a troublesome aspect for the environmental authorities as some of these firms are small-scale dismantlers and are dispersed throughout large urban and rural areas (ELV industry representative, personal communication, 09 July 2007).

Figure 7.2 – The ELV processing system



Source: based on Den Hond (1996).

Zoboli (1998) indicates the reaction of different stakeholders to the proposal of the directive; the reactions of automobile firms, dismantlers and plastic producers are summarised in Table 6.1. The *Association des Constructeurs Européen d'Automobiles* (ACEA) publicly opposed the proposal (ACEA, 1998). The major points that were raised by the ACEA were the preference for mechanical recycling, the restriction on certain materials, the future targets for recyclability, the choice of a directive and the free take-back proposition. As expected, the dismantlers accepted the free take-back and also accepted the quantified targets, the choice of the directive, and the use of authorisations and certificates of dismantling. The plastic producers followed the ACEA's position in all the points of the ELV directive proposal and criticised the quantified targets, as they perceive that they might lose the market to other materials.

Despite the open opposition from automobile firms and the plastic producers, and some criticism from the dismantlers, the EU ELV directive was established in 2000. The next

section provides a more detailed explanation of the EU ELV directive.

Table 7.4 - Reactions by main industrial actors to ELV Directive proposal

Points of the ELV directive Proposal	Car producers	Dismantlers	Plastic Producers
Choice of a directive	Criticised in favour of a VA	accepted	criticised
Quantified targets	accepted	accepted	criticised
Authorisations and certificates in dismantling	Accepted	accepted	accepted
Preference for mechanical recycling	criticised	---	criticised
Restrictions on heavy metal and on PVC	criticised	---	criticised
Regulations on recyclability	criticised	criticised	criticised
Free take back	opposed	accepted	opposed
Parts' marking and dismantling manuals	accepted	---	---

Source : Zoboli (1998)

7.5 - The effects of the EU ELV directive

This section discusses three specific effects of the implementation of the EU ELV directive in Europe. Initially, the cooperative partnership between automobile firms and the Dutch government is presented. This has been a unique system that was adopted in the Netherlands and has been indicated by the EU as one of the most efficient recycling and recovery national systems. Following this, the establishment of large recycling facilities in Spain as a result of the directive is outlined. This shows how the recycling market has been directly affected by the implementation of the EU Directive. Finally, the effects on automobile makers are introduced. Data here was gathered at two major automobile firms in the United Kingdom concerning design modifications and changes in the use of materials.

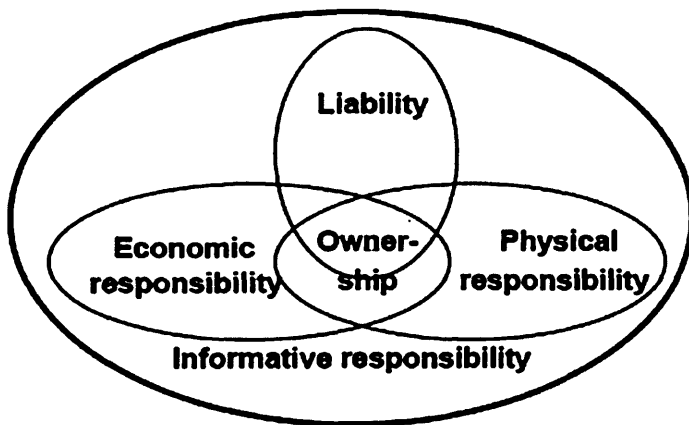
The adoption of the Extended Producers Responsibility Principle concept has generated a series of distinct yet complementary interpretations. On the one hand, the EPR concept has been interpreted as a concept that solely addresses issues related to waste management (Shiota, 1999). On the other, a wider adoption of the notion can be depicted. The EPR concept also serves as a guide to the environmental production systems evolution. The introduction of the concept permeates business decisions in all the phases of the product and involves other stakeholders involved in the production process (Lifset, 1993; Lindhqvist, 2000).

Lindhqvist (1992) provides a useful understanding of the types of responsibilities addressed by the implementation of the concept and which have a direct impact on firms. According to his analysis, the EPR concept involves liability, financial responsibility, physical responsibility, informative responsibility and ownership. By liability, Lindhqvist (2000) means that firms become legally liable for the environmental negative externalities generated by their products and services. The EU ELV extends the liability of automobile firms for the collection, dismantling, treating and recycling of old vehicles. Economic responsibility refers to the financial liability of funding the system.

Manufacturers take on the financial responsibility for the collection, recycling and final disposal of the products. However, it is relevant to point out that the ELV system has been adopted differently in each European Member State. The Dutch system, for example, operates as a deposit refund system

In the case of the EU ELV directive, manufacturers take responsibility for all these areas. In some cases, firms have been contracted to take care of specific parts of the end-of-life phase, but the entire system is the manufacturers' legal responsibility. Figure 6.3 provides a graphical representation of the types of responsibility envisioned by Lindquist, and how these different types of responsibilities interact. The graph shows that informative responsibility is the widest option, and encompasses all the other forms of responsibility.

Figure 7.3 – The Extended Producer Responsibility Principle



Source: Lindqvist (1992).

The assimilation of the EPR concept by the EU ELV directive can be used by firms to assess their business model in environmental terms (Toffel, 2003). Additionally, the informative responsibility leads to a wider accountability by the producer towards the consumer (Lindqvist,1992). The necessity of providing information in relation to the

product to the consumer is a central element in the implementation of the EPR concept with the EU ELV directive.

7.5.1 - The short term effects

The short term effects of the implementation of the legal license are divided in two major areas: impacts on the other stakeholders involved in the process of dismantling and collecting old vehicles and the impact on the changes in design and materials.

To have a better grasp of the effects on the scrapping industry, the example of the effects on the Spanish market are taken as representative. The Spanish case is indicative of the large impact that the introduction of the ELV directive had on the scrapping industry. In 1996, an ELV framework agreement was established by the Ministry of the Environment and the Ministry of Industry. The negotiation process that led to the signature of the agreement had large stakeholder participation, which included: automobile firms, automobile importers, auto-part producers, automobile dealers, automobile insurers as well as the dismantling and recycling industry. This framework was responsible for governing the situation until 2000, when the EU ELV directive started to be implemented. The directive was eventually fully established in November 2003.

The interviews and visit were focused on the implementation of a large facility that was established in the Basque Country. A new and large recycling facility that was set up in 2004 in the north of Spain is analysed. The facility is a clear indication of how the sector has changed due to the incorporation of the Directive at the European level. Significantly, Spain has the highest recovery rates in Europe (90%) (SIGRATO, 2008).

The adoption of the EU ELV Directive fostered the implementation of larger ELV treatment centres in Spain. In 2000, around 3,000 scrap yards existed in Spain and

Portugal. In 2007, 800 had the received approval to operate under the new rules of the Directive. Several new and large facilities were established and some of the smaller and older operations disappeared. The establishment of the GCR Car Recycling facility in the north of Spain is illustrative of the modifications that occurred in the market. A facility with the potential to recycle 25,000 vehicles per year was established in 2004 in the city of Bilbao. After the car recycling firm started its operations, 17 other smaller dismantlers closed their businesses. Some of these were not able to adapt their operations to the more stringent requirements of the directive, while others felt that the last owners would prefer to deliver their vehicle to larger and newer facilities (ELV Representative Spain, personal communication, 05 December 2006).

Nowadays, Spain has 320 authorised recycling facilities and the highest recycling rates in the Europe. According to the last assessments of the Spanish Association of End-of-Vehicle Treatment (SIGRAUTO), the country has been able to recover and recycle 90% of the average weight of all the vehicles brought to dismantling centres. This is due to specific technologies that have been locally developed to recycle glass and other plastic composite parts (SIGRATO, 2008).

7.5.2 - The environmental impacts

The ELV policy developments in the United Kingdom started from the involvement of industry and government in the activities of the CEST Group and resulted in the constitution of a cooperative initiative, called the Automotive Consortium on Recycling and Disposal (ACORD). This involved the car manufacturers and importers (SMMT), material and component suppliers, shredders, dismantlers, the recycling industry and the Departments of Industry and of Environment. After a preliminary plan in 1992, ACORD launched the implementation plan in 1995. Incineration was included among the possible solutions, the targets being the reduction of ASR by 40% by 2002 and 80% by 2015 (Ferguson, 2007; den Hond, 1996).

Following the implementation of the ELV Directive that came into effect in November 2003, the automobile industry had to adopt several measures to ensure that the requirements would be met. Ford Motor Company serves as an illustrative example of efforts that were implemented by major automobile firms in Europe.

In the United Kingdom, the strategy of Ford Europe was formed and major steps were implemented in all the European countries affected by the Directive. Ford UK established collecting and treatment sites to meet ELV Directive requirements and Ford signed an agreement with Cartakeback Ltd to provide collection and recycling services for the customers of Ford Group brands sold in the United Kingdom at the time, namely for Ford, Jaguar, Land Rover, Volvo, Aston Martin and Mazda. Ford ensured free car take back for every vehicle under their brands, which included the following conditions for free take- back; the cars should be:

Valid for all passenger vehicles with up to nine seats and up to a permissible total weight of 3.5 tonnes; Vehicles must be delivered to a Ford-appointed free take back facility; Vehicles must be complete, containing the essential components including engine, transmission, coachwork, wheels and catalytic converter (where fitted); Vehicles must be free from additional waste (such examples include garden/household waste, additional tyres etc) (Ford Motor Company, 2006).

Ford has developed a vehicle recycling program that encompasses 'design-for-recycling guidelines', which were initially established in 1991. Amongst the most important pillars of this strategy, the reduction in the number of parts, the speed to dismantle a vehicle, the increased use of recycled material and the reduction of hazardous materials are the most relevant. This includes efforts to recover and recycle plastics. The introduction of the EU ELV Directive has fostered the establishment of several new technologies in vehicle recycling, decontamination and reuse in the ELV supply chain. However, there has not been a significant step forward from vehicle manufacturers with regard to the design of the vehicles that would be more suitable for the end-of-life phase (Gerrard and Kandlikar, 2007). The design of new vehicles is still not fully concerned with the necessity of it

being dismantled; the need for recycling, treating and dismantling the vehicle has become a growing concern amongst automobile designers, but issues such as aesthetic design, functionality, manufacturability, economic costs and brand tradition are more important (Representative Nissan Europe, personal communication, 03 July, 2007).

Gerrad and Kandlikar (2007) also indicate that there is a considerable time lag between the design of a new vehicle and its eventual production and disposal. Innovations have been focused on recycling and not on deeper design modifications. This leads to sub-optimal solutions where the system fosters recycling instead of remanufacturing and reuse.

In general terms, automotive firms focus their business model on selling and financing new vehicles, with the result that other potential areas of business such as remanufacturing and reuse are satellites. In this sense, reused parts many constitute a secondary business but also take away interest from the main focus of the firm. Therefore, commercial agreements with other firms that specialise in collecting, treating and recycling end-of-life vehicle has been the best option pursued by vehicle manufacturers.

Following the interviews in the sector in the United Kingdom and in Spain, automobile firms indicate that an important aspect of the end-of-life collection system is the collection point in itself (ELV Representative Spain, personal communication, 05 December 2006; Mike Rivers, personal communication, 25 July 2007). According to their understanding, the collection point for ELVs must not be next to the new car selling points as they perceive both businesses on opposite sides of the scale. Automobile firms therefore desire to separate the business of selling new vehicles and the collection and treatment of old cars completely (Mike Rivers, personal communication, 25 July 2007).

Table 7.4 – Expectations of the EU ELV directive

Expectations of the EU ELV directive	Assessment
Design changes	
1. Changes in the material composition of new cars	Limited
i. Increased use of recyclable and environmentally beneficial materials	Limited
ii. Increased use of recycled material ('recyclate')	Verified
iii. Removal of 'banned' substances	Verified
2. Increased 'design for disassembly, re-use and remanufacture'	Limited
<i>Changes in the extent of ELV recovery:</i>	
3. Increased levels of re-use and remanufacture	Verified
4. Increased levels of recycling of ELV materials	Verified
<i>Improved information provision:</i>	
5. Provision of the following information:	
a. Part coding standards	Verified
b. Disassembly processes, disposal and recovery of vehicle parts	Verified
c. ELV environmental performance, targeted at vehicle users/purchasers	Verified

Gerrard and Kandlikar (2007) presented an evaluation framework to understand the primary effects of the ELV directive. They assessed five anticipated changes that could have been fostered by the implementation of the ELV directive, including: 1- Changes in the material composition of new cars; 2 - Increased 'design for disassembly, re-use and

remanufacture’; 3- Increased levels of re-use and remanufacture; 4 - Increased levels of recycling of ELV materials; 5 - Provision for the following information in relation to Part coding standards, disassembly processes, the disposal and recovery of vehicle parts and ELV environmental performance targeted at vehicle users/purchasers. Table 7.4 provides a summary of the EU ELV expectations. The table is divided in three large sections: Design Changes, Changes in the extent of ELV recovery and improved information provision. Under each of these headings there are subdivisions that have been analysed. The assessment is the summary of the interviews.

Despite the usefulness of the framework of Gerrard and Kandlikar (2007), their study is limited by the use of company reports and other media sources to gather information with regard to the steps taken by automobile firms, the dismantling industry and governments. The conclusions presented in Table 8.4 have made use of information gathered from face-to-face interviews.

7.6 - Conclusion

The EU ELV directive constitutes an important landmark in environmental regulation as applied to the automobile industry. This case study provides a different angle from the two previous ones as it the most recent regulation to be established and has taken a longer period for member states to enact the legal license. In this respect, the *ext-post* information available to conduct a more detailed analysis of the impacts of the EU ELV directive has been more limited as the impacts of the ELV directive will only be fully felt as automakers design new vehicles and the 2015 targets are put in place. However, the introduction of the EU ELV directive provides a relevant case to understand the adoption of a broader legal license that implements the extended producers’ responsibility principle.

This is a significant step towards broader sustainability preoccupations in the license to

operate, as the concerns have shifted to more complex environmental concerns than the simple direct end-of-pipe measures. The introduction of the extended producers' responsibility principle (EPR) has the potential to have a significant impact on the economic license to operate of the industry, as well as the implications of the business model of the firm with regard to the use and waste management of materials. Lindhqvist (1992) provides a functional notion of the types of responsibilities addressed by the implementation of the concept which have a direct impact on the firm.

The implementation of the legal license contributes relevant insights into the relationship between environmental regulation and the auto industry technological development, commercial imperatives and wider social benefits. Following the pattern of the other cases presented in this thesis, the industry has opposed the implementation of such a directive. More lenient 'voluntary agreements', were offered by the industry, based on shared responsibility between automakers and the recycling industry. However, the industry, eventually, accepted the implementation of the Directive at the European level, as the EC established the same rule to be incorporated by all the Member States.

In the case of the ELV, scrappage schemes have been set up with recycling incentives, and therefore there could be problems with interconnectivity. The industry did however agree with the EU on subsidies for the scrappage schemes, as they have given ground to negotiate on these agreements. Moreover, the agreed targets on the ELV directive potentially helped to defuse criticism of the environmental cost of the scrappage schemes.

The incorporation of the Directive in different European Member States has had several effects on policy. In order to consider these issues, this Chapter has briefly addressed these problems in different contexts. Ford Motor Company has served as a portrait of the response by automobile firms. Following the analysis conducted by Gerrard and Kandlikar (2007), the following primary effects were identified: changes in the material composition of new vehicles; increased 'design for disassembly', re-use and remanufacture and increased levels of remanufacture and re-use. The effects on the

recycling industry were illustrated by the introduction of the Directive in the Spanish market; this has been a factor in the reduction of the number of small and uncontrolled dismantling facilities and has fostered the establishment of larger facilities that follow more stringent environmental standards.

Chapter 8 - Conclusions

This work seeks to provide a contribution to the body of literature that has been classified as the 'greening of industry'. As previously indicated at the heart of this study, the following research question has served as the main thread of analysis:

What is the relationship between environmental regulation and auto industry technological development, commercial imperatives and wider social benefits?

Following the theoretical discussion provided in Chapter 2 and the researchable propositions that have been investigated in the case studies, a set of conclusions are presented in this chapter to respond to the central research question. The chapter is divided into the following sections: the cases studied, the suitability of the license to operate framework, the dominance of the commercial imperatives, the auto industry technological development (which has merely followed the minimum requirements imposed by regulations), extensions of the license to operate framework, implications for the 'greening of industry', implications for industry, implications for policy makers, limitations of the analysis, future developments and a portfolio of future research.

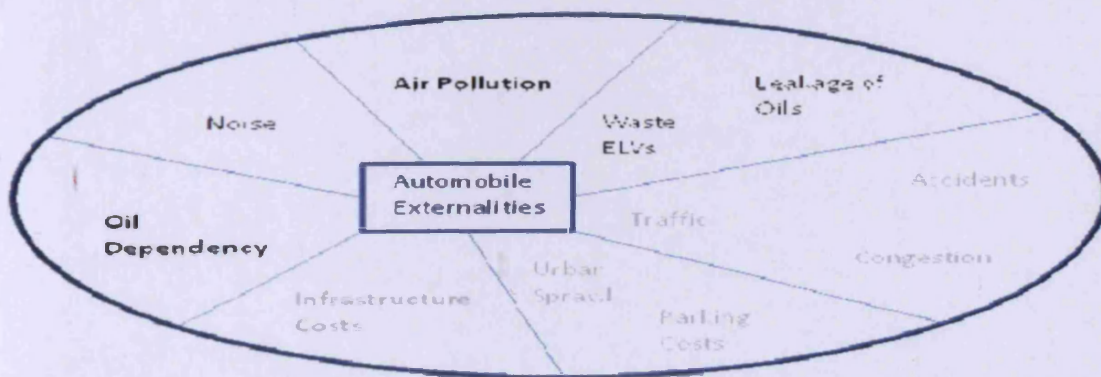
8.1 - The cases studied

The cases show how and to what extent regulation has been able to direct corporate environmental performance in the automobile industry. Here the industry, while respecting commercial imperatives, has been able to implement various technology solutions to the legal requirements imposed to deal with negative environmental externalities, so generating significant social benefits. Here, pioneering regulations that have affected the automobile industry were selected since they represented new areas of regulatory pressure at the time; they were also important cases for the investigation of the

relationship between regulation and automobile industry technological development, economic necessities and wider social benefits.

Figure 8.1 shows the negative environmental externalities analysed by previous literature on the environmental effects of the automobile (Delucchi, 2003). The cases selected in this thesis focus on air pollution, oil dependency, noise, waste from end-of-life vehicles and the improper discharge of oils, these being direct consequences of the use of the automobile itself and related to the technical limits imposed by the internal-combustion engine vehicle. Figure 9.1 also presents other areas that have been dealt in the literature, but these are not directly addressed in the cases selected in this thesis. Rather, these are indirect consequences of automobile use and refer to transportation systems as well as infrastructure arrangements. It is relevant to mention that Figure 9.1 does not indicate climate change as an automobile environmental externality addressed by the academic literature; a more complete classification of the effects of automobile use would include climate change as a prominent element.

Figure 8.1 - Automobile environmental externalities addressed by the academic literature



Source: Adapted from Delucchi (2003).

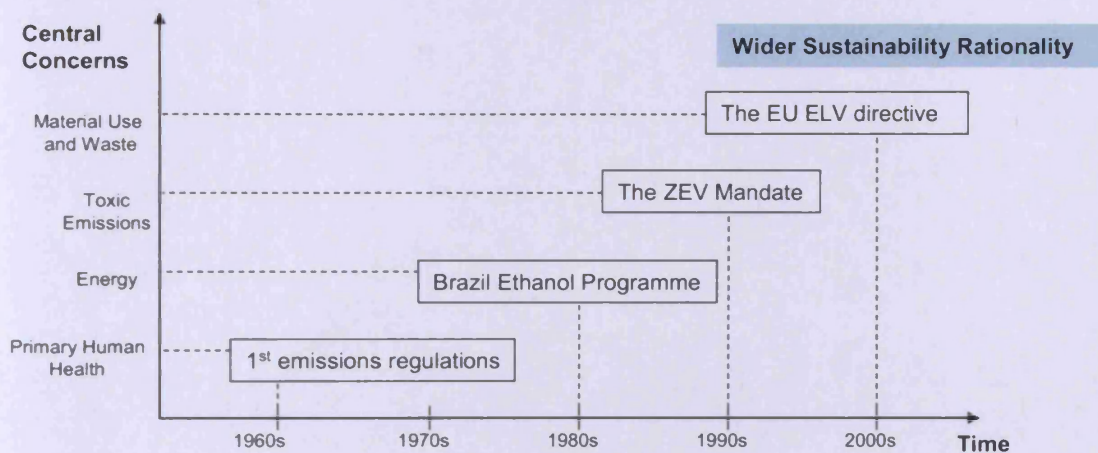
The cases indicate that social pressures have been responsible for shaping the legal license with regard to the environmental effects of automobile use; the case studies also show that regulations have generated positive environmental benefits to society. For each of the cases, new technologies were developed and adopted with the main focus of fulfilling the requirements of the legal license.

The selection of the case studies presented in this thesis followed a historical perspective for the social perception of the environmental impact of the automobile. Figure 8.2 shows the cases that have been selected along with the central concerns indicated by the legal license at the time. The figure also provides an idea of the development of regulation towards wide sustainability concerns, which are relevant for the 'greening of industry'. Although it can be argued that all environmental regulations have human health as a central concern, other issues have been highlighted by legislators as the primary focus of regulation; these include the reductions in air emissions, energy use, toxic emissions and the use of materials and waste management. The cases, therefore, portray a chronological development as regards the areas that have been subject to regulatory pressure. These changes arise as a result of improved knowledge and an understanding of the environmental impacts, and from greater vehicle ownership and use. The development towards wider sustainability concerns is therefore relevant for the discussion provided in this thesis, and for the development of the 'greening of industry' body of literature in the context of the automotive industry. As regulation has begun to address wider sustainability concerns, corporate environmental strategies need to take the environmental dimension into account since the cases have indicated a direct link to the business model of the industry.

The selection of the cases follows the concern of the field to understand the 'big picture' of corporate greening (Kallio and Nordberg, 2006). In this sense, the relationship between environmental regulation, auto industry technological development, commercial imperatives and wider social benefits has been investigated in cases of environmental regulation, these having been brought out for auto industry technological development.

The cases are complementary in this respect, as they are able to provide a historical account of the evolution of the regulatory process for a specific industry and for the stakeholders involved in the process, and add to the discussion on the 'greening of industry'. Additionally, the case studies are illustrative of the flexibility of regulation, especially on how environmental regulations can be adopted differently in specific political and local environments. They are also representative of three different regions of the world in continuous time frames where the use of the automobile has constituted an environmental and socially relevant issue.

Figure 8.2 - The central concerns of the case studies



The air quality emissions regulations in California and the European Union End-of-Life Vehicle directive are classic cases of environmental regulation. In both instances, regulators implemented the legal license to deal with specific negative environmental externalities produced by the automobile. In the California case study, the process of regulation from the pioneering regulations of the 1950s to the present day was studied.

The initial group of mandates constituted strict command-and-control laws that forced the industry to take environmental-related measures which directly affected the way vehicles were designed. Another important measure to be established was the ZEV mandate that required an increase in Zero-Emission Vehicles (ZEVs) to be offered by automobile manufacturers in the State of California. The emissions standards pioneered in California then became the basis for similar legal regulatory mandates in several parts of the world.

The European Union End-of-Life Vehicle directive was innovative in introducing the 'producers extended responsibility principle' to the automotive industry: according to the European mandate, vehicle manufacturers are legally and financially liable for vehicles until the end of their lives. The ELV directive also provides important elements for the incorporation of sustainable development concepts into its policy making. Further, it has a wider preoccupation with material use that incorporates more complex thinking around the relationship between industry and the environment. In addition to this, it can still be argued that the final preoccupation is with human health, yet the reasoning behind the legislation derives from a deeper environmentalist rationale. Here, the ELV regulation has the potential to incorporate in the regulatory system a deeper understanding of sustainability.

The case study on the Brazilian *proalcool* programme presents a case of an auto industry technology-inducing mandate with positive environmental benefits. Here, the *proalcool* is not a classic case of the 'greening of industry' as fostered by environmental regulation. Despite the fact that environmental benefits are mentioned in the initial document of the programme, the main focus was initially on energy security. In 1978, after the second world oil embargo, the Brazilian government decided to explicitly foster the use of sugar-derived ethyl alcohol fuel as a substitute for imported oil. This provided an important lesson on how the nature of the license to operate can evolve. The case shows where the classic case of the 'greening of industry' has been reached via a different route, and provides an important lesson in the field, as it has been shown that the 'greening of

industry' can be achieved through non-traditional routes and with diverse regulatory forms. The environmental benefits provided by the use of ethanol were particularly significant for the highly populated cities of Sao Paulo and Rio de Janeiro, which had historically suffered the effects of automotive emissions. For its part, the US has replicated this concern with energy security as regards the support of corn-derived ethanol, but in Brazil the emphasis is now on the environmental aspect of the program. The Brazilian experiment also provided important insights concerning the debate that emerged in the 2000s, both in Europe and the United States, around the use of ethanol as an environmentally-friendly fuel.

8.2 - The suitability of the 'license to operate' framework

The initial contribution of this work was to test the suitability of the 'licence to operate' framework in order to respond to the issues regarding environmental regulation and technological development associated with economic imperatives and wider social preoccupations in the context of the automobile industry.

The 'license to operate' framework has been used to unveil how the relationships between environmental regulation and auto industry technological development, commercial imperatives and wider social benefits come about in each of the selected cases. According to the 'license to operate' framework, multi-faceted legal, economic and social licenses simultaneously motivate and constrain the actions of industry, so producing a relevant effect on the environmental performance of the industry (Gunnigham et al., 2003, 2004; Hoffman, 1999). A wide range of stakeholders influence licenses simultaneously, and the interaction between the terms of the three licenses produces a combined effect over the management style of the industry. How stakeholders perceive the negative externalities produced by industry is highly dependent upon the type of industry and the interplay between the three licenses since the net result of the

interactions between stakeholders is context specific (Gunnigham et al., 2003). The framework therefore requires a rich description of the external contingency of the events which have led to the constitution of the legal license and determines how the three licenses interact with each other so that the relationships between the key elements of the main research question can be depicted.

The 'license to operate' framework has also been used to discuss issues in other industrial sectors, such as the chemical, paper and mill industries, but it has not been used to examine concerns in the automobile industry (Hoffman, 1999). This industry was selected because it constitutes a very important global industrial sector and has significant implications for the environment (Nieuwenhuis and Wells, 2003). The automotive industry has also served as a benchmark for other industries undergoing similar regulatory pressures (Delucchi, 2003). In this sense, it has the potential to contribute to the development of the 'greening of industry' body of literature.

The 'license to operate' framework is also flexible, as it can be applied to an entire industry or to individual firms. Moreover, the malleability of the framework has desirable properties with which researchers can discuss industry-related problems. However, as indicated by Gunningham and Grabosky (1998), a good description of the external contingencies is necessary to provide meaningful insights, based on the empirical appreciation of the formation of the three licenses. Initial studies using the framework were concerned with understanding the differences between the leaders and laggards within the same industry, and establishing how firms facing similar licenses have been able to display different environmental performances (Gunnigham et al., 2003). This work has taken an alternative route, applying an aggregate framework to specific regulations in diverse points in time as well as to historical backgrounds in order to understand how the interplay between the different types of licenses influence the environmental performance of the firms within the automobile industry. The differences observed between the firms are therefore indicative of the diverse interpretations of the macro-level licences that each firm may have in each of the cases.

The selected cases were specifically picked to understand the relationship between the legal license and technological development, alongside commercial imperatives and wider social benefits. These cases show that the relationships are framed for specific historical and circumstantial backgrounds, thereby making generalisations complicated. The selected cases point to an intricate connection between environmental regulation and the economic performance of the industry, which is much more complex than the initial theories of the Porter and van der Lind hypothesis (1995), for example. According to this initially influential perspective, properly designed environmental regulations would have a positive competitive effect for firms and regulators would be able to direct firms to seek more profitable outcomes. Other developments of the hypothesis have also failed to demonstrate the complexity of the relationships, as detailed by Lanoie et al. (2007). The second generation of the 'greening of industry' studies, criticises the Porter and van der Lind hypothesis by presenting a detailed perspective of the dynamic and intricate links that need to be accounted for in environmental regulation. These include: consumer response, the prices of complementary and substitutable goods, the economic situation of the industry, the political environment, market structure, the barriers to entry and legal issues (Reinhardt, 2000).

With the use of the 'license to operate' framework, it can be concluded that the relationships in question need to be perceived under a broad framework which can account for the influence of several stakeholders and this must include not only economic elements but also other less quantifiable issues, such as the social dimension. In this sense, the 'license to operate' is suitable for understanding the multifaceted relationships required in this study and is appropriate to respond to the central research question. The framework therefore incorporates a more nuanced understanding of the various elements that influence corporate environmental performance as captured by the social, legal and economic licenses (Gunnigham et al., 2003). This multi-level analysis is in line with the newer generation of studies in the 'greening of industry' body of literature which perceives the importance of accounting for the influence of several stakeholders in the

process of regulation so that a more flexible theoretical framework can be constructed to comprehend the big picture of corporate greening (Kallio and Nordberg, 2006).

The cases selected considered the way environmental regulations impact upon the environmental performance of the industry. Here, the development in both environmental regulation and corporate environmental strategy has been influenced by the growth of wider social preoccupations concerning the environmental impact of industry. However, despite the relevant role that environmental regulation has played in improving the environmental performance of the automobile industry, no drastic environmental transformation has been observed due to the limits imposed by commercial imperatives. Automobile firms still rely on the all-steel-body structures and the internal combustion engine as the core pillars of their business model (Nieuwenhuis and Wells, 2003). More importantly, the cases have indicated that the industry has not been able to introduce commercially radical technological innovations, such as hydrogen-powered vehicles or full electric vehicles because of the restrictions imposed by the economic license.

In this respect, the basic characteristics of the automobile industry, as presented in Chapter 4, shape the economic license and make corporate environmental performance reactive to the pressures posed mainly by the legal license, and to a lesser extent, to the social license. In this sense, the economic license has emerged as the dominant license shaping industry corporate strategy. The industry has therefore taken a more proactive role in influencing the formation of the legal license and searching for other sorts of governmental support, focusing on the present business model of the industry and following the non-market environmental strategy defined by Baron (1995). The principal action of industry has been to influence policy makers to delay or change the implementation of standards or, in more recent cases, to pursue negotiated cooperative outcomes that involve direct or indirect subsidies favouring the present business model of the firm (Hillman and Hitt, 1999). In this respect, the 'license to operate' framework has served as a suitable instrument with which to analyse the interactions between environmental regulation and corporate environmental performance in the automotive

industry, taking into account technological development, economic restrictions and social demands from various stakeholders.

8.3 - Commercial imperatives prevail in the response provided by industry

According to the 'license to operate' framework, multi-faceted legal, economic and social licenses simultaneously motivate and constrain the actions of industry so having a relevant effect on the environmental performance of the industry (Gunnigham et al., 2003, 2004; Hoffman, 1999). However, the cases have indicated that the response the industry has had to social and legal pressures has been restricted by commercial imperatives, because of the economic limits posed by the internal combustion engine and the all-steel-body structure. Despite the fact that environmental performance is simultaneously shaped by the interaction between the terms of the three licenses, the economic license appears as the dominant license, directing the management style of the industry. In this sense, it can be concluded that in selected cases, the economic license to operate emerges as the prevailing force that guides the relationship between the legal license (regulation) and auto industry technological development, and has meaningful social benefits.

As previously argued in Chapter 3, in order to understand how the 'license to operate' framework can be applied to issues in the automobile industry, it is necessary to provide a thorough description of the main features of the industry; this includes the environmental impact of the automobile (discussed in Chapter 1) and the business and economic characteristics of the industry (presented in Chapter 3). The business of the mass-produced vehicle is thus based on the internal combustion engine and the all-steel-body structure (Nieuwenhuis and Wells, 2007). These two technological pillars have made the automobile a mainstream product and are still the basis of the modern business of building cars on a large scale. Consequently, the business model acts to restrict the

shape of the licenses to operate and the relationship that the industry has with the natural environment (Orsato, 2009).

The automotive industry can be characterised as an oligopoly with product differentiation (Berry et al. 1995); sunk costs are significant and help to form high barriers to entry for new competitors. The industry is therefore composed of a limited number of groups which possess a wide number of brands. Some of the larger ones try to compete in various markets, offering a vast number of brands to the consumers, including high volume , specialist and niche brands. Here, the market division of the types of producers is pertinent in order to understand the types of business strategies adopted by the industry (Williams et al., 1994). Cost reduction strategy is the most common, where firms rely on the economies of scale to lower the unit cost of each single product. These firms try to compete on the general market with very slim negotiation margins. The economic license to operate is therefore shaped by the economic limits imposed from the internal combustion engine and the all-steel-body structure, as the cost reduction strategy is based upon large scale production.

The other business strategy is cost recovery, where the business model of the firm rests upon product differentiation (Williams et al., 1994). Specialist and niche producers fall into this category and the types of business strategy are also a fundamental factor in understanding the potential response that the industry can produce to regulate the pressures presented by the legal license. The environmental cost differentiation proposed by Orsato (2006) and Reinhardt (2000) would therefore be classed as cost recovery.

The industry has particular market characteristics for each country and this contextualisation holds important lessons for the analysis of the 'license to operate' framework since international groups have global operations but offer different products in specific markets. Here, the geographical location of assemblies and factories, currency exchange rates and international trade agreements impact on the choice of vehicle line ups, which are more suitable for the specific domestic market characteristics.

Sturgeon and Florida (1999) indicate that the modern automobile industry has made the transition from an old model of competition, characterised by a focus on the domestic markets, to a global model, where the production function of the firm is organised on a regional and global basis. This distinction has a significant impact on emerging markets which have recently evolved from simple adopters of old models and production equipment to developers of R&D. The industry has also changed from an export-led industry to a network-led industry, where each major firm carries out production with a focus on supplying the major markets, mostly because of modularisation and supplier outsourcing (Sturgeon and Florida, 1999).

With this new `global` model, high volume manufacturers try to maximise investments if they can spread the `sunk costs` in several operational plants around the world (Nieuwenhuis and Wells, 2003). Additionally, comparable global models provide larger flexibility to export or import to certain markets, which require additional products. In the context of the `license to operate` framework, the industry may be interested in pressing for harmonised technical and legal standards in diverse markets. If, however, the industry perceives that certain countries have older legal licenses and the industry has already reached superior environmental performance levels, a harmonisation of standards may be promoted to gain a competitive advantage or shape the legal license.

For each specific national market, the competitive structure impacts on how the industry can influence the shape of the three licenses; industry has traditionally forced the formation of the legal license through lobbying. The cases have shown that industry has been able to delay the implementation of standards in the case of California, for instance (Gerard and Lave, 2003). However, in the Brazilian case study, the industry has had a higher influence on the formation of the overall policy, demanding several direct and indirect subsidies (Roststein, 1979). In the ELV case study, the industry created a strong lobby to persuade regulators to follow the cooperative solution that had been offered by ACEA and did not directly change the central business of producing and selling new

vehicles (Orsato et al., 2002).

From the license to operate framework perspective, the business and economic characteristics of the automobile industry help to shape not only the economic license, but also the political proactive strategy. The automobile industry, as an oligopoly with product differentiation, has a considerable interest in engaging in an industry-wide corporate political activity to influence the formation of the economic license. The case studies have also indicated that the different political systems significantly influence the effect that the legal license has on the corporate environmental strategy. In fact, in all the cases selected, industry has taken a pro-active role in shaping the legal license according to a wide range of strategies.

In the cases, the automotive industry operated as a block to defend their interests, shaping several licenses simultaneously. In fact, the only case where a firm was able to gain from a proactive environmental strategy that differed from the rest of the industry was with Toyota in the ZEV mandate case study. Here, the Toyota Motor Company took a proactive environmental product differentiation strategy, the launch of the Toyota Prius, which generated positive economic gains for the firm (Reinhardt, 2000). However, Toyota joined other automakers when the ZEV mandate was challenged in court. This is in line with the Orsato (2006) classification of corporate strategy since the organizational processes and products may work independently.

The prominence that has been given to the economic license by the automobile industry in each of the cases holds important lessons for the development in the 'greening of industry' body of literature. The industry understands that the present business model of the firm is constrained by the internal combustion engine and the all-steel-body structure, these being, in essence, unsustainable. As previously indicated, technological development has been constrained by the commercial imperatives that firms must comply with. As a result, automakers have taken the economic constraint as a justification for opposing regulation. This economic constraint also dictates the technological solution

presented, based on end-of-pipe measures or incremental innovations for the present business model of the firm. However, due to the fact that the environmental dimension has recently become an element of great political salience, the industry may face growing pressures from the social license, and consequently from the legal license, which will demand novel technological solutions.

8.4 - Due to the dominance of the commercial imperatives, auto industry technological development has merely followed the minimum requirements imposed by regulation.

The cases presented in this work indicate that the legal license to operate has been essential to foster technological development in the automobile industry and that the industry has been able to partially influence the formation of the legal license, as it desires to defend the current status of the business model of the industry. The cases have therefore been explicitly selected to display the most relevant pieces of regulation under the specific criteria presented in Chapter 4.

The Brazilian ethanol case study presents an important example of how the legal license to operate has been the central factor forcing the industry to adopt ethanol-only engines. Without the government intervention that simultaneously shaped the legal, economic and social licenses to operate, ethanol-only engines would not have been established (Moreira, and Goldemberg, 2000) even after the industry had already indicated the technical possibility to do so. When FIAT S.p.A. launched the first ethanol-fuelled vehicle - the FIAT 147 (Veja, 1979), other competitors soon followed, producing similar small compact cars. In aggregate terms, very limited market effects can be observed in the industry as no firm gained a greater market position because of the implementation of ethanol. However, positive environmental and social effects were seen after the ethanol engines were introduced to the market.

An important aspect of the Brazilian ethanol experience has been the significant role played by the government in shaping the economic license; this included: the organisation of the supply chain of ethanol, the process of R&D and the creation of an appropriate economic environment with a combination of market-based instruments and command-and-control measures for ethanol to become cost competitive (Goldberg et al., 2003). The government was also able to directly influence the social license, as a large marketing campaign was conducted to convince the Brazilian consumer of the qualities of the ethanol-powered vehicles (Veja, 1979). In short, the government was able to successfully direct the industry's environmental performance because it could simultaneously influence the legal, economic and social license.

The ELV directive case study also supports the idea of the relevant role that the legal license played in changing the roles adopted by stakeholders, with potentially significant technological effects in terms of material use and the increased use of recycled materials (Gerrard and Kandlikar, 2007). The case indicates that the directive was directly responsible for enhancing the material use in the new vehicles sold. Moreover, an important aspect of the ELV directive was that the legal license was established when automobile firms could contract others to physically take care of end-of-life vehicles. This makes economic and business sense, as the core business of automobile manufacturers is centred on selling new vehicles (Rivers, personal communication, July 2008).

The extended producers' responsibility principle is a benchmark in the environmental regulation of the automobile industry, as the legal license made the automobile industry responsible for collecting and treating old cars (Lindhqvist, 1992). However, the industry fought for the adoption of this legal principle and tried to persuade the European Commission to take on a solution based on shared responsibility (Orsato et al., 2002). Since the industry was already involved with ELV collection and treatment in certain countries, it could benchmark the experience. However, when the directive was

established, the industry adopted measures to ensure the better use of material and a more sustainable design.

The case study of California is also representative of the importance of the legal license for the technological development in the automobile industry. The case indicates how the legal license was responsible for forcing the implementation of several technological developments, for instance with catalytic converters (Brillant, 1989). In the second part of the case study, the ZEV mandate presents an interesting example where the legal license sparked the technological development of electric and hybrid-electric vehicles (Collantes, 2006). It is important to indicate here that Toyota was able to gain the first-mover advantage for being able to successfully launch the hybrid vehicle in the North American market (Sperling, personal communication, 24 March 2006). Nowadays, Toyota is the market leader in the hybrid electric vehicle technology and has become the benchmark for other car firms in the US; in both cases, positive benefits have been observed for society.

In the cases studied, the automobile industry has been concerned with the formation of the legal license since this may pose a tremendous threat to the business model of the industry. The latter is still based on the traditional business model of the internal-combustion engine and the all-steel- body structure, and the cases presented have indicated that the industry has incorporated the changes after considerable resistance. Without the imperatives of the legal license, the adoption of these technologies would have taken longer to be developed and implemented on a large scale.

8.5 - Extensions of the 'license to operate' framework

A relevant aspect that emerged in the cases was the difference between the political systems in each of the three geographical areas since the cases were specifically selected in three regions of the world and in diverse historical contexts. Additionally, the

established political systems in place have profound implications for the formation of the legal license and the impact that the industry can have in influencing the licenses to operate. Here, the interaction between the legal and social licenses depends upon the role that social stakeholders can adopt in each political system. Therefore, the political system has influence over the way in which the legal license is imposed, and how the relationship between industry and policy makers is framed.

The Brazilian study case took place under a military dictatorship regime. At the time, the central military government had imposed limits to political freedom on civil society, establishing formal restrictions on the press and academia. Government sponsored policies were therefore taken very seriously by the general public. However, despite the restrictive environment for the population, the automobile industry had an extraordinary relationship with the central government; large subsidies and market protection against foreign competition had been part of the industrial policy for the sector over the preceding decades (Leite, 1990). When the proalcohol programme was designed, several subsidies were planned for the industry, including government sponsored R&D for ethanol-only engines. Notwithstanding the limited political freedoms in place for society, consumer purchasing power was still perceived as crucial for the success of the program and a large marketing campaign was officially established to provide consumer support for the initiative. More importantly, the federal ministries involved in the proalcohol program were diverse and each one adopted a different role in fostering the development of ethanol.

⁴ The California emissions case study indicates the larger impact of political activities in the formation of the legal license. The social pressure to reduce the amount of smog, especially in the cities of Los Angeles and San Francisco, was crucial for the initial public action to restrict the amount of air emissions from mobile sources such as the automobile (California Air Resources Board, 2006). More recently, pressures imposed by environmental groups in the California Air Resources Board also supported strong environmental regulation. Kagan (personal communication, 30 March 2007) argues for

the importance of the legalistic American system to understand the consecutive legal disputes taken up by the automobile makers against the establishment of the ZEV mandate since this was originally designed by members of the California Air Resources Board. It is also important to mention that the approach taken in California was different from that of the federal government, which was lagging behind in terms of strict mandates.

The ELV case study is also important in order to understand the influence of the political system in the negotiation process of the implementation of the ELV directive. Due to the fact that automakers did not want to be hit by the producer's responsibility principle, they came together to reach a cooperative agreement and having shared responsibilities with the dismantling industry. The cooperative agreements that had been reached in Germany, Italy and France served as the benchmark for the negotiation process between the European Commission and the car makers (Orsato et al. 2002). However, as the ELV had been incorporated as a priority waste stream, the use of a directive emerged as a necessity to harmonise ELV policies at the EU-level. The process respected a long stakeholder consultation course of action which ended with the imposition of the EU directive 2000/53/EC going against the wishes of the automobile industry.

For the selected cases, a useful development of the 'license to operate' framework would be to unpack the original legal license and to create a 'political license to operate' as such political processes are underexplored in the original version of the 'license to operate'. The separation between the legal and political licenses recognizes that the forming processes are unique. This approach overcomes some of the criticism that may be attributed to the original version of the framework which does not allow for a more nuanced understanding of different governmental agencies and bodies. Governments are not homogeneous bodies and, as indicated by the cases, have diverse processes in different governmental spheres. Politicians, environmental agencies, monitoring agencies, data collection agencies, central government and members of congress may

have diverse objectives and opposing perceptions about how to deal with the automobile industry.

Under this more elaborate version of the 'license to operate', the legal license still refers to the combination of several legal requirements and permits issued by environmental, health and safety officials necessary for the industry to operate. In the case of the automobile industry, automakers are required to act in accordance with minimal legal standards which generally follow mandatory technology. As previously indicated in Chapter 3, the legal requirements in question are concerned with the automobile environmental externalities, as indicated in Figure 8.1.

The political license represents the demands of political stakeholders, as it is concerned with the wider political relevance of industry. In the case of the automobile industry, the political support that the industry possesses has been fundamental for allowing corporate strategies that seek to shape the legal license.

Politicians can be very supportive of the automobile industry due to its economic importance for certain regions and countries. Political stakeholders can also have a strong influence on the agencies responsible for permit-granting process, and may intervene in the negotiation of standards or provide the industry with compensatory benefits. Consequently, the industry must have pro-active political behaviour so that the political license to operate can be strengthened and the legal license relaxed. The industry may also negotiate compensatory funds if strict legal licenses are imposed and there is the perception that the costs relating to the implementation of new technological standards commercially penalise the industry. This has been shown in the selected cases where industry has lobbied for less strict legal licenses or negotiated for subsidies. In this sense, the political license is defined by the stakeholders who have a political interest in the economic and social benefits provided through the operation of the industry.

As with the original version of the 'license to operate' framework, the result of the interaction between the terms of the licenses is larger than the actions of each one individually because stakeholders are able to influence multiple licenses simultaneously. The interaction between the social and political licenses is therefore relevant, as the conditions of some of the legal license requirements expand the reach and impact of the political license by directly empowering political and social groups.

As with the original version of the 'license to operate' framework, the terms of each of the licenses are subject to the interpretation of the main stakeholders who may possess different opinions with regard to the activities of industry (Gunningham et al. 2003). Hence, the complexity of the interactions between the stakeholders and the perception of the externalities of industry is highly dependent upon the social, historical, political and economic contexts of each one of the cases.

In order to provide a more detailed depiction of the expanded version of the license to operate framework proposed here, Figure 8.3 offers a graphical representation. The original version of the license to operate framework, indicated in Chapter 3, represents each of the licenses with the same shape, indicating similar weights. Here, the industry's environmental performance is simultaneously shaped by the economic, social, political and legal licenses.

Figure 8.3 – The expanded 'License to operate' Framework

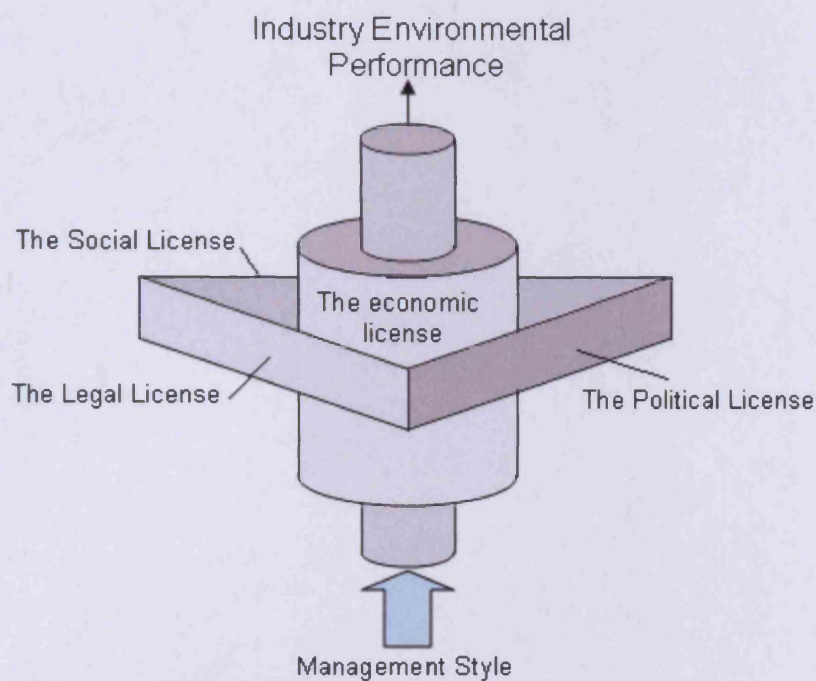


Figure 8.3 recognizes the prominence of the economic license to operate and adds the political license to operate to the group of licenses. As previously discussed, the economic license to operate has emerged as the dominant force guiding the corporate behaviour in the selected cases. Hence, to account for this larger influence, the economic license to operate is represented by a larger cylinder around a smaller one that represents the management style of the industry. The political license to operate is therefore portrayed as an additional license in the group of licenses. Despite the prominence given to the economic license to operate, the four different licences (social, economic, political and legal) are intertwined, constituting a joint effect in the

management style of the industry and consequently in the environmental performance of the industry.

As previously indicated, the approach used in this work has taken an unconventional look at the framework. The aggregate framework was applied to context-specific points in time where auto industry technological development was being pushed by legal licenses so having a relevant effect on the environmental performance of the firms generating positive social benefits. In accordance with the framework, the differences observed between the automobile firms in each market are indicative of the diverse interpretations of the macro-level licences in the internal management style of the firms.

In all the cases studies, the environmental dimension is an important aspect since the environment has a wide impact on the formation of the licenses because it possesses profound social, economic, political and regulatory implications. The environmental dimension is therefore a central issue that helps stakeholders shape each of the licenses; this is because a greater range of stakeholders monitor and pressure the industry to adopt specific behaviour and responses towards the negative environmental externalities produced or the natural resources used. Several stakeholders with an environmental interest have been indentified, including: green consumers who perceive the importance of sustainable mobility, environmental policy makers who understand the need to transition to less harmful and less resourceful sources of transportation, green politicians, stockholders who might perceive the rate of return of the investment as being directly related to the environmental performance of the firm, and industry workers who understand the necessity of working for a firm that is helping to solve climate change issues while contributing to the common good.

8.6 - The implications for the 'Greening of Industry'

As previously discussed in Chapter 3, the 'greening of industry' field has been criticised for trusting industry to find long-term, profitable solutions to environmental issues. The intrinsic perception has been that pro-active management strategies combined with the benchmarking of successful stories would be able to strengthen the economic license to operate and take the industry from a mainly unsustainable condition to a more profitable and sustainable one.

The field has been largely influenced by authors who proposed categorisations of a corporate environmental strategy that would lead industry to a sustainable path. Orsato (2006) offers an important classification where firms would be able to adopt proactive green strategies to find market gain sustainability in the products or services offered. Reinhardt (2000) also discusses the conditions under which industry could profit by perceiving opportunities to gain market positions from environmental regulation. Orsato (2009) further shows that environmental thinking has evolved according to a proactive proposition of corporate environmental strategy (Reinhardt, 2000).

From the sustainability view point, questions may be raised as to whether the present level and pace of technological development following a pattern of incremental innovation is sufficient for the industry to move towards sustainability. This observation is particularly pertinent in the context where, in the future, the requirement may be for larger and more rapid change as environmental pressures increase. Here, the 'greening of industry' does not allow for radical change, where the terms of the economic license are fully reshaped in a rapid manner since the main characteristics of the economy or the economic licenses to operate are not challenged or questioned as regards their fundamentals. Hence, the licence to operate framework retains an implicit neoclassical conceptualisation of business, which keeps its legitimacy and hegemony as the primary mechanisms with which to control and allocate scarce resources. In this sense, there is considerable reliance on a gradual and incremental transformation as an adequate

response to the sustainability challenges that society faces.

The case studies in this thesis indicate that the present business model of the industry might even be on the verge of collapse, as the industry appears to be operating at the limits of the economic license to operate. The economic license to operate is the priority for the industry since the industry has been struggling for some time. However, this license has the potential to be completely reshaped with the advent of electric cars and the transition from being an industry that makes cars to one that provides mobility. Consequently, the industry is lobbying the political license so that subsidies can be given to the industry and the basic pillars of the industry can be changed.

In addition to this, the literature of the 'greening of industry' has placed little emphasis on a scenario of wider economic constraints which have been observed from 2008 onwards, or the issue of whether, under these conditions, proactive environmental steps are taken by an largely unsustainable industry such as the automotive one. More importantly, the environmental dimension has recently gained central importance with the realization that the world is heading for a catastrophic scenario due to climate change (Smith et al., 2009). In restrictive economic times, not coping with the economic demands has placed additional pressure on the industry to provide solutions that are simultaneously sustainable and profitable.

A wide range of interest groups that construct the social license, also impact on the economic license; these include local communities, national environmental groups, workers, the media, consumers and society in general. Social stakeholders construct the social license and have a direct influence on the formation of the legal license because policy makers and regulators can be pressured to impose stricter regulations (Gunningham et al., 2003). In the case of environmental issues, social stakeholders can pressure regulators to impose stricter regulations and restrict the consumption of specific products. Social actors also have a significant influence on the formation of the economic licence. From this perspective, the combination of larger constraints on the economic

license and the social licenses to operate pose a relevant challenge for the development of a more sustainable automobile industry.

An important stakeholder who needs to be accounted for in an explicit manner by the field is the consumer; consumers need to be central to the development of a more sustainable industry. In the case of the automobile industry, they can severely influence the demand for new vehicles and enhance pressures over the social and legal licenses. It can be argued that the focus of the field in the supply side of industry needs to be reconsidered, thereby adding additional importance to the consumer. It has been proposed by the GIN network that the 'greening of industry' field should shift to the 'greening of industrial systems', which would incorporate not only the industry but also other relevant stakeholders (GIN, 2009).

The study cases have also indicated that the 'greening of industry' literature needs to consider the relevance of market forces shaping the economic licence alongside the pressures posed by the social license and political licenses. These have a significant impact on the formation of the legal license to operate, and consequently, on the environmental performance of the industry. Hence, the wider process of policy formation has taken into account the importance of the interplay between the different licenses to operate. The Brazilian ethanol program is representative of a state-led initiative to achieve a partial system of innovation, and large subsidies were put in place for R&D development, the distribution of fuel and the establishment of initial demonstrations to gain the trust of consumers in the new technology (Zapata and Nieuwenhuis, 2008). In the California case study, the interplay between the licenses emerged in a different manner, since the regulators, especially the California Air Resources Board, were more preoccupied with setting up the legal license than addressing some of the wider economic implications (Sperling, personal communication, 10 March 2006). The ELV case is also more preoccupied with the legal license, since the automobile industry will have the physical and financial responsibility to treat and recycle old cars (Toffel, 2003). Automakers in this case have been involved in adjusting the ELV processing system,

taking into account the consumers, the dismantling industry, the shedding industry and the materials industry.

8.7 - Implications for the industry

Automakers have traditionally opposed environmental regulation. However, in the cases investigated in this thesis, regulation has provided positive effects for society in terms of environmental benefits. The automobile industry has historically questioned the technical feasibility of the standards proposed as well as the costs relating to their implementation, and has lobbied for subsidies. In accordance with the 'license to operate' framework, industry has therefore adopted proactive political strategies to influence the formation of the political and legal licenses to operate. The initial focus of the industry was on the economic license, and environmental measures are adopted only if the industry is pressured by the legal license.

Firms have traditionally taken a proactive role in dealing with the formation of the legal license. In all the case studies presented in this work, political collusion has been observed, since the industry has searched for more flexible standards and greater flexibility with regard to the potential implementation of the standards. However, in a situation of economic constraints and growing social pressures, cooperation with regulators can be beneficial for firms. Cooperative relationships, through a solid political license to operate, can reduce uncertainty as regards new technological investment, and provide the firm with the security to construct long-term corporate environmental strategies that match the investment cycles in the automobile industry (Reinhardt, 2000).

Traditionally, governments have provided support for the development of the automobile industry in their territories; several countries have perceived the presence of a large and strong automobile industry in their country as being socially desirable due to the positive local and national economic effects. The industry therefore has a strong position to

aggressively negotiate subsidies or other types of grants in order to adopt novel technologies.

The Brazilian case study illustrates this argument. Here, the automobile industry was specifically attracted to the country by the vast subsidies provided by the government to draw large industrial groups in the 1960s (Benevides, 1976). Hence, when the initial studies indicated the political willingness to foster the development of ethanol, the industry rapidly pushed for subsidies to be incorporated into the larger policy, including the R&D costs, the marketing campaign to gain consumer support and the support for the distribution of the fuel (Leite, 1990).

Notwithstanding this good negotiating position, it might be wise for the auto industry to perceive the importance of the environmental dimension as a central element in their business model (Nieuwenhuis and Wells, 2003). In fact, the growing importance of the environment for society may pose significant restrictions on the economic license to operate. The social licence to operate has also increased in importance for the industry as it is deeply connected to the economic license; the joint effect of the two licenses also has a significant impact on the legal license.

Since regulation is evolving and adopting a deeper understanding of the effects of industrialised products on human life and on the environment, industries should tailor their products and services in that context and decide what steps can be taken towards to meet these challenges. Because the environmental dimension and technological development are directly connected, industry needs to perceive technological strategy and environmental strategy as a single theme. However, all the case studies presented in this research support the conclusion that industry has concentrated its efforts on incremental innovations rather than more radical solutions to environmental problems which would challenge the basic business model of the industry. Moreover, despite the large barriers to entry, disruptive technologies, such as electric vehicles and hydrogen fuelled vehicles, could potentially be brought to the market by external entrepreneurs following the

innovators dilemma discussion (Christensen, 1997).

Automakers have, opposed regulation in the case presented. However, the effects of the legal license have been positive and this has provided the industry with benefits in a number of cases. For example, safety and environmental regulation have been effective in safeguarding domestic markets from foreign competition. Since other areas of the world have adopted EU regulations at a later stage than in Europe, this has created a market for European products, yet, the license to operate does not allow for this to be incorporated.

The automobile industry has generally opposed the implementation of standards that required investment in R&D and has consistently overestimated *ex-ante* costs of regulation (Sperling et al., 2004). Automobile technological development has been fostered through the pressures posed by the legal license, and this has been adopted because of the legal impositions and not because of economic reasons. The strategy of firms has therefore been to maximise economic profit by stretching sunk-costs and requesting additional flexibility as well as other types of government subsidies.

The formation of the legal and political licenses has been directly influenced by the industry, which has adopted politically proactive behaviour. Here, several tactics have been followed, yet the industry has consistently argued about the impossibility of meeting standards, offering other outcomes, including extended deadlines, direct subsidies and government sponsored R&D solutions. From the perspective of the 'license to operate' framework, the economic license has been of paramount importance in each of the selected cases and has contributed to hindering more radical sustainability solutions for the industry.

The selected cases have also shown that the government has been central in selecting the policy arrangements which shaped the licenses to operate and, as a result, this has influenced the environmental performance of the industry. The cases have revealed several governmental approaches for influencing both the legal and the economic licenses

to operate. Such examples include: investment in R&D to foster technological development, the reduction of information asymmetry and the enhancement of information disclosure. Information is relevant since policy makers should have a better idea of what is possible in technological terms, in line with the specific economic conditions. The cases also show relevant examples where regulators were able to invest in basic R&D and set suitable environmental goals. A significant example of a government intervention that fostered direct R&D was observed in the Brazilian ethanol program case study. Here, the CTA research centre was responsible for developing ethanol-only engines, and provided the necessary information regarding the technical feasibility of the initiative (Veja, 1979). Technology was later adopted by major automakers who had a reduced cost of adoption and adaptation to their specific needs and technical constraints. Therefore, the consumers also profited, since they had information relating to the reliability and levels of performance of the ethanol-only vehicles.

The analysis of the ZEV mandate, described in Chapter 7, provides another important example of where environmental regulation has been able to create positive economic effects for a specific firm. However, in all the other cases, firms opposed the regulation and no competitive effects were observed. The Toyota response to the ZEV mandate was the only case where a firm was able to adopt a proactive position in launching a product and this generated a considerable market advantage. Following the analysis presented by Reinhard (2000), the Toyota Motor Company was able to assume an environmental product differentiation strategy and acquire considerable market gain in California. The Prius was presented as a unique product with improved environmental attributes; it respected the three requirements presented for environmental product differentiation (Reinhardt, 2000), and was able to create a willingness in customers to pay for improved environmental attributes. They succeeded in this by communicating the enhanced environmental attributes of the product and other attributes of its products to the consumer and regulators. Competitors were unable to rapidly imitate the Toyota Hybrid Synergy Drive System that had been developed to power the Prius. The competitive advantage that Toyota was able to gain was centred on the type of product offered and the

differentiation strategy of providing environmental features. According to the framework of environmental regulation and the corporate strategy presented by Orsato (2006), the case can be broadly classified as an eco-branding type of competitive advantage.

The ELV case study is illustrative of pro-active behaviour by the firm to present a cooperative solution to government so that command-and-control measures would not be established. In Germany, when the Ministry of the Environment – BMU - provided a signal that it would establish the Extended Responsibility Principle for industry to take care of old vehicles, the automakers association – VDA - rapidly set up a study group to present a feasible solution for regulators. In 1991, PRAVDA (the used-car utilisation project of the German automobile industry) was set up, proposing a shared responsibility among all the stakeholders involved in the ELV issue. Similar cooperative agreements were established in France and Italy, with the accord-cadre and the Fare system. However, direct opposition to establishing a Euro level directive was proposed by the commission in the 1990s. Despite the considerable opposition of the carmakers and the extensive work that had been carried out in these countries to reach a shared responsibility agreement, the EPR concept was established by the ELV Directive.

Industry has always been aware of the potential threats the legal license poses to its respective business models . In this context, non-market strategies are crucial elements that the industry can adopt in the formation of legal restrictions. As regards the environmental dimension, the social licence has become more important in the context of the environmental performance of the industry; it has also become prominent with the rapid expansion of the corporate environmental strategy. The dissemination of environmental ideas in society in general have played a further and important role in the growth of environmental thinking in recent years, since social pressures have a tendency to develop larger political salience.

8.8 - Implications for policy makers

The need to call in the government significantly reduces the power of firms to carry out a process of change. Therefore, the intrinsic perception that firms would be the central instigators of change may not reflect reality.

Policy makers are able to influence the corporate environmental performance of industry using a wide range of strategies. Ideally, public policy should shape the four licenses. However, the case studies show examples where the licenses have been influenced in diverse manners.

In the Brazilian ethanol case study, the Brazilian government was able to influence the formation of the social, economic and political licenses. To pressure the social license, a strong marketing campaign was put together to convince the Brazilian consumer that ethanol-only vehicles were reliable and had similar levels of performance as petrol-fuelled vehicles. The economic license was shaped by the large direct and indirect subsidies that were implemented, including tax breaks, subsidies for the price of the fuel, and most importantly, the governmental and technological development of ethanol-only engines. Here, the political license was shaped by the shared perception that providing subsidies to the ethanol industry would be translated into larger macroeconomic benefits for the country.

The economic license has also been developed by several of the policy makers who have implemented the regulation and by the shape of the political license. In the case of the North American ZEV mandate, large subsidies were given to the North American automobile firms to develop the next generation of vehicles; in the Brazilian case study, the Brazilian government provided indirect subsidies in the form of government-led research and development, which was passed onto the automakers.

Policy makers may also interact with industry in the formation of the legal and political

licenses in order to build cooperative relationships, which may provide a better understanding of the business model of the industry and show to what extent it is possible to expand the industry's current business model. The analyses of the case studies suggest that governments must be able to pose credible legal threats and create an environment where information exchange is encouraged. The information regarding what is possible under the pressures posed by the economic licenses at specific points in time is crucial for the regulators so that they can understand what can be achieved under any specific economic state.

Another important implication for policy makers refers to the credibility that policy makers must gain. Credibility produces long-term effects which shape social, legal and political licenses. The short-term vision initially adopted by the regulators and firms to solve the air emission problem in the United States has provided lessons for the adoption of a long-term policy view. Regulators should ideally indicate long-term regulatory paths, so that industry can combine the new investment cycles with newer technological developments. Regulators need to bear in mind that firms will maximise sunk-costs and minimise their investment in uncertain future technologies. However, regulators are also burdened with imperfect knowledge, both as regards environmental science and concerning the capability of the industry to respond. Hence, the long-term policy can be difficult to construct, as can be seen in the case of CO² regulation in Europe. Ultimately, the long-term policy may end up weaker because regulators are more cautious about what can be achieved, or they may be less aware of potential environmental consequences if action is not taken.

One of the strategies presented in the case studies, refers to the integrated environmental technological policy which is focused on creating conditions that will reduce negative environmental externalities and enhance aggregate funding in R&D. Here, public investment in R&D reduces the uncertainty of technological developments and minimises the problem of asymmetric information. However, depending on the economic and political situations, society must not be prone to provide large indirect subsidies to

industry.

The case studies conducted in this work bring to light specific characteristics of the automobile industry and show examples of both types of regulation approach. In the technology prescriptive case, no negative economic impacts to firms have been observed. In these cases, automobile firms have acted collectively and all the firms have been affected similarly. However, The ZEV case study is representative of a case where standards were set. In this case, competition was enhanced and positive outcomes were generated for the first movers in the case of Toyota.

8.9 - Limitations of the analysis

The 'license to operate' framework has limitations that restrict the conclusions as well as the implications for policy makers and firms. Despite considering the influence of several stakeholders, the framework is not able to forecast future regulations. The drawback of a wide framework is that many elements are considered according to a set model; this also accounts for particular relationships (Gunningham, 2007). Through vagueness and large categories, it is always possible to argue that something fits, but the significance of some of the issues can be lost if this is not richly contextualised within a historical understanding. In this respect, the framework is suitable for dealing with historical cases.

Another drawback of this framework is that firms and regulators can be perceived as single homogeneous players. However, this may not be true in all cases. Governments and firms are large bodies with different sections and agencies that sometimes have contradictory goals. In the case of a government agency, the problem of regulatory capture can emerge, and with large automobile firms with various divisions there may be divergence as to how much to invest in Research and Development and which products should be launched on the market. These are important elements that are not

appropriately captured in this analytical framework. However, the extension of the framework proposed here is able to dilute some of this criticism, with the addition of a 'political license to operate'.

The market structure of the automobile industry is an important element that needs to be accounted for. As previously indicated in Chapter 5, the automobile industry is characterised by a concentrated market in which a few large firms operate. The cases selected are representative of three important world markets: the United States, Europe and Brazil. Each one of these has particular characteristics, but they display the oligopolistic competition characteristic of the automobile market. As far as regulation is concerned, automobile firms have, in most instances, operated as a block, and have worked together to defend their interests, confronting the proposed standards and requesting more flexibility and less stringent standards.

Another important aspect is that licenses can pull in different directions. Sometimes it may not be possible to clearly understand the net effect of several of the costs and benefits imposed at a specific time, or even to perceive how each of the licenses affects the management style of the firm. In this respect, the framework is more suitable to comprehend past events.

The framework is pitched in a continuous improvement form. However, there may be cases where the licenses can bring about a negative net effect. The recent episode with the Toyota Prius is relevant to illustrate this point. The Toyota hybrid actually went into reverse when the social license collapsed because of problems with the accelerators, wheel motors and brakes. This damaged the reputation of the company, so tightening the economic license to operate. In this sense, the relationships may not be always unidirectional or positive for the industry. At times, developments in the social license can pose a significant constraint on the economic license. Therefore, in order to further develop this work, it would be profitable to apply the 'license to operate' framework to

other industries that have been subject to environmental regulations. Such a comparison would provide additional elements that could enhance the understanding of the application of the framework to context specific instances.

Another potential area of development in this work would be to consider the benefits and costs relating to the international harmonisation of environmental standards. This has not been discussed in this work as the case studies have been taken in different historical contexts. However, in an increasingly globalised world, this has recently been hotly debated. The harmonisation of environmental standards has contradictory effects upon the automobile industry: it may reduce costs since economies of scale can be maximised and cost savings generated. On the other hand, the industry has profited from different environmental standards, such as old and obsolete technologies which can be applied to less stringent markets, with the sunk costs that have been invested stretched over long periods of time. Emerging economies are generally supplied with less advanced products.

Several observers in the industry have perceived a future scenario where the global demand for automobiles will become more similar. Firms may want to provide the same product around the world and several synergies and economies could thereby be achieved. However, due to the differences of legislation and consumer tastes, this may not be possible. The tendency towards the internationalisation of environmental policies and approaches to environmental regulation may also be observed in the regulators. Moreover, if the industry is already offering a more sophisticated product in terms of environmental performance, governments and regulators may be more inclined to set a regulatory framework that will support this innovation. This has been the case with the ELV directive in Europe, where the market is already taking care of the industry's responsibility to collect and recycle old car hulks.

Nevertheless, the framework does not provide an indication of time; this is a relevant aspect of elements that have been treated by other frameworks, especially with regard to the political economy, and it considers the political salience of particular themes. Here,

the length of time is advantageous to the industry and supports back-up planning, so providing confidence for the future.

8.10 - Future developments

By connecting the discussion provided in this work - which is situated in the 'greening of industry' body of literature - with the current developments in the industry, it can be argued that public policy has the potential to change the economic license to operate. As a consequence, drastic changes to the automobile industry may take place. In the context of the 'license to operate' framework, the cases have indicated that the legal license has generated technological effects with important business effects that tend to challenge the business model of the industry. Here, deeper social environmental preoccupations can lead to stronger pressures on the formation of legal licenses that might defy the present business model, and the incumbents may lose market share for new entrants who rely on more sustainable radical innovations. In this respect, the joint effect of the social, legal and political licenses are changing the boundaries of the economic license to operate.

The recent financial crisis has also had a significant effect on the economic license to operate. The solid political licence to operate has led to vast economic support being given to the industry, displaying the limits of the 'license to operate'. GM in America, for example, received a large amount of governmental aid; some authors even indicated that the firm was partially nationalised (Mufson, 2009). The requirement for this kind of intervention changes how the industry perceives the legal license for the future, as well as the process of forming the legal license. In this specific case, the terms of the license strongly favour policy makers. This political licence in the case of GM, and indeed other auto companies around the world, legitimised and brought about a profound restructuring of the business to reduce capacity, close down several brands, reduce employment, and off-load certain liabilities from the balance sheet. All of these actions thereby reinstated

(at least for the time being) the economic licence to operate, as indicated by the partial resale of GM shares by the US government on the open market.

The 'license to operate' framework can be helpful in understanding present and future issues in the industry. However, this view only applies when the framework is populated with context-specific details and only then does the framework become more meaningful. The framework is also not suitable to predict the future outcomes of regulations. The case studies here have been specifically selected as *ex-post* cases, since the framework is helpful for positioning the researcher in the events that have already happened, taking into account the short-term and long-term effects of the legal license. Therefore, as previously discussed, the framework indicates how changes in the legal licenses have been translated into changes in the environmental performance of the industry.

8.11 - Portfolio of cases for future research

8.11.1 - Empirical

The suggestion for future research in the area would have to bear in mind what is possible under constrained scenarios, taking into account the technological capacities of the industry. For the automobile industry, the advent of electric vehicles appears the most relevant technological development which has the potential to bring about a revolution in the industry by completely reshaping the terms of the licenses to operate. The automobile industry is in the early stages of such transformation towards all electric vehicles, as major automakers and new market entrants begin to offer electric vehicles that have a similar performance to internal combustion vehicles and larger ranges between charges. Mass produced vehicles, launched in 2010, such as the General Motors Chevy Volt and the Nissan Leaf can potentially dictate the directions of future research.

In this sense, cases that contrast environmental leaders and laggards in the same industry and cases of alternative energy sources (wind and solar applications) that have a disruption potential may enhance the field.

Another area that has not been fully explored under the 'greening of industry' umbrella, is research in developing nations. The study of the 'greening of industry' in developing nations has been fragmented and limited to specific cases, mostly looking at specific successful cases of industry or pollution prevention measures by governments (Van Rooij, 2010). The field could therefore greatly gain from the expansion of the scope of studies enhancing the knowledge about the 'greening of industry' in these countries

The particular characteristics of developing nations are relevant as regards reorienting environmental regulation. Traditional pollution prevention strategies which have been adopted in developed nations may not be appropriate in developing nations as there is lack of resources for monitoring and regulation enforcement, a weak enforcement capacity and a capture-prone governance (McAllister et al. 2010). The way the political and legal licenses are shaped have peculiar features that need to be taken into consideration. However, several factories in developing nations have more advanced processes in areas of rapid growth (World Bank, 2000).

Despite the effort to produce a collection of cases by the World Bank (2000), the literature is still fragmented, as several studies have begun to address the characteristics of developing nations (Kathuria, 2009) to see how a new less legalistic form of regulation is emerging in certain countries, including: Asia (Angel and Rock, 2000), China (Carter and Mol, 2006), Costa Rica (Riveira, 2004), Mexico (Blackman and Bannister, 1998), India (Bishwanath and Banerjee, 2004) and Brazil (Lemos, 1998; Jayaraman and Lanjouw, 2004).

In the context of the 'license to operate' framework, the political and legal licenses represent diverse dimensions for developing nations which may be more prone to support

industry in these countries than developed ones. Several countries have radically supported the development of the automobile industry. For instance, the Brazilian case study presented in this work indicates that that industry has been able to build a strong political license to operate which has served to support the economic license in times of need in the form of subsidies or other structural support policies.

8.11.2 - Theoretical

Frameworks that account for radical and rapid change need to be further researched. The license to operate, for instance, comfortably deals with incremental change, as previously described in the case studies in this work. However, the framework may not be as suitable for rapid change. The prioritization of the licenses, as well as how the licenses are shaped, as shown in the cases studies, may be changed in the process of discontinuous industry restructuring.

The indication of time is also problematic; frameworks like stage models are still incremental and follow a continuous improvement rationale. So far, the 'greening of industry' body of literature has been fine for understanding the required changes in the automobile industry due to incremental changes to the internal combustion engine and the all-steel-body structure. Nevertheless, future research should make use of frameworks that are able to account for more radical change both in terms of scale and the pace; here electric vehicles may constitute the basis for discontinuous change.

It is worth considering how useful the license to operate framework is as regards comprehending the significance of contemporary developments for future outcomes. As a rule, the framework appears to work best in historical reconstructions of events where the start and end points are known, and hence a post-hoc rationality or explanation can be imposed upon the data. What is less certain, however, is whether the framework allows us to understand how far a certain new development (let us take zero emission zones in

urban areas as an example) constitutes significant new imperatives for the license to operate.

Furthermore, with respect to the underlying assumptions of the license to operate framework and the greening of industry approach, it is not clear where the limits to the viability of the license really lie. That is to say, more radical critics might conclude that environmental problems are inherent in modern industrial capitalism, and to that extent, industry cannot simultaneously be the cause of the problem and the solution.

8.11.3 - Methodological aspects

This research is based on historical case studies following the methodological approach indicated in Chapter 4. A potential development for the 'greening of industry' body of literature would be to engage in more action oriented research with firms that are going through the greening course of action. The insider's view of what happens during the negotiation process of environmental regulation on the firm's management style provides an important aspect that the literature needs to investigate. Moreover, decisions regarding corporate strategy and technological development may provide a more nuanced understanding of corporate environment performance during instances of regulatory pressure. Such insights might also be gleaned, albeit from a different perspective, by action research within a regulatory or governmental body. At the methodological level, it is also important to highlight greening not only as an action initiated as a response to environmental regulation but as a broader set of measures adopted by industry that provides positive environmental externalities to society.

Table 8.1 - The effect of the legal license on the other licenses

	US initial CO2 regulations	ZEV Mandate	Brazilian ethanol programme	EU ELV Directive
Technology requirements of the legal license	Catalytic converters	Engine development; Hybrid vehicles	Ethanol engines/ Flex Fuel engines	Reduction in material use/ enlargement of recyclability of materials
Industry behaviour	Initial opposition, Strict legal compliance	Opposition, lobby and court battles. Japanese firms have been able to gain first mover advantages, launching the Toyota Prius and the Honda Insight.	Initial opposition; acceptance after large subsidies were offered	Initial opposition and proposition of alternative legal instruments; eventual alliances with existing industry and legal compliance.
Effects on the economic license to operate	Limited to the industry, no competition effects have been observed in the first wave.	Limited to the industry, no competition effects have been observed in the first wave. Positive effects for Toyota with the Prius.	Limited effects for the industry. Positive macroeconomic effects for Brazil.	Positive effects for the local dismantlers; an unknown for the industry.
Effects on the social license to operate	Drastic reduction in pollution in large centres.	Significant reduction in emissions. However, long-term effects have not been assessed.	Positive environmental benefits, reduction of emissions in large city centres and great consumer support for the initiative	Wider sustainability issues

Source : Case Studies

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Annex 1 - Interviews

1.1 - Case Study 3 (California Tailpipe Emissions Regulations)

Person	Date
Professor Daniel Sperling	08 March, 2007
Professor Daniel Sperling	24 March, 2007
Professor Robert Kagan	12 April, 2007
General Motors USA Representative	04 May, 2007
Professor Joan Ogden	10 May, 2007
Professor Mark Delucchi	10 May, 2007
Dr. Gustavo Collantes	11 May, 2007
Professor Allan Lloyd	15 May, 2007
CAL EPA	22 May, 2007
Toyota USA	23 May, 2007
Nissan USA	23 May, 2007
CARB Staff	11 June, 2007

1.2 - Case Study 1 (EU ELV directive)

Person	Date
Professor Gerrant Williams (Warwick)	17 September, 2007
Representative Nissan Europe	03 July, 2007
Representative ford UK	09 July 2007
ELV Representative UK	09 July 2007
ELV Representative Spain	05 December 2006
Mike Rivers (Ford – UK)	25 July 2007
Cervera, Representative ELV facility Spain	4 December 2007
Representative Car take Back UK	02 August 2007
SMMT representative	22 August 2007
UK government Representative 1	22 August 2007
UK government Representative 2	22 August 2007

1.3 - Case Study 2 (Brazilian Ethanol Experience)

Person	Date
Professor University of Brasilia	11 December 2006
Fiat do Brasil 1	11 December 2006
Ministry of the Environment	11 December 2006
ANFAVEA	12 December 2006
Ministry of Trade and Commerce	15 December 2006
Ministry of Agricultural Development	15 December 2006
Professor at University of São Paulo 1	18 December 2006
Professor at University of São Paulo 2	18 December 2006
Fiat do Brasil 2	19 December 2006
Environmental Env. NGO	19 December 2006

