Environmental Regulation, Eco-Competitiveness, and Financial Competitiveness in the Auto Sector

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Abstract

This thesis tests whether stringent product-based national environmental standards lead to increased eco-competitive behavior for global automobile companies. Eco-competitiveness is defined by as a company's ability to mitigate risks and capitalize on opportunities related to environmental issues, and is measured using the Innovest Strategic Value Advisors EcoValue'21 rating. In addition to product-based environmental standards, this thesis evaluates a number of alternate causal factors that may lead to enhanced eco-competitiveness. Derived from the literature, these factors can be broadly classified as market opportunities, stakeholder pressure, and internal factors. I use Charles Ragin's Fuzzy Set methodology, which is a qualitative comparative analytic method, to test my hypotheses. My results suggest that strict product-based environmental regulations correspond with increased eco-competitiveness, supporting the primary hypothesis. Additionally, certain measures of market opportunities are also strongly connected with enhanced eco-competitiveness. In addition to the link between regulation and eco-competitiveness, the thesis also tests whether enhanced eco-competitiveness leads to better financial performance for global auto companies. The results regarding the link between eco-competitiveness and financial competitiveness are mixed.

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Introduction

This thesis spawned from a single sentence, uttered by Marc Brammer, the Research Director of Innovest Strategic Value Advisors, an independent investment research firm specializing in analyzing companies' performance on environmental, social and strategic governance issues. In the summer of 2006, Brammer made the bold claim that, "If the U.S. had strong regulations and Japan had weak ones, G.M. would be Toyota and Toyota would be G.M." He was referring to G.M.'s financial meltdown, which occurred on the backdrop of Toyota's meteoric rise to eminence in the global automobile industry.

Brammer's contention was that the regulatory environment in which the companies operate dictates their long-term financial competitiveness. Companies in countries with strict environmental regulations are pushed to succeed financially, while companies in countries with weak environmental standards are not. While it is easy to claim that relative stringency of the environmental regulatory context contributed to the divergent fates of the two companies, it is difficult to prove that strict environmental regulations, against which the auto industry habitually lobbies, actually lead to improved financial performance for these companies. This is the task I have undertaken in this thesis. In this introductory chapter I lay out my question, and define key terms and concepts used in my analysis. After establishing my question, I turn to its significance; what are the ramifications for policy makers? for business? After explaining my hypothesis, I briefly introduce my research approach and the methodology. The Introduction concludes with an outline of the following chapters.

Research Question

In this thesis, I ask if more stringent national environmental regulation leads to more eco-competitive companies. Eco-competitiveness can be defined as a company's ability to mitigate risks and capitalize on opportunities related to environmental issues. Eco-competitiveness is a key concept in this thesis. A highly eco-competitive company understands the environmental impacts of the entire product life cycle and seeks competitive advantage through environmental responsibility.

In conceptualizing eco-competitiveness, an important distinction exists between *process* and *product* environmental impacts. Process impacts refer to the environmental damage that occurs during the manufacturing stage. In the automobile industry, this is commonly measured as the amount of pollution emitted from manufacturing plants. Similarly, process regulation refers to environmental standards that regulate manufacturing processes, such as best available technology standards that require power plants to install certain technologies to reduce their pollution profiles. Throughout this thesis, I use the term *eco-efficiency* to characterize any company's performance in mitigating process pollution.

While eco-efficiency plays a part in this thesis, I am primarily concerned with product-based impacts and regulation. Product impacts refer to environmental damage that occurs during the useful life of a given product. In the case of automobiles, these impacts range from the pollution from cars and trucks to the disposal costs for a vehicle at the end of its life. These impacts are regulated by a different set of product-based regulations, such as fuel economy standards throughout the industrial world and end-of-life standards in the EU. Throughout this thesis, I use the term *eco-inventiveness* to characterize a company's ability to design products that are less environmentally harmful than competing products.

Eco-competitiveness is not equal parts eco-efficiency and eco-inventiveness. Rather, it depends on the particular industry. In the automobile industry, where most of the associated environmental impact occurs during the useful life of the automobile, the eco-competitiveness score is weighted to consider eco-inventiveness more strongly than eco-efficiency. In a ball bearings company, on the other hand, most environmental impact occurs during the manufacturing process, and eco-efficiency would be weighted more heavily than eco-inventiveness in the eco-competitiveness rating.

Finally, it is important to distinguish these three concepts from corporate environmental performance, which refers more directly to quantifiable environmental impacts, such as mercury emissions. Some of the literature uses quantifiable measures such as TRI emissions in a statistical framework to model corporate environmental performance. In contrast, eco-efficiency, and especially eco-inventiveness and eco-competitiveness are inherently qualitative states, and measuring these qualities is more difficult than measuring corporate environmental performance.

At the heart of this thesis, therefore, is an investigation of the drivers of corporate eco-competitiveness. I focus my analysis on the automobile sector (see Table 1). My primary hypothesis is that stringent national regulation drives eco-competitiveness in automobile companies. Is this relationship a foregone conclusion? Is it obvious that strict environmental regulation results in improved environmental performance? Under certain circumstances, perhaps. However, my research design sidesteps such obvious linkages in three ways.

Table 1: Auto Company Universe

Company	Country
Honda	Japan
Toyota	Japan
Renault	France
Peugeot	France
Volkswagen	Germany
Fiat	Italy
Nissan	Japan
Hyundai	Korea
BMW	Germany
Ford	United States
DaimlerChrysler	Germany
General Motors	United States

First, my analysis emphasizes eco-competitiveness, rather than simple compliance or environmental performance. My measure of eco-competitiveness is the Innovest EV'21 rating. While I will discuss the EV'21 rating in further detail below and how the rating is formed in Chapter 3, it is important to note that it is not a measure of mere environmental performance or compliance. Although compliance with relevant laws is included in the analysis, the EV'21 rating is more concerned with a company's ability to manage environmentally-related risks and opportunities from past, present and future activities. For the automobile sector, the bulk of environmental risks and opportunities relate to key central strategic decisions relating to product development and marketing. In making these decisions, companies aim to maximize shareholder value, which may or may not be maximized by complying with certain product-based regulations. Thus rather than measuring current compliance, the EV'21 rating focuses on environmental competence and the extent to which environmental concerns are integrated into product development strategy. It is not obvious, or even necessarily intuitive, that strict environmental laws would have the power to shape central strategic concerns.

A second complication to the link between stringent national environmental regulation and eco-competitiveness is the fact that each automobile company in my set is a global manufacturer selling cars on multiple continents. This means that each company is operating under a patchwork of significantly different standards. I argue above that even in a single country strict standards would not necessarily lead to eco-competitive behavior, and this argument is strengthened when considering that automobile companies do not necessarily sell the most cars in their domestic markets. For example, Honda sells many more automobiles in North America (50% sales) than in Japan (21%), and even though Ford sells a large percentage of their cars in North America (55%), they also sell a significant number in the E.U. (37%). Strategically, this complicates how auto companies respond to different regulations in different markets. Should Honda focus its strategy based on strict Japanese regulations or more relaxed North American standards? Will the stricter regulations of the E.U. affect Ford's central strategy, or will the company merely sell a limited line of cars that meet those standards? The answers to these questions are not clear because multi-national auto companies consider myriad factors when developing products, of which environmental regulations are only one.

A third factor that adds uncertainty to whether stringent environmental regulations lead to eco-competitiveness is the nearly infinite ways in which companies can respond to product-based regulations. When faced with regulations, companies can generally choose to be compliant, non-compliant, or over-compliant. Even if every company decided to pursue an eco-competitive strategy to produce and sell cars based on their environmental performance, the results would undoubtedly differ dramatically. In Chapter 3 I discuss some of the different technologies that different companies are pursuing for alternative fuels and drive trains; the future of personal transportation is remarkably open-ended. Even with current technology, there is a dramatic difference between approaches to enhance vehicle environmental performance among the auto companies. This aspect sets product-based regulations in contrast to process-based regulations, where companies strive to increase their eco-efficiency. While there is innovation in this field, the goal of increasing process efficiency is essentially an engineering challenge rather than a strategic question. Product development is much more open-ended, with an infinite universe of product line choices to accomplish varying goals related to growth and profitability. Again, it is not clear that product-regulations in domestic countries will be a key determinant of product development strategy.

Significance

Practical Significance

In practical terms, this research is relevant to both policy makers and business managers. Environmental policy makers attempt to craft regulations that maximize environmental benefits while minimizing economic costs. The tradeoff between environmental benefit and economic costs is a deeply ingrained assumption in both policy and industry circles. However, this tradeoff is generally considered in regulations pertaining to process-based pollution, where industry must undertake substantial investments to meet emissions standards. Looking at product-based regulation effects, this thesis hypothesizes that multinational corporations operating under more stringent regulations enjoy competitive advantages in the global marketplace. Understanding this potential can help policymakers write laws that attempt to maximize the "double dividend," or the benefit to both the environment and to industry.

This research question is also significant to business managers, especially for multinational companies operating under a patchwork of international product-based standards. Although corporate managers will not necessarily be interested in whether more stringent environmental regulations will make them more eco-competitive, they will be interested in whether seeking a more eco-competitive strategic path will lead to greater financial returns. While financial returns will not be at the core of my research design, I will test whether increased eco-competitiveness leads to increased profitability in the auto sector. The assertion that companies that are better environmental stewards enjoy greater financial returns is a critical question for both business managers and the environment. By law, publicly traded corporations are required to pursue strategies that will maximize shareholder returns, which has historically prevented corporations from investing too heavily in "do-goodery." However, if it is convincingly demonstrated that competing on eco-efficiency and eco-inventiveness is in the best interest of shareholders, corporations may become leading institutions in environmental performance.

Academic Significance

This research question touches on a number of different research areas: the Porter hypothesis, financial returns to environmental performance, ecological modernization, and beyond-compliance. The Porter hypothesis literature explores whether national environmental regulations aid or hinder competitiveness of domestic companies. This robust line of research addresses the reduced form of my research question, which is whether auto companies operating under more stringent environmental regulatory regimes are more financially competitive than those under more relaxed standards. Porter proposes a number of causal mechanisms associated with cost savings from eco-efficiency improvements and competitive advantages from eco-inventiveness. However, by using selective case studies, Porter is unable to systematically develop a strong causal relationship. This thesis contributes to this research by introducing eco-competitiveness, a more strongly developed, quantifiable causal factor linking stringent environmental regulation with financial competitiveness.

The financial returns research fills some of this gap by examining how corporate environmental performance affects competitiveness, ignoring the regulatory environment (although most studies are done with U.S. companies). The most recent work on this topic generally finds that better environmental performance is correlated with higher profitability (as measured by ROA) and higher market valuation (as measured by Tobin's *q*). Two recent studies have actually used the Innovest EV'21 rating as the independent variable in their analyses. Whereas these papers have both looked at a broad range of companies to gain more statistical robustness, my paper focuses on a single sector, which allows a more thorough investigation into the mechanisms through which better environmental performance leads to better financial performance.

Ecological modernization theory explores how the capitalist structure can be used to solve critical environmental problems. This research is especially relevant to this question because some studies address how modern outcome-oriented product-based standards spur innovation in the auto industry. Essentially, ecological modernization is a different application of Porter's hypothesis: Porter concentrates on the benefits for business while ecological modernization concentrates on the benefits for the environment. Accordingly, there are many questions as to how effectively market structures can solve environmental problems. While my research question focuses on the benefits to business (rather than the environment) of strong environmental regulation, the ecological modernization school's focus on technology in the auto industry helps build the connection between environmental regulation and corporate environmental performance (which as discussed, is distinct from eco-competitiveness).

The 'beyond-compliance' literature examines why some companies choose to exceed environmental regulatory standards. Within this research area, which can be described as organizational research, environmental regulations are only one factor that can lead to beyond-compliance behavior. This research area attempts to predict which types of companies are more likely to over-comply, in what circumstances companies will choose to over-comply, and why companies might over-comply. Eco-competitive companies are those that proactively address environmental issues, even in the absence national regulations. While my thesis explores how environmental regulatory regimes influence environmental performance in the auto sector, the beyond-compliance literature provides a number of alternative hypotheses that may be more closely connected with strong corporate performance on environmental issues.

Argument

In this thesis I test the proposition that companies operating under strict product-based environmental regulations will be more eco-competitive than companies operating under less strict regulations. This implies that in the presence of strict product-based regulations on the national level, global auto companies are more likely to enact an eco-competitive global strategy. For example, since Japanese auto companies must meet the highest fuel economy standards in the world, they would be expected to gain competence in not only developing advanced environmental technology, but also commercializing fuel-efficient automobiles. This competency provides a distinct competitive advantage in the global market, especially as fuel prices rise and concern about global climate change heightens.

In addition to my primary hypothesis, I also test a number of other causal mechanisms that may lead to increased corporate eco-competitiveness. These causal mechanisms are market opportunities, stakeholder pressure, and internal factors. Ecological modernization literature regarding automobile companies suggests that managers consider market opportunities to be a greater driver of product development than environmental regulation. In contrast, beyond-compliance literature tends to point to individual qualities of a particular company as the main driver of over-compliant behavior as opposed to external factors such as regulations or market opportunities. Stakeholder pressure is an intuitive causal factor that has not been shown to be important in the literature, but merits investigation in this project.

My findings support my primary hypothesis that strict product-based environmental regulations drive eco-competitive behavior. However, I also find that market opportunities, as modeled by the eco-efficiency of an entire economy, are equally strongly associated with eco-competitive behavior. In Chapters 5 and 6 I attempt to explain these results and reach a deeper understanding of the forces driving eco-competitiveness.

Research Design

This thesis uses a qualitative comparative analytic approach to determine which causal factors most influence the eco-competitiveness of auto companies. My universe of cases includes twelve global auto companies headquartered in six different countries.

Each company markets its products on multiple continents and operates under a global patchwork of environmental regulations. In selecting the company universe, I attempted to choose only direct competitors, thus leaving out companies such as Porsche and Harley Davidson, which operate in more niche markets.

The majority of the thesis concentrates on different causal mechanisms that influence my primary dependent variable: eco-competitiveness. For my eco-competitiveness data I use Innovest EcoValue’21® ratings. These ratings attempt to characterize the interaction between a company’s environmental risk exposure on the one hand and its capacity to manage that risk strategically and profitably on the other. The EV’21 rating measures three broad areas of data: historic liabilities, operating risks, and sustainability risk. Historic liabilities refer to the current risks that result from past actions, such as cleanup costs. Operating risks covers the risk exposure from current activities, such as strength of environmental, health and safety systems. Sustainability risk is a measure of potential future profitability based on eco-efficient production and eco-inventive products.

The EV’21 data is collected in two forms: quantitative and qualitative. Quantitative data mainly covers historical and operational risk factors and is used to benchmark company performance in a given sector. Some examples of quantitative data used are number of Superfund sites, ratio of environmental fines relative to sector average, corporate governance statistics, and emissions data. Qualitative measures are mainly used for the final component, and are used to identify potential environmentally-related business opportunities and gauge general managerial competency on environmental, social and governance issues. Some qualitative measures are company-wide environmental management capability, level of environmental staff training, management of supplier relations and potential strategic profit opportunities. These data are gathered from company websites, SEC filings and other annual reports, third parties and company interviews.

This research is compiled and converted in Innovest's proprietary matrix. For each company, a score between 0 (worst in class) and 10 (best in class) is given for each of approximately 60 key performance indicators. The matrix adjusts the scores based on weightings that were devised through extensive back-testing and adjusted through beta testing. In the end, the scores are converted to ratings similar to bond ratings, ranging from CCC to AAA. I use the raw scores to measure eco-competitiveness.

For my independent variables, I test four different sets of causal factors that may lead to eco-competitiveness. In addition to my primary hypothesis, which examines the effects of product-based regulation on company eco-competitiveness, I will also test other potential causal factors including market opportunities, the environmental efficiency of the economies, stakeholder pressure, and internal corporate factors. I operationalize each of these causal factors with at least one quantitative indicator. These operationalizations are detailed in Chapter 4.

It is important to note that for all of the external causal factors, I use country-level data. In order to test my hypotheses, I apply these independent variables – including home-country regulations, market opportunities and stakeholder pressure – to the auto corporations that are headquartered in that country. Thus data for France is applied to Renault and Peugeot while data for Japan is applied to Toyota, Honda and Nissan etc.

Given the small universe of companies that I am analyzing, I use Charles Ragin's fuzzy set methodology rather than regression statistics (Ragin 2000). As opposed to linear regressions, fuzzy set methods allow the researcher to test for necessary and sufficient conditions for a particular outcome. I explain the fuzzy set rating methodology in detail in Chapter 5.

Roadmap

Having introduced my research question and some background information, the following lays out the structure of the thesis. Chapter 2 provides a literature review summarizing the state of knowledge for a number of schools of literature that seek to connect environmental regulation, eco-competitiveness or corporate environmental performance, and financial outcomes. Chapter 3 details my dependent variables, delving into the Innovest rating procedure and introducing return on assets as my measure for profitability. Chapter 4 explains the operationalizations and results for my primary hypothesis and alternate hypotheses. Chapter 5 explains the fuzzy set methodology, presents my results, and interprets their meaning. Chapter 6 has concluding remarks about my hypotheses and areas for further research.

Chapter 2: Literature Review

Overview

This thesis examines the effects of environmental regulation on the eco-competitiveness of global auto companies and then the link between eco-competitiveness and financial competitiveness. This design connects areas of environmental regulation, corporate eco-competitiveness and corporate financial competitiveness (see Figure 1). A number of research areas have been used to connect these concepts in different ways, including the Porter hypothesis, financial returns to environmental performance, beyond-compliance firm behavior, and ecological modernization.

Figure 1: Research Question Schematic

Figure 2: Literature Review Schematic

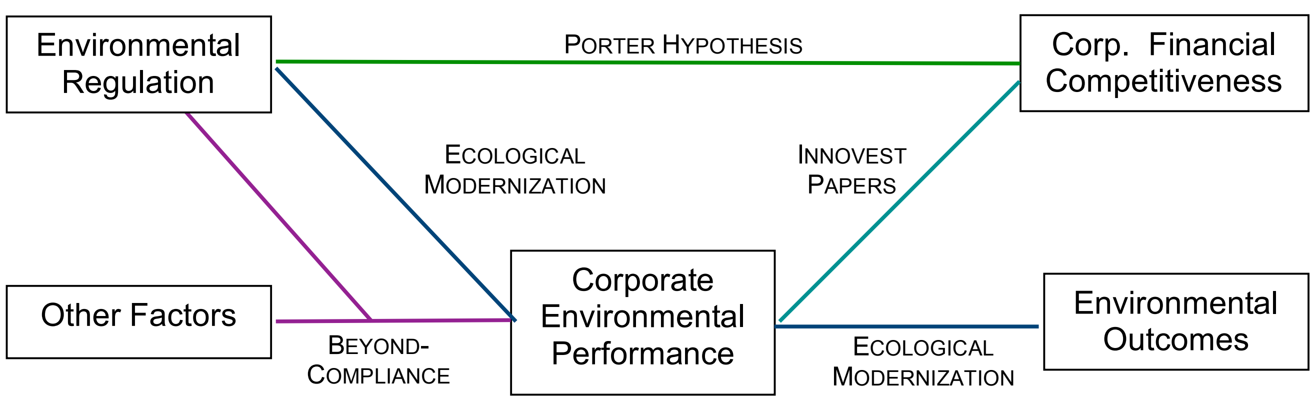


Figure 2 models the relationships that the different bodies of literature establish. My research question requires that I connect environmental regulations and other causal factors to eco-competitiveness. Additionally, to increase the policy relevance of the argument, I test the relationship between eco-competitiveness and financial competitiveness. As you can see from the diagram above, the different schools of literature have different objectives and use different causal mechanisms. The Porter hypothesis attempts to connect increased regulatory stringency directly to financial returns, focusing on process-related regulation. Innovest papers link eco-competitiveness with financial outcomes, establishing the argument that eco-competitiveness has a positive effect on financial outcomes for companies. Regulatory factors are not included in these analyses. Ecological Modernization literature connects environmental regulations with corporate environmental performance (not eco-competitiveness) and assesses performance based on environmental rather than financial outcomes. This literature focuses on product-related regulations. Finally, beyond-compliance literature aims to identify the causal factors that lead companies to adopt more stringent standards than are necessitated by regulation. This literature also focuses on process-based regulation.

Porter Hypothesis

The development of the “Porter hypothesis” (or revisionist school) literature emerged from classical economic theory, which holds that environmental regulation increases costs, thus reducing profits (Jenkins 1997). This view simply sees environmental regulation as requiring a firm to internalize externalities, such as pollution. Since pollution control imposes additional direct costs on a firm, the firm will be less competitive. The other pillar of the classical approach is that investing in pollution abatement diverts both capital and human resources from other potential investments.

Since pollution abatement does not increase productivity, environmental regulations also impose significant opportunity costs on companies.

The revisionist view challenges classical theory by incorporating innovation into the model. The classical theory holds products, technology and processes constant, which inevitably leads to increased costs as a result of environmental regulation. However, in reality, these aspects of a company are not fixed. Porter's hypothesis is built upon this 'dynamic' view of competitiveness and asserts that environmental regulations can increase competitiveness by stimulating innovation that will actually cut company costs in the end.

In order for this hypothesis to hold, Porter outlines "good" regulation, which aids competitiveness, and "bad" regulation, which does not increase competitiveness. Porter considers command and control standards to be bad regulations. This is because they prescribe *how* a company must improve its environmental performance rather than providing a standard and allowing the company to decide how to meet it. This point leads to significant empirical problems, since almost all environmental regulations before 1995 were of the command and control type. This severely limited the research options directly related to the Porter Hypothesis.

Porter identified "innovation offsets" as the primary mechanism through which more stringent environmental standards would lead to increased competitiveness. The idea of the innovation offsets is that environmental regulation would lead to products that pollute less and are 'better' in some way (product offsets) and processes that are more eco- and cost efficient (process offsets) (Porter 1995b). These innovation offsets take into account the dynamic nature of companies and their ability to respond to incentives with technology to improve their processes.

Porter defines product offsets as occurring when environmental regulation leads to products that are safer, higher-performing, or lower cost (Porter 1995b). He addresses product offsets in his analysis, primarily focusing on the case of phasing out CFCs, a situation where a market for new technology and products emerged from environmental regulations. Aside from this case, Porter mainly frames product offsets as either leading to lower costs because of associated process innovation or cheaper disassembly and enhanced recyclability. While these are certainly aspects of eco-efficiency and eco-inventiveness, they do not focus on the useful life of the product, rather its manufacture and end-of-life. Porter's discussion of product-offsets is relevant to my argument; however, I contend that his treatment of these issues is incomplete.

Porter discusses processes-offsets through the perspective of enhanced resource productivity. In his own words:

> 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 1995a).

This view sees pollution as a form of economic waste and inefficiency. Processes that yield pollution are by definition inefficient, and improvement in material utilization would benefit the company. Additionally, environmental regulation forces companies to handle this waste, which is a costly and unproductive activity. Thus, Porter postulates that environmental regulation that is properly designed to foster innovation in manufacturing processes will stimulate companies to improve their resource productivity and save costs while engaging in eco-innovation to increase the value of a product.

Although resource productivity is a central tenet of the revisionist school, this paper will only sparingly incorporate it since the primary concern is regulation that stimulates product rather than process innovation. That being said, resource productivity is essentially the same as my concept of eco-efficiency, which represents a portion of the Innovest EV'21 rating; thus the concept will implicitly be involved in the analysis.

Another mechanism Porter identifies, which will be more applicable to this paper, is first-mover advantage. First-mover advantage can occur when regulations are deployed at different times across the world, differentially affecting companies in different countries temporarily. Porter appropriately illustrates this concept with an example from the automobile sector:

> It is no secret that Japanese and German automobile makers developed lighter and more fuel-efficient cars in response to new fuel consumption standards, while the less competitive U.S. car industry fought such standards and hoped they would go away. The U.S. car industry eventually realized that it would face extinction if it did not learn to compete through innovation. But clinging to the static mind-set too long cost billions of dollars and many thousands of jobs (Porter 1995a).

In this example, the Germans and Japanese gained competence and aligned their production patterns to favor light and fuel-efficient cars in response to stringent fuel economy standards. Meanwhile, the big U.S. companies were building SUVs and not preparing for tightening environmental regulations. Thus a shift toward more stringent fuel economy standards in the U.S. would hurt domestic companies and benefit the German and Japanese automakers because of the first-mover advantage. This claim of the Porter hypothesis is exactly the claim my thesis is testing – that strict environmental regulations actually helped Japanese companies become eco-competitive and gain a financial advantage over the less regulated U.S. companies.

Although Porter supported his claim that well-designed environmental regulations are actually beneficial for business with sensible and intuitive mechanisms, a number of scholars vehemently disagreed. One of the primary challenges to the revisionist school is its assumption that the private sector systematically overlooks profitable opportunities in Porter's model (Palmer 1995, Walley and Whitehead 1994). This claim is a softer version of the classical theory, which assumes that firms *always* make profit-maximizing decisions. Palmer agrees that there are times when managers will overlook opportunities to mitigate environmental impact and increase profitability, but that these inefficiencies are not as pervasive as Porter suggests. Defending this perspective, Palmer cites 1992 numbers from the Bureau of Economic Analysis (BEA), which show that environmental expenditures were over $100 billion and "offsets" were a little less than $2 billion (Palmer 1995). While the argument that environmental costs will not be overshadowed by offsets may be true, the numbers Palmer cites are misleading because they mostly account for compliance with regulation that Porter readily admits does not foster innovation. This limitation is omnipresent in early attempts to prove or disprove the Porter hypothesis empirically.

With these theoretical camps established, a number of authors attempted to verify Porter's hypothesis empirically. The results generally fell in between the two extremes. Jaffe (1995) explored whether environmental regulation reduces net exports in the manufacturing sector, focusing particularly on the manufacturing of "pollution-intensive" goods. He found that international differences in environmental regulatory stringency, as measured by compliance costs, neither threaten nor advantage the U.S., which at the time operated under stricter environmental regulations. This result suggests environmental regulations do not lead to significant changes in the competitive landscape, even in "pollution-intensive" industries. Thus, governments may enact stringent environmental standards for public health reasons without harming international competitiveness. On the flipside, the regulations will not boost companies' competitiveness. Jaffe and Palmer (1997) attempted to link environmental compliance expenditures with R&D expenditures and successful patent applications to test whether firms that are more affected by environmental regulations become more innovative as a result. They found that environmental compliance expenditures have a lagged effect on R&D expenditures, but no significant effect on successful patent applications. In summing up the debate, Jenkins (1997) states: "The efforts to clarify the linkages between environmental regulation and competitiveness are still rudimentary, and it has not been possible to determine conclusively which are the main variables which intervene in the relationship." My thesis suggests that eco-competitiveness may be the main variable that intervenes in the relationship in the case of product-based regulation.

Although the Porter hypothesis literature provides a rich context for my research question, the framework is somewhat limited in this application. The first, and probably greatest difference is that this literature is almost entirely focused on the cost side of the profitability equation. The debate over innovation offsets and enhanced resource productivity tends to be placed within a very narrow cost reduction context. This is because the literature focuses on process pollution in manufacturing industries. This angle narrows the question to whether the costs of complying with regulations are offset by the cost reductions resulting from enhanced resource productivity. This interpretation leads scholars to assume that the Porter hypothesis fails if it costs more money to implement environmental management systems than is saved through increased process efficiency, which is essentially Palmer and Walley & Whitehead's contention. My thesis concentrates on product innovation, which appears on the revenue side: will more stringent environmental standards help some firms gain a competitive advantage through their product lines? The concept of eco-competitiveness considers both product and process innovation, allowing me to explore the wider version of the Porter question, including product innovation, which is more difficult to analyze empirically. Thus, rather than exploring the costs to industry in complying with environmental regulation, this thesis builds upon the research demonstrating that eco-competitiveness links to financial competitiveness, and explores whether stringent environmental regulation leads to higher eco-competitiveness in the auto sector.

The other major difference is the scale of the research. The research above is either based on case studies, which are illustrative but difficult to generalize, or on studies of "pollution-intensive" industries, which have a wide variety of environmental issues and processes. My analysis only refers to the automobile sector. This will allow me to avoid the problem of selecting specific case studies while also providing the opportunity to dig deeply into the specific issues that affect this highly environmentally relevant sector. Another advantage of this sector is that the regulatory items are primarily innovation-fostering regulations, rather than the end-of-pipe solutions that are prevalent in the manufacturing industries.

Financial Returns to Eco-Competitiveness

A related yet distinct line of research examines the connections between eco-competitiveness and financial competitiveness, largely ignoring the effects of regulation. These papers use a variety of methods and measures, and in general converge on the conclusion that superior eco-competitiveness is associated with superior economic returns. Three papers in particular are closely related with this research. Two of them (Derwall 2005, Guenster 2006) use the Innovest EV'21 rating as their independent variable, as I do. The other (Dowell 2000) compares multinational corporations that adopt their own internal stringent environmental standards with those that adapt local standards in developing countries.

These papers expand upon the theoretical Porter literature by offering both management and financial theories for why more environmentally responsible companies enjoy better or worse financial performance. The literature hypothesizes two potential relationships: companies with higher EV'21 ratings are more profitable and companies with higher EV'21 ratings have higher share price values. Before delving into the different results of the studies, I present different causal mechanisms linking eco-competitiveness with financial competitiveness. I distinguish between management theories, which explain causal mechanisms relating profitability, and financial theories, which explain causal mechanisms relating to stock market value.

Management theories explore how environmentally responsible firms can experience better profitability. Guenster (2006) suggests three general causal mechanisms: (1) environmental responsibility is associated with reputational benefits, which can improve relationships with employees, customers, suppliers and lenders; (2) environmental and social responsibility can serve as a proxy for management quality; and

(3) environmental responsibility may reflect innovativeness (consistent with Porter) when environmental issues are governed proactively.

Dowell et al. (2000) also provides four mechanisms for why a single internal environmental standard would benefit a multinational company compared to merely meeting a patchwork of mostly less stringent local standards: (1) cost savings related to lower standards might not even exist; (2) a single corporate standard may be cheaper to deploy; (3) standards tend to rise, which would allow multinationals to accelerate this trend to out-compete local firms; and (4) there are heightened reputational effects associated with higher environmental standards. By focusing on the mechanisms that link eco-competitiveness with financial outcomes regardless of the policy context, this literature can encompass a broader view of environmental responsibility. This is because the decision of an individual company to implement stringent environmental standards implies strong management and allows for potential reputational benefits. However, merely reacting to regulation that is deployed for an entire industry prevents the firm from enjoying these intangible benefits, which were available to firms taking voluntary action.

While management theories provide intuitive explanations for why better environmental performance may lead to higher profitability, financial theories are more concerned with how this performance affects share price, which is a puzzle that depends on a number of financial market mechanisms (Derwall 2005). Whether or not environmental screening affects investment returns depends not only upon the factors listed above, but also upon the financial markets' ability to factor the consequences of environmental responsibility into share prices. Financial theory suggests (Derwall 2005) two tenets: (1) investment portfolios deliver returns proportional to the associated risk, thus high risk yields high return, and (2) optimal portfolios are well diversified. Both of these asset-pricing tenets suggest that socially responsible investors will suffer from suboptimal returns. If environmental responsibility leads to reduced risk, then shareholders limit their opportunity for higher returns. Also, by weeding out a whole universe of investments, socially responsible portfolios will be less diversified, another disadvantage in the financial theoretical framework.

The empirical evidence on eco-competitiveness and financial performance seems to favor both increased profitability and share price value for eco-competitive companies. The associated studies employ statistical analysis over a broad set of companies to examine how environmental performance affects share price and profitability. Dowell's (2000) study examines how multi-national enterprises' (MNEs) level of environmental management system affects their market valuation, measured by Tobin's q. The independent variable represented environmental management stringency in developing countries, which either corresponded to local standards, U.S. standards, or a global internal standard. The local standard represents the weakest performance, and the global internal standard is the strongest. Tobin's q, as discussed in the first chapter, is a calculation that is used to broadly assess firm value.

Dowell reaches a number of interesting conclusions. First, the majority of MNEs in his sample employed their own internal standards, and by far the fewest companies merely met local standards. Interestingly, companies that adopted U.S. standards performed insignificantly higher than those who chose local standards; however, companies that adopted their own internal standards performed significantly better than those that employ either local or U.S. standards. One potential interpretation of Dowell's results is that higher-quality firms adopt high environmental standards, despite local requirements, and that lower-quality firms race to the bottom to gain short-term financial advantages (Dowell 2000). These results support the case that better environmental performance is associated with high-quality management.

Guenster performed two statistical tests correlating Innovest's EV'21 rating with ROA and Tobin's q for the entire universe of companies ranked by Innovest (approximately 1200). One test assumed a linear relationship, relating Innovest rating directly to financial performance. The other separated high rated (AA and AAA) companies from low rated (CCC and B) and compares their performance. The results suggest significant differences between low and high rated companies in both ROA and Tobin's q (Guenster 2006). The paper also finds that the underperformance (measured as the coefficient on ROA term) of the least eco-efficient companies is almost twice as large, relative to the reference group, as the outperformance of the most eco-efficient companies (Guenster 2006). Another interesting finding is the strong time variation – highly eco-efficient companies were selling at a premium more than twice as large in the later sub-period – which suggests that investors have become more interested in eco-efficiency.

Derwall's study (2005) concentrates on risk-adjusted market returns to high EV'21 ratings. Much like Guenster, Derwall uses Innovest's EV'21 rating as his dependent variable. However, instead of measuring ROA and Tobin's Q, Derwall uses the CAPM (capital asset pricing model). The CAPM predicts returns based on the relative risk of the portfolio, represented by its beta. The CAPM corresponds to the theory that higher risk leads to higher potential returns. Another aspect of the CAPM framework is Jensen's alpha, which represents returns not accounted for by the risk inherent in the portfolio. Thus, a higher alpha means that a portfolio performed better than its risk profile suggested. Derwall found a 3.05% difference in performance between the higher-rated portfolio and the lower-rated portfolio, which is economically large, but not statistically significant.

Derwall performs a second analysis incorporating other variables to control for style biases (size, value vs. growth, momentum effects), which can have a significant effect on returns. The results suggest that strong environmental performers provide significantly stronger returns – 5.06% a year (significant at 10% level) – when controlling for additional style factors (Derwall 2005). Derwall also found a shrinking eco-efficiency premium in more environmentally sensitive sectors. These results taken together suggest that the market does not correctly factor environmental performance into pricing, but is in the process of correcting for this error when the benefits of eco-efficiency are more obvious to investors.

These studies provide evidence supporting the link between high Innovest EV'21 ratings and strong financial performance. As opposed to the Porter literature, in which the effects of environmental regulations remain contested, this literature has much more consistent findings. Part of this reason is that the Innovest EV'21 rating is a much more precise and comprehensive indicator of eco-competitiveness than other metrics, such as TRI emissions used in earlier studies.

Although these studies have strong conclusions, they are based on a large, broad sample of companies that face different environmental issues. It is unclear for which industries the relationship between eco-competitiveness and financial competitiveness will hold on the sector level. In other words, it is possible the correlation between eco-competitiveness and financial competitiveness is very strong in certain sectors, but very weak or nonexistent in others. The auto sector is especially interesting in this regard because almost all of the environmental impact occurs during the life of the product. It is much more straightforward to measure the pollution of a pulp & paper company and invest in a more efficient one. In contrast, global automakers have diverse product lines and operate in multiple geographic segments with a patchwork of different environmental regulations governing their products. Thus the connection between environmental performance and financial performance will likely be much more complicated and dependent on more external factors when compared with classic ‘pollution-intensive’ industries like pulp & paper and mining.

Ecological Modernization

Ecological modernization theory asserts that environmental problems can be solved through innovation within the capitalist system. The theory is closely related to Porter’s idea that properly constructed environmental regulation can stimulate innovation. While Porter is interested in the implications this has for business, ecological modernization is interested in the implications for the natural environment. Essentially, the ecological modernization literature poses two questions: (1) “to what extent can regulation stimulate innovative solutions to environmental problems in the private sector?” and (2) “can these innovations successfully solve environmental problems?” This paper is more interested in the first question, since it is focused on financial outcomes for firms rather than environmental outcomes.

One of the key advantages of the ecological modernization school is that many studies focus on the automobile industry, since it is highly regulated, highly technological, and environmentally sensitive. One such study (Smith and Crotty 2006) focuses on the EU ELVD (End-of-Life Vehicle Directive), which promotes design such that 85% of the vehicle can be recycled. In performing surveys of UK auto companies, the authors found two important results. First, regulation had limited benefits. This tended to be a result of technological 'lock-in' where firms cannot immediately change technological directions. Rather, auto companies are locked into development cycles, and supplier and customer contracts that undermine sudden innovative development. This idea is one of the central criticisms of ecological modernization theory.

The second, and perhaps more relevant, conclusion was that regulation was not a main reason for introducing new products or processes. Efforts to achieve compliance tended to be incremental solutions, consistent with the business-as-usual approach. This finding is problematic from the perspective of ecological modernization, since it undermines the government's ability to improve environmental problems through cooperation with the private sector. Smith and Crotty found that instead, innovation tended to result from exploiting new market opportunities or improving technological diversification. Their results suggest that market opportunities can be a more powerful causal factor than environmental regulations in promoting eco-competitive behavior.

Orsato (2005) considers ecological modernization in the case of automobile fuel efficiency. He, much like Smith and Crotty, finds that automobile companies are limited by lock-in and are generally unwilling to move away from core competencies. He identifies the problem as such:

> Modern cars are embarrassingly inefficient in terms of energy utilization. However, for the consumer who is not aware of or interested in issues of energy efficiency and environmental performance, ICE-powered (internal combustion engine) cars still provide better *motoring* performance than electric vehicles. The result has been a persistent failure of markets for such alternatives (Orsato 2005).

In this view, the market alone will not stimulate auto companies to develop alternative technologies. This occurs for two reasons: (1) because the easy, incremental improvements have already been made, and researching and developing alternative vehicles is extraordinarily expensive; and (2) consumer demand for alternative vehicles is not strong enough to justify this investment. However, in reality, companies vary in the environmentally progressive technologies they are developing. While I delve more deeply into these different technologies later, part of my research question aims to explore to what extent environmental regulations have the potential to push companies into more aggressively pursuing technologies such as electric and fuel cell vehicles.

Another study compares and contrasts the "going-green" approach of Volvo, Ford and Toyota (Williander 2006). This paper finds that all the companies were proactive in developing new technology, but the different approaches and assumptions led to different outcomes. Ford and Volvo both attempted to develop methane (and later bi-fuel) powered automobiles that were as similar as possible to the regular versions. Toyota, on the other hand, developed the Prius, which is a gasoline powered hybrid car that does not attempt to fit into the mold. Toyota enjoyed a better outcome because the company found a way to "bundle common and private good into a unique product" (Williander 2006). This means that while the Prius is better for the environment, it is also a "cool" car to own; it is technologically advanced and has a unique style that displays its eco-friendliness. Volvo and Ford, in contrast, failed because they challenged the technology they could not control, (i.e. fuel infrastructure) rather than their own technological paradigm.

The lesson from Williander is that environmentally advanced automobiles can be successfully marketed, but it is important to invest heavily and take risks. Ford and Volvo assumed that their goal for 'no sacrifices' represented a low-risk strategy, since consumers would not have to make sacrifices for the environment. Toyota, on the other hand, developed a conceptually new vehicle that forced consumers to advance technologically, and it worked.

In assessing the impact that environmental regulation has on innovation in the auto industry, the ecological modernization literature provides a primarily negative picture. Companies seem to be limited in their capacity for quick change, due to technological lock-in and contract obligations. Environmental regulation also tends to be low on the 'corporate radar,' and usually only spurs incremental change. Furthermore, many auto companies have already attempted (and failed) to introduce bold new technology to improve fuel efficiency.

Beyond-Compliance

The fourth and final body of literature relevant to my thesis is the beyond-compliance literature. Beyond-compliance is a loosely associated group of institutional perspective approaches that attempts to answer the question: why do companies adopt strict internal policies beyond the requirements of extant laws? In terms of my research question, this literature bolsters the ecological modernization literature's attempt to clarify the linkage between environmental regulation and environmental performance. A brief review of this literature sheds some light on factors that most affect a company's decision to exceed environmental regulations.

Prakash (2001) attempts to answer this question by dividing environmental policy scenarios across two factors: (1) whether profitability can be assessed; and (2) whether it is required by law. The interesting scenario is when profitability cannot be assessed and there are no laws requiring action ("type 2"). His research suggests that some firms may adopt type 2 policies to obtain early mover advantages or to raise the cost of entry for competitors, assuming stringent regulations will follow (Prakash 2001). However, this does not explain why different firms *selectively* adopt type 2 policies. Prakash argues here that selective adoption can better be explained by internal dynamics of the firm, rather than the external context.

Arora & Cason (1996) found similar results in their research into the decision to participate in the EPA's 33/50 program. The program attempted to reduce the use of 17 toxic chemicals by 33% by 1992 and 50% by 1995 relative to 1988 baseline levels. The program was purely voluntary: no penalties for non-participation, and no favorable treatment for participation. The results indicated, similar to Prakash's, that over-compliance can be a rational response to potential future regulation that can give companies early mover advantages while increasing the costs of entry for competitors (Arora and Cason 1996). However, a stronger finding in this study was the importance of company image. Indeed, companies that exceeded requirements subsequently expended additional resources to inform consumers of its superior environmental performance.

Nakamura (2001) attempted to explain why Japanese firms are significantly more likely to implement ISO14001 environmental management systems than firms in other developed countries. Specifically, the study focused on three issues: (1) the factors that lead Japanese companies to incorporate environmental goals into decision making; (2) the characteristics of firms achieving ISO14001 certification; and (3) the characteristics which explain early adoption of environmental certification (Nakamura 2001). Through statistical analysis, the results show that Japanese certification rates are significantly affected by the following factors: firm size [positive], average age of employees [negative], export ratio [positive], and debt ratio [negative] (Nakamura 2001). External factors such as government pressure and civil society pressure were not key determinants compared to these internal factors. This conclusion supports Prakash's conclusion that internal factors are more significant than external factors in determining over-compliance.

The general conclusions of the beyond-compliance literature suggest that there may be strategic motives for firms to compete on environmental performance (early mover advantage and imminent regulatory changes), but that much variation among competitors can best be described by factors internal to the firm. This has two implications for my study. First, the findings suggest that internal firm characteristics are a more powerful driver of firm eco-competitiveness than external factors, such as the regulatory context or market opportunities. Second, however, is that because the automobile sector is exceptional both in terms of the environmental impacts and regulation of its products, it implies a reason to maintain a focus on external factors driving eco-competitiveness. In other words, because the environment is a high-profile issue for auto companies, external factors should play a greater role in development decisions relative to internal factors compared with other less environmentally intense industries. In order to balance these two implications, I test both internal and external causal factors.

Conclusion

This literature review aims to contextualize my question and provide background research from the disciplines that contribute to my question and causal mechanisms. These sources of literature suggest different mechanisms for which factors lead to increased corporate environmental performance, and how this affects financial outcomes. I look to improve upon this research by introducing a new mechanism, eco-competitiveness, which is a more robust indicator based on eco-efficiency in production and eco-inventiveness in products. Through this mechanism I hope to establish a stronger connection between environmental regulation and financial performance for product-based regulations than has been researched before.

Chapter 3: Outcomes – Innovest EV'21 Rating and Return on Assets

Introduction

This chapter focuses on explaining my dependent variables. My thesis question proposes two links: (1) between product-based environmental regulations and eco-competitiveness; and (2) between eco-competitiveness and financial competitiveness. I model my first outcome, eco-competitiveness, using the Innovest EV'21 rating. I model my second outcome, financial competitiveness, using return on assets, a profitability metric. This chapter explains both measures, with the primary focus on the EV'21 rating. I do this for two reasons. First, the rating is not well known within academic literature, thus requiring a robust explanation of the factors that contribute to the rating. Second, my analytical focus in this thesis is on the link between environmental regulations and eco-competitiveness, thus requiring a more detailed explanation of eco-competitiveness.

Innovest EV'21 Rating

In this thesis, I operationalize eco-competitiveness using the Innovest EV'21 ratings for the automobile sector. The rating methodology separates the most eco-competitive companies, ranked AAA, from the least eco-competitive, ranked CCC. Innovest undertakes two basic steps when rating companies in a given sector: identifying common environmental and social challenges faced by each company and comparing each company's approach to either minimizing the risk or seizing the competitive advantage. Although this paper will focus solely on the environmental side of the rating, a full Innovest rating combines the EV'21 rating with the social rating (IVA) to form the final COMBO rating.

Table 2: Innovest EV'21 2006 Ratings

Honda	AAA
Toyota	AAA
Renault	AA
Peugeot	AA
Volkswagen	AA
Fiat	BBB
Hyundai	BBB
BMW	BBB
Nissan	BBB
General Motors	BB
DaimlerChrysler	BB
Ford	BB

Innovest refers to the major sector-wide environmental and social issues as "industry driving forces." Industry driving forces vary by sector, and while the automobile, auto parts and industrial machinery industries face many of the same challenges, this is not true for sectors such as banking and telecom. All sectors have both environmental and social industry driving forces, but this thesis will only consider the environmental side.

Although the aforementioned issues are highlighted, the EV'21 rating for all sectors is divided into environmental risk factors, environmental strategy/management, and strategic profit opportunities. Ratings in these three areas are highly connected to company performance regarding the industry driving forces. In its auto sector report, Innovest identifies value drivers, best practices, and company performance for each of these elements. The report focuses most closely on key strategic product development capabilities, since most environmental risk and benefit in the auto sector relates to the performance of the automobiles rather than the efficiency of manufacturing. The remainder of this chapter will delve into the rating process outlined above and report on the major findings related to the ratings used in this thesis. Any information not otherwise cited derives from the Innovest Auto Sector report (Brammer 2006).

Industry Driving Forces

The first step in the Innovest rating process is identifying the most important environmental issues that the sector faces as a whole. The primary environmental industry driving forces for the automobile sector include fuel prices, climate change and the EU ELV (End-of-Life Vehicle) and ROHS (Restriction on Hazardous Substances) directives.

Fuel Prices & Fuel Efficiency Technology

Over the past couple of years, fuel prices have skyrocketed, and a gallon of gasoline currently stands well above $2 per gallon. These high gas prices have helped the commercialization of leading edge fuel efficiency technology, such as hybrid-electric engines and continuously variable transmissions while helping nurture more long-term environmental technologies, such as lithium-ion batteries and hydrogen fuel cells. Hybrid automobiles, which were primarily developed to meet Japan's high fuel efficiency standards, are enjoying rapid growth in the global auto market, and Toyota plans to sell over one million hybrids by 2010 while reaching full profitability on the Prius by 2008. While this is a still a tiny segment of the automobile market, in the U.S. alone the number of hybrids sold grew tenfold between 2000 and 2004, from 9,500 to 100,000 (Berman 2005), and exceeded 250,000 in 2006 (Duffy 2006). The success of the Prius has compelled all leading auto manufacturers to invest in hybrid technology, and rising gas prices will continue to fuel the growth of the hybrid market.

The adoption of hybrid electric vehicles is part of a broader industry trend of moving toward the eventual phase-out of the internal combustion engine as the main power train in favor of electric motors. This trend is one of the greatest growth opportunities in the industry, and all of the major auto companies are investing substantial R&D capital in alternate drivetrains and battery power. Although the hydrogen fuel cell is commonly seen as the "Holy Grail" of automobile technology, it is considered a long-term investment, and there remain significant hurdles to widespread commercialization of hydrogen vehicles. In the meantime, improving battery technology, whether for gasoline hybrid electrics, diesel-electrics, plug-in hybrids or pure electric vehicles, has become an increasingly competitive field. Toyota, Honda and Ford are currently engaged in joint ventures to develop lithium-ion batteries, which are more efficient and less toxic than the current nickel-cadmium batteries. The relative ferocity with which these companies seek improved battery technology may determine the winners and losers over the next few years.

Global Climate Change

Reinforcing the effects of increasing fuel prices is increasing anxiety and regulation regarding global climate change. According to the Carbon Disclosure Project 4 (Innovest 2006), a project backed by 225 institutional investors representing over $31.5 trillion of assets demanding greater transparency on climate change issues for the world's biggest companies, the following are the implications of climate change for the automobiles and auto components sector:

- Material increases in operating costs due to higher fossil fuel prices
- Indirect exposure to GHG emissions regulation
- Direct exposure to emission regulations on personal and commercial vehicles
- Competitive emphasis on low-emissions, high-efficiency engine technology

- More public policy support for hydrogen economy-related R&D
- Competition from sustainable public transport initiatives, particularly in cities
- Opportunities for next-generation, zero-emission vehicles, particularly in developing world markets

Nearly every company in the competitive set (CDP4 lacks information from Honda, Hyundai and Fiat) has allocated board-level responsibility for climate change related issues, and each company considers climate change to represent a commercial risk/opportunity and has developed products in response to climate change. Climate change is undoubtedly a major issue in the auto sector, and a company's rating will in some sense depend on whether climate change issues pose a major risk or a prime opportunity for a company.

EU ELVD & RoHS Directives

Another major issue for automobile manufacturers relates to the EU's End-of-Life Vehicles Directive (ELVD) and Restrictions on Hazardous Substances Directive (RoHS). The ELVD became effective on July 1, 2003 and covers four areas:

- Original manufacturer is responsible for recycling vehicles.
- Certain hazardous substances – such as lead, mercury, cadmium, and hexavalent chromium – can no longer be landfilled.
- Targets by weight fraction were set for levels of material recovery, which must be either re-used or recycled, of 85% by January 1, 2006 and 95% by January 1, 2015.
- There are a number of exemptions for some heavy metals, including lead, mercury, and hexavalent chromium in particular parts.

These elements sparked a massive data collection campaign throughout the extensive global supply networks. Automobiles contain approximately 50,000 parts each, which use thousands of materials and chemicals and change frequently. Due to the global nature of the auto industry, all major companies must adopt a strategy to comply with these standards to remain competitive in the European Union.

The RoHS directive aims to phase-out the hazardous materials lead, mrecury, hexavalent chromium, cadmium and flame-retardants. RoHS came into force in 2002 and companies must cease using these materials starting in July 2006. These materials are used widely in auto components, and compliance with this directive requires major shifts in the materials used in the electronics industry and massive supply chain inspection efforts. Unprepared companies will likely be left behind and non-compliant with the directive.

Best Practices and Company Performance

After identifying the key industry driving forces, as discussed above, the Innovest analysis proceeds to analyze each company along the three following performance areas: environmental strategy & management, key strategic product development capabilities, and production efficiency & risk factors. Company scores on specific indicators within these three broad areas will determine their EV'21 score. In the Innovest report, a discussion of each area is structured around three sections: (1) a brief summary the "value drivers" that connect eco-competitiveness with financial performance; (2) a list of industry "best practices"; and (3) a short description of the best and worst performers. In this section, I will briefly explore each firm performance area in order to further elucidate the EV'21 ratings.

Environmental Strategy & Management

When examining environmental strategy, Innovest seeks to determine the extent to which environmental concerns and opportunities are integrated into the mainstream business structure. For example, placing environmental departments within the legal department, as opposed to devoting a board committee to environmental concerns, demonstrates a vision of the environment as merely a source of legal concerns. Since the environment is such a focal issue in the automobile sector, most companies have been reporting environmental performance for years and understand the benefits of implementing sustainability-related strategies. Leaders in the sector incorporate environmental considerations into the business plan and day-to-day operations, which can create significant business opportunities.

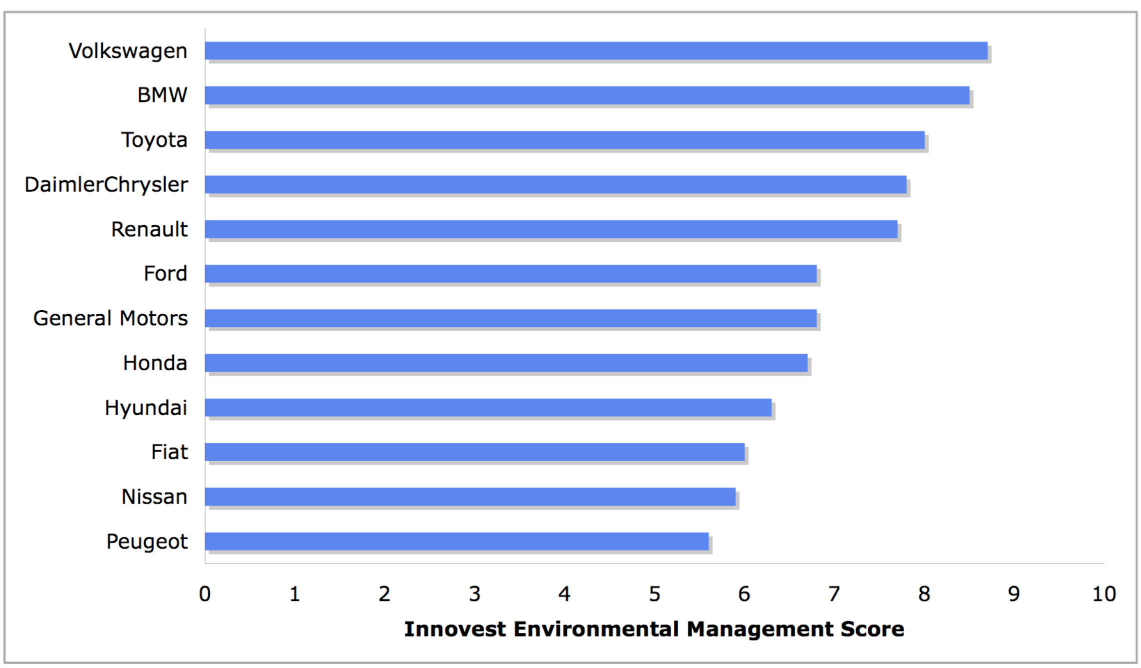
The following are selected best practices within the auto sector. As you will notice, these practices cover a wide swath of business areas, ranging from board committees to human resources. It is for this reason that the best way to manage environmental issues is to fully integrate environmental strategy into day-to-day operations. This is the list of best practices as identified by Innovest:

- High-level, group-wide environmental strategy and policy with defined goals for the next five to ten years
- Environmental strategy oversight by dedicated committee of Board of Directors
- Certified Environmental Management System (EMS), such as ISO14001, to manage environmental impacts
- Development of a culture of environmental awareness through training and award programs for employees who develop programs to reduce company's environmental footprint
- Being signatory to international initiatives and demonstrating committed stakeholder engagement more generally
- Integrating environmental issues into core business strategy through product development, life cycle analysis and resource efficiency
- Company-wide monitoring of resource use, emissions, and waste usage
- Annual environmental reporting certified by external auditors

The report identifies Toyota and Volkswagen as examples of leaders in environmental management capacity. These companies delegate top management to support senior environmental officers. Environmental risks are assessed by the Board of Directors and are integrated into overall business risks. These companies also have a robust network of environmental officers that implement the EMS. Furthermore, these companies monitor environmentally related business risks and opportunities related to present and future legislation. These companies also annually release comprehensive sustainability reports that monitor progress and targets in different environmental performance indicators. Taken together, these elements suggest a proactive environmental strategy that goes beyond compliance.

The laggards in the sector generally have poor environmental management disclosure and decentralized, ad hoc environmental strategies. The real laggards include Ssangyong and Harley Davidson, which have both been excluded from my set. Many of these environmental strategy elements separate unacceptable company behavior from acceptable behavior. As such, the bigger auto manufacturers in the world have managed to pull together a strong environmental management system with annual reporting. Thus, within my set, environmental strategy and management does not represent the focal factor distinguishing top performers from bottom performers.

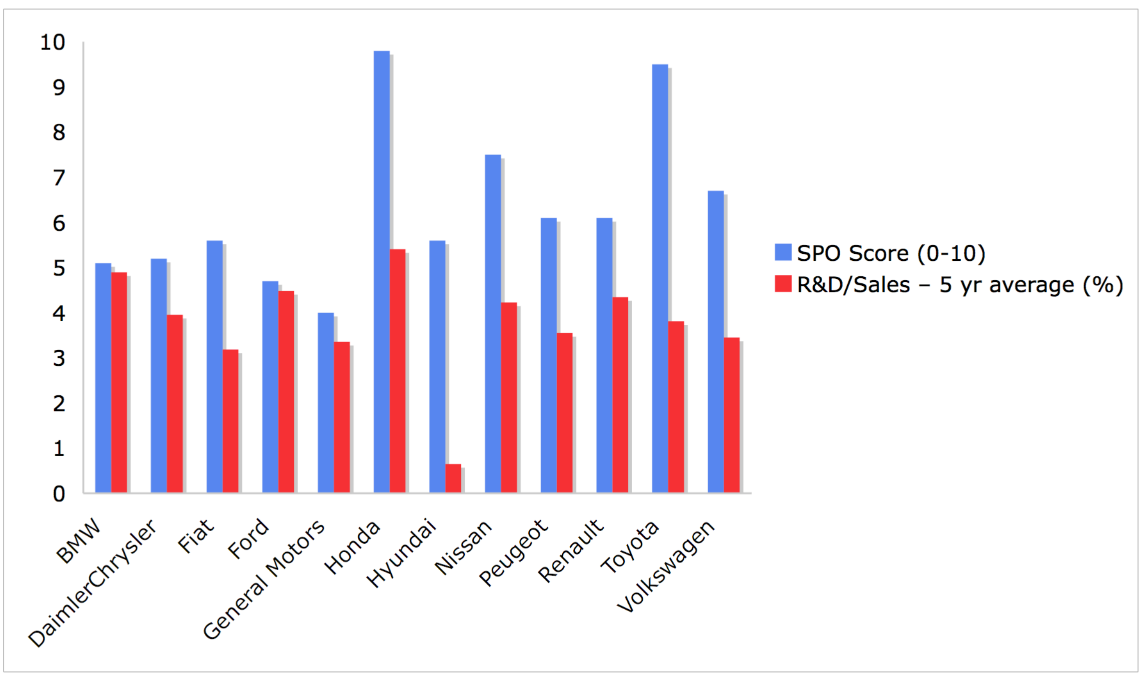
Figure 3: Innovest Environmental Management Ratings



Key Strategic Product Development Capabilities

The primary differentiating factor in the environmental analysis of auto companies is their strategic product development capabilities. This describes not only a company's ability to research and develop advanced environmental technologies, but also its ability to effectively commercialize those technologies. The relevant section in the Innovest report first comments on the relationship between R&D expenditures and strategic profit opportunity score (SPO), then proceeds to summarize some short, medium and long-term environmental technologies and the relative company positioning. As the Innovest vision of the technology horizon is crucial in the companies' relative scoring, it is important that I relate this vision accurately.

Figure 4: R&D Spending and Strategic Profit Opportunities



[1]

Many studies attempt to represent a company's 'innovativeness' using R&D expenditures as a proxy measure. As Figure 5 shows, R&D expenditures are not at all

[1] Source: Innovest (Brammer 2006) and Thomson Financial (Thomson 2007)

correlated to strategic profit opportunity score. Rather, Innovest focuses on how effective a company is at commercializing environmental technology, rather than just developing it. The best example is General Motors. The company has one of the strongest R&D programs, yet rather than commercializing leading edge, fuel-efficient innovations, GM chooses to increase the proportion of trucks to cars in its fleet. Innovest notes that after sector leader Honda, the next five leaders – Toyota, VW, Peugeot, Renault and Nissan – have average or below average R&D spending. However, since their research is directed toward forward-looking environmental technologies, they enjoy higher scores than bigger R&D programs, such as BMW or Ford.

Leading innovators spread R&D resources over short, medium, and long-term environmental technology. Innovest defines short-term environmental technologies as "technologies that auto companies have been selling for the past several years that can still be expected to show increased sales in the near future." The most widely known of these is hybrid technology, but areas such as fuel saving devices (such as cylinder shut off and engine shut off), Common Rail Diesel, lighter materials, and recyclable parts to meet the EU ELV are also considered. As I have discussed the growth of the hybrid market above, I move on to the less widely known short-term technologies. European companies have chosen to pursue diesel as the most efficient technology to reduce fuel consumption. Historically, diesel engines have been difficult to market in countries with high pollution emission standards, such as the U.S; however, European companies are looking to high-pressure injection systems and particulate filters to reduce harmful emissions. That being said, VW has been forced to delay entry into the U.S. until 2008 due to high NOx standards. In addition to diesel, there is promise in creating lighter automobiles by using aluminum rather than steel body panels. Lighter weight vehicles enjoy better fuel efficiency, but suffer the burden of proving that safety has not been jeopardized.

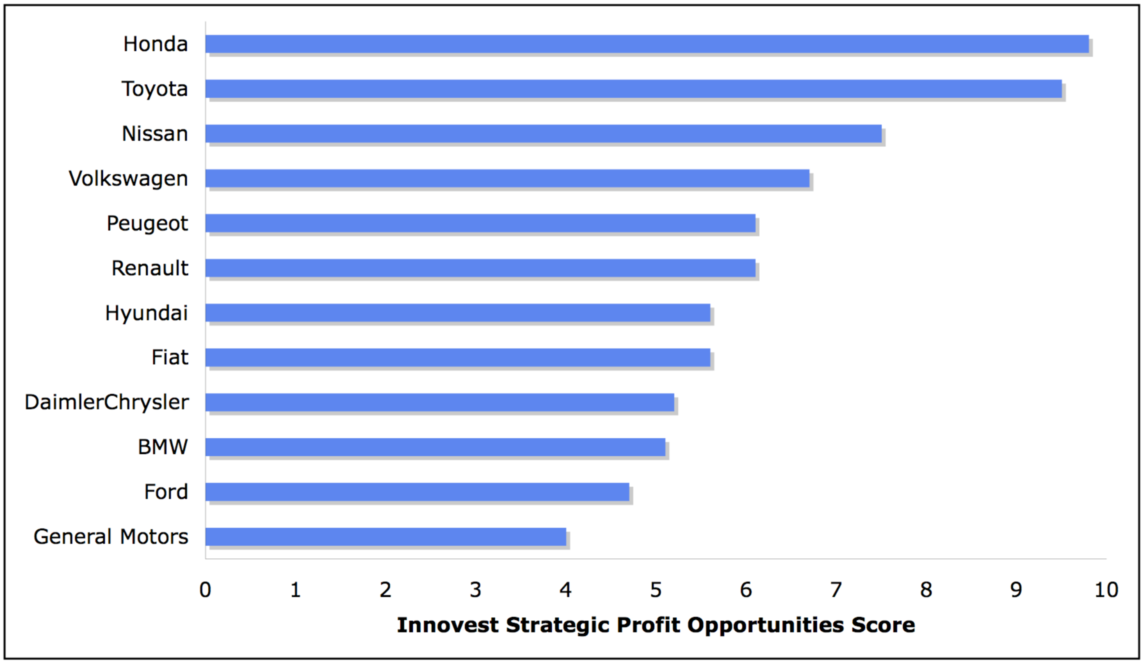
Medium-term environmental technologies refer to products still in the R&D phase, but are expected to be in production between two and five years. These technologies include second-generation versions of short-term technologies – such as improved batteries for hybrid applications – hydrogen internal combustion engines, electric cars, and biofuel/alternative fuel vehicles. Of the medium-term environmental technologies, lithium-ion batteries, which are now used in mobile phone and laptop computers, represent the most promise. These batteries are lighter and more efficient than the NiMH batteries that are currently used for hybrid electrics, but it has proven difficult to develop a durable and powerful large-scale lithium-ion battery. Many automakers are engaged in joint ventures with battery producers to win the race to market LI batteries; however it is still too early to know which companies will win this race.

Another major area of medium-term environmental technology is alternative fuel vehicles (AFVs), especially biofuels. The U.S., with its large corn lobby, has taken the global lead in production of corn-based ethanol, which will double in production by 2012. However, since corn-based ethanol is processed using coal-based power, the ultimate determinant of eventual success will be the application of cellulosic ethanol, which is made with special enzymes to break down organic plant material. Ford and GM are pushing the hardest in creating flex-fuel vehicles that can run on different ethanol blends. As opposed to ethanol, most European manufacturers favor biodiesel – which uses plant-based sources for a diesel equivalent. The European Commission is likely to focus on biodiesel, and accordingly, VW and DaimlerChrysler are the two firms most dedicated to this technology.

The long-term environmental technology that almost all auto companies are focused on is hydrogen, whether for use in a fuel cell or internal combustion engine. GM has stated the goal of being the first company to sell fuel cell vehicles at a profit. Despite this claim, however, DaimlerChrysler is currently the sector leader with well over 100 fuel cell vehicles in test fleets and the scale to eventually bring costs down. Honda is also a leader, having one of the best performing fuel cell vehicles on the road and also developing a micro-infrastructure for hydrogen generation that would not require a massive hydrogen infrastructure, which is often cited as the key obstacle to the commercialization of hydrogen vehicles. Additionally, Toyota, Ford, Hyundai and BMW all have large fuel cell vehicle programs.

The overarching message regarding environmental technology is that the Japanese companies, especially Toyota, have won the short-term battle over environmental technology with the hybrid electric vehicle. This current dominance is likely to translate into new successes, as Toyota and Honda build upon their technological and reputational advantages in environmental technology. However, strong progress in biofuels would advantage U.S. and European companies. In the long-term, the field is open. All companies are seeking hydrogen technology, and it is likely that the company that pursues it the strongest will end up winning the race to market a hydrogen fuel cell automobile.

Figure 5: Innovest Strategic Profit Opportunity Ratings



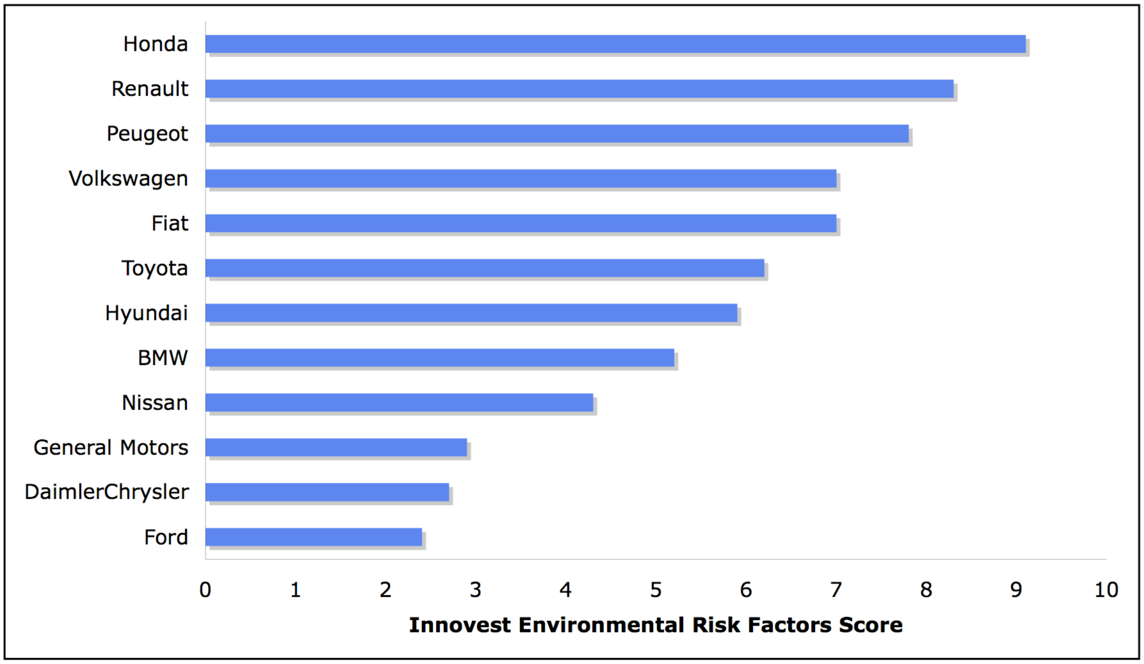
Production Efficiency & Risk Factors

The third performance area in the Innovest rating is production efficiency and risk factors. This rating encompasses eco-efficiency in production as well as current risks derived from historical liabilities. The ability to manage costs deriving from energy and resource use is a significant indicator of management quality as a whole. This is because either the government or market fixes the most expensive parts of the manufacturing process, such as labor and raw materials, while energy use is controllable and can lead to significant cost savings. Also, since the auto industry is a major purchaser of raw materials, efficient usage has a direct effect on profitability, especially as raw material prices are volatile and tend to rise. For example, steel prices rose to nearly $700 per ton in January 2005 due to expanded Chinese demand, but stabilized around $400 per ton by December 2005. Additionally, many predict that water will become increasingly strained from pollution and demand, and lowering water use will aid community relations as other entities compete for water resources. Also, creating less waste is a sign of higher productivity and saves costs of landfilling. Greenhouse gas emissions are also being increasingly scrutinized and it is important for companies not only to measure their emissions, but also to actively manage them to prepare for likely mandatory caps.

In response to these challenges, auto companies are reducing operating costs through GHG reduction opportunities. Ford currently supplies about five percent of its energy needs in North America through alternative power and has saved over $50 million since 2000 from renewable energy and efficiency projects. Likewise, GM obtains approximately three percent of its US energy requirements from renewable sources. Manufacturers are also attempting to lower costs and risks related to water and material use.

Comparing different companies' actual emissions is complicated. The U.S. has the Toxics Release Inventory (TRI), which is the most thorough in the world. The Japanese use the PRTR register, and Europe has a voluntary EPER register. These databases are not standardized, and since companies place facilities all over the world, it is difficult to aggregate a firm toxic emissions number. Further complicating this effort is the trend of outsourcing production not only to emerging economies, but also down the supply chain to tier 1 suppliers. This pushes the dirtier parts of production onto different companies, making it even harder to compare. Despite these challenges, Innovest researches all registered emissions in the relevant databases and compiles an approximate emissions figure for each company that allows for comparisons.

Figure 6: Innovest Environmental Risk Ratings



Leading Edge Practices

Leading edge practices signify environmental competence in management outlook. While the best practices described above are specific measures that managers should take, leading edge practices are more general criteria that describe top performers. Innovest identifies the following leading edge practices to minimize environmental risk: ISO certification, Environmental Technologies, and Life Cycle Analysis. The ISO (International Standardization Organization) has different families of standards – 9000 for quality management and 14000 for environmental management. ISO14000 certification is meant to minimize harmful effects on the environment in production and achieve continual improvement in environmental performance (ISO.org). Companies with ISO14000 certification have a stronger focus on environmental impact management, waste reduction, and decreased consumption of energy, water and mineral resources. In addition to reducing environmental risk exposure, ISO certification can uncover hidden cost-saving opportunities, especially in reduced energy use and waste recycling.

The most significant leading edge practice is to develop leading environmental technology to reduce the environmental impact of automobiles during their useful lives. This task is divided into two parts: increasing internal combustion efficiency in the short run, and developing alternative fuel vehicles for long-term commercialization. Other than increasing fuel efficiency, companies are concerned with efficient design, high recyclability, and minimizing toxic materials in cars. Also, noxious gases, such as NOx, SO_2 and PM are a major concern, especially to European auto manufacturers who favor diesel technology, which while reaching higher fuel efficiency also creates more noxious emissions.

Life Cycle Analysis (LCA) is a tool that examines the environmental impact along the entire course of a vehicle's life, from production, through service life, to end of life. Through life cycle analysis, companies can target specific reduction in environmental harms at different points of the useful life. ISO14000 certified environmental management systems aim to reduce environmental harm during the production of the automobile. Enhanced technology for reducing auto emissions and increasing fuel efficiency target the major environmental burden for the automobile – its service life. And regulations such as the ELV and RoHS directives aim to reduce harm at the end of life by reducing persistent environmental toxins and increasing automobile recyclability. Auto companies can use LCA to apply pressure to tier 1 suppliers to increase their environmental competence to ensure minimized impact at all stages of vehicle life.

Financial Indicator: ROA

Return on assets (ROA), otherwise known as "return on investment" is calculated by dividing a company's net income by its total assets (debt and equity) and expressed as a percentage. The percentage indicates company profitability and the ability of managers to effectively allocate limited resources (Investopedia.com). ROA can vary widely across the market, but by focusing solely on the automobile industry, much of this variation is negated, leaving a true measure of management quality. ROA has been used in previous studies as a profitability measure linking corporate social responsibility and financial performance (Waddock & Graves 1997, Guenster et al. 2006). Since ROA is volatile and subject to abnormal fluctuations in any given year (see GM below), I choose to use an average to get a more accurate sense of financial performance over the past five years. Table 3 shows ROA for my set in 2005 and the average ROA over the previous four years.

Table 3: Company Return on Assets

	2005	Average (2001-2005)
BMW	3.49	4.154
DaimlerChrysler	1.99	1.556
Fiat	3.37	0.872
Ford	2.5	1.874
GM	-0.07	1.834
Honda	6.13	5.988
Hyundai	4.57	4.498
Nissan	5.09	6.318
Peugeot	1.94	3.126
Renault	5.56	4.962
Toyota	5.23	4.838
Volkswagen	1.3	2.174

Conclusion

This chapter gave an overview of the two outcome variables under study: eco-competitiveness and financial competitiveness. I measure eco-competitiveness using the Innovest EV'21 rating. This chapter provided an overview of the Innovest rating process and some of the key indicators that Innovest looks for when rating a company. While environment related risk, management, and strategy are factored heavily in the final score, Innovest has identified strategic environmental product development as the driving force that will affect financial returns in the coming years. As such, the Innovest rating serves as an advanced proxy for eco-competitiveness that goes beyond examining compliance into prediction of future performance based on a holistic vision of environmental performance that covers the entire product life cycle and corporate structure.

While financial competitiveness is not a core element of my analysis, I do examine the link between eco-competitiveness and financial competitiveness. I use profitability, modeled by return on assets, to measure financial competitiveness. This chapter provided a description of return on assets and how it is calculated.

Chapter 4: Causal Factors

Introduction

In order to test my primary hypothesis, I must use specific indicators to model the extent to which a country has stringent product-based environmental regulation for auto companies. However, in the literature, other explanations for factors that affect corporate environmental performance emerge. In the analysis portion of the thesis, I test multiple hypotheses to gain a better understanding of which factors affect eco-competitiveness. In this chapter, I describe the independent variables to be tested: environmental regulatory regimes, market opportunities, stakeholder pressure, and internal company factors. This chapter describes my reasoning in choosing these variables and presents the descriptive statistics on the various indicators.

Primary Hypothesis (H1)

My primary hypothesis is that more stringent product-based environmental regulatory regimes correspond to higher EV'21 ratings in the auto sector. This thesis is concerned with whether environmental regulatory regimes can shift the competitive strategies of auto companies in a more environmentally sustainable direction. Companies such as Honda and Toyota have centered their competitive strategies around fuel-efficient, dependable small and mid-size cars, whereas companies such as Ford and GM have focused on increasing the size and power of their vehicles rather than their fuel efficiency. To what extent is this strategic decision based on the differential regulatory environments of the two companies' home countries? My hypothesis is that the regulatory environment of the home country plays a strong role in the formation of competitive strategy.

Indicator 1: Fuel Economy Standards

Fuel economy standards are the primary product-based regulatory tool used to increase fuel efficiency in the automobile sector. These standards are supply side initiatives that compel auto manufacturers to either meet standards or pay a fine (in most countries). As a result, by enacting high fuel economy standards, countries incentivize auto companies to sell more fuel-efficient models.

> *H1a*: *Auto companies operating in countries with higher fuel economy standards will be more eco-competitive than competitors operating in countries with lower fuel economy standards.*

Although fuel economy standards are command and control in nature, they are entirely flexible regarding how they should be met. Thus automobile companies have significant latitude, as discussed in Chapter 3, to determine their optimal technological trajectory for meeting the standards. Furthermore, because the penalties are primarily financial in nature (though the U.S. CAFE standards carry potential criminal liability [An & Sauer 2004]), compliance is only one factor in a large universe of competitive considerations. For example, a recent study found that Ford, GM and DaimlerChrysler have all just barely complied with the standard while BMW and Mercedes have violated it every year since 1987 and have paid approximately $500 million in fines as a result (Jacobsen 2006).

Table 4: Environmental Regulatory Regimes

	Fuel Economy Standards[2]		Fuel Taxes[3]
	Standards as of 2002 (normalized)	Proposed Future Maximum (normalized)	$/liter
France	37.2	44.2 by 2008	$0.77
Germany	37.2	44.2 by 2008	$0.86
Italy	37.2	44.2 by 2008	$0.74
Japan	46.3	48 by 2010	$0.41
Korea	26.6	26.6	$0.68
United States	24.1	24.7 by 2007	$0.11

While fuel economy standards are uniform in spirit across the world, there are a significant number of differences in how they are calculated. Each country above (except Germany, France, and Italy, which are all governed by the EU standard) has different definitions of different vehicle classes (e.g. passenger cars vs. light trucks for U.S. CAFE standard). Furthermore, the U.S. calculates fuel economy based upon miles per gallon, whereas the E.U. calculates fuel economy based on grams of CO_2 emissions per kilometer. Finally, even the processes used to calculate fuel economy, known as test cycles, are different, which means that 30 mpg in the U.S. is actually less fuel efficient than 30 mpg in Japan. Figure 7 below shows the performance of a single car using three different test cycles: CAFE, which is used in the U.S. and Korea; the NEDC, which is used in the E.U.; and the Japan 10-15 cycle.

In their report for the Pew Center on Climate Change, An and Sauer (2004) normalize all of the major fuel economy standards for measurement and categorical differences. These are the numbers used above, with the exception of Korea. The Korean standard is divided into small engines, which are required to achieve 39.9 mpg

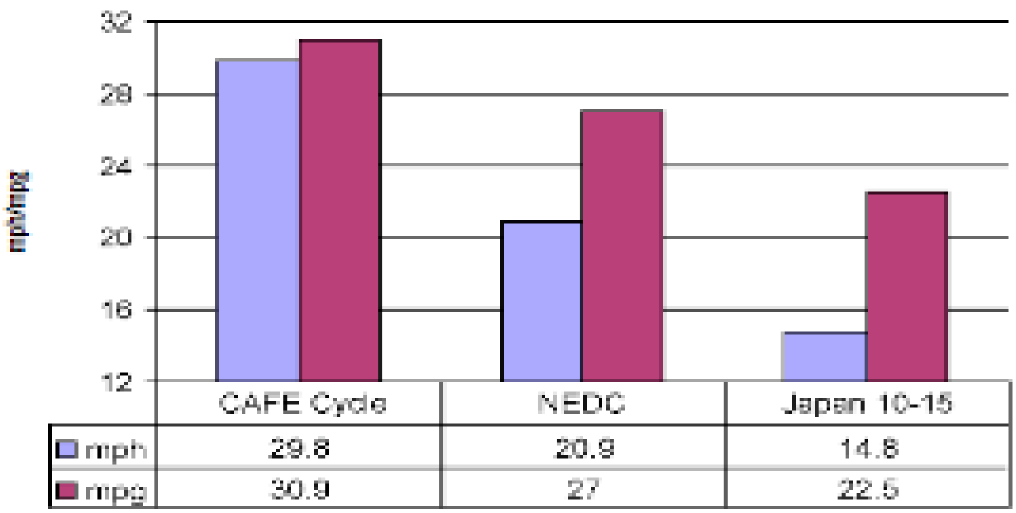
[2] From An & Sauer 2004

[3] Data from automotive industry reports (ACEA, JAMA), API, and Korean National Tax Service

and larger engines (above 1501 cm3 displacement), which are required to achieve 26.6 mpg (based on the CAFE cycle). I chose to use only the larger engine standard, since no Hyundais or imports have engines smaller than 1500 cm3. Even though all of these numbers are best approximations, they display clear categorizations based on standards, which allow for fuzzy set membership assignment.

Figure 7: Fuel Economy Performance of 2002 Ford Focus Using Different Test Cycles

[4]



Indicator 2: Fuel Taxes

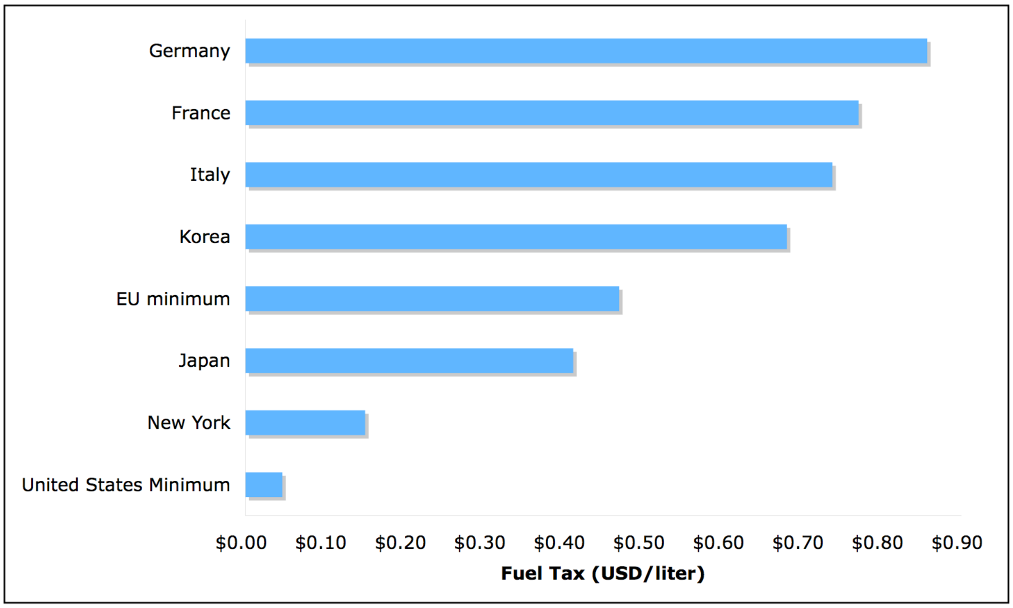
Fuel taxes are another regulatory tool used to encourage fuel conservation. Whereas fuel economy standards act directly upon auto manufacturers, fuel taxes act on consumers, incentivizing us to drive less and perhaps buy more fuel-efficient vehicles. Fuel taxes have historically been used by governments for a variety of purposes, such as rasing revenue (fuel taxes account for up to 10% of government revenue for many OECD countries [Fuel Tax Inquiry 2001]), environmental protection, and energy independence. In general high gasoline taxes signal government commitment to reducing oil

[4] Source: An & Sauer 2004

consumption. This in effect increases the user costs of driving less fuel-efficient vehicles.

Hypothesis 1b: Auto companies operating in countries with higher fuel taxes will be more eco-competitive than competitors operating in countries with lower fuel taxes.

Figure 8: Fuel Taxes Across the World



[5]

Fuel taxes are much simpler to calculate and normalize than fuel economy standards. The fuel tax information came from automobile manufacturing groups for the U.S., European countries and Japan, and from government sources for Korea. All figures were converted to U.S. dollars per liter (1 gallon = 4 liters). All taxes are as of 2006. An interesting aspect of fuel taxes is that they are generally deployed on a more local level when compared with fuel economy standards. In the European Union, each country has different fuel taxes, which must exceed the E.U. minimum of 47 cents per liter (36

[5] Source: (ACEA 2006) for Europe; (JAMA 2006) for Japan; (API 2006) for U.S., (National Tax Service 2006) for Korea

Eurocents per liter). The U.K. has the highest fuel tax in the E.U. at 89 U.S. cents per liter. This national control allows for more specific analysis of the connection between environmental regulatory regimes and auto companies.

Similarly, in the United States fuel taxes are controlled by the U.S. states with a federal base of 4.6 cents per liter (18.4 cents per gallon). Total state & federal gasoline tax ranges from the lowest, Alaska, at 6.6 cents/liter to the highest, New York, at 15 cents per liter; the US Average is 11.4 cents per liter (API 2006). While increased variation aids the E.U. analysis, is slightly confounds U.S. analysis, since the country is the relevant unit of analysis. However, within the fuzzy set framework, this complication disappears, since even New York's gas tax is far below any of the other countries'. See Table 4 and Figure 8 above for different fuel taxes in selected countries.

Hypothesis 2: Market Opportunities

The primary competing hypothesis is that instead of environmental regulations driving differing levels of firm eco-competitiveness, it is actually different market opportunities that do so. For example, perhaps consumers in Japan care more about the environment and are willing to pay a premium for a more fuel-efficient car. This concept is supported in the ecological modernization literature, which broadly finds that auto companies primarily respond to market opportunities rather than government regulation. I break this hypothesis down into two sub-hypotheses: consumer market opportunities, which are modeled by organic food market size and waste recycling rates, and eco-efficient economies, measured by carbon emissions and renewable energy production.

Indicator 1: Organic Food Market Size

Testing a society's willingness to pay an "eco-premium," or higher costs for more environmentally responsible goods is fraught with difficulty. Broad enough survey data does not exist, and even if it did, revealed preferences would provide a much better approximation of consumer behavior. I chose the size of the organic food market as a percentage of total retail food sales as a proxy for willingness to pay an eco-premium. The global market for organic food is approximately $36.7 billion, or 1.25% of the global food retail industry (Datamonitor Global Organic Food 2006). Food certified as organic is both more expensive than conventionally grown food and is considered more environmentally responsible.

H2a: Auto companies operating in countries with larger organic food markets will be more eco-competitive than competitors operating in countries with smaller organic food markets.

Table 5: Organic Food Market

	Organic Food Market as % of Food Retail Sector[6]
France	0.89%
Germany	2.68%
Italy	1.45%
Japan	0.18%
Korea	1.05%
United States	2.34%

Despite the advantages of using the organic food market as a proxy for willingness to pay an eco-premium, the data is not ideal. Although organic food does not

[6] Source: Datamonitor Reports (Datamonitor 2006) except South Korea organic food market, from Economist Intelligence Unit (EIU 2006)

have many advantages over conventional food, it is not clear how many people who buy organic food do so for environmental versus health reasons. Also, an automobile is a capital purchase, and the eco-premium can be much higher for an automobile than for a tomato. In fact, consumer psychology findings indicate that as perceived personal sacrifice for the common good increases, willingness to make that sacrifice decreases (Williander 2006). Despite these limitations, organic food market size offers a reasonable and different proxy for environmental priorities of a given country.

The above percentages derive from dividing the size of the organic food market by the size of the entire food retail industry. Except for South Korea's organic food market, all data comes from Datamonitor industry reports. Datamonitor is the world's leading provider of online data and analytic forecasting (datamonitor.com). The South Korean organic food market size data is based on analysis by the Economist Intelligence Unit, another provider of business analysis and forecasts.

Indicator 2: Waste Recycling

Waste recycling is an environmentally friendly practice in which both consumers and businesses participate. Rather than modeling an individual's willingness to spend to protect the environment, waste recycling rates serve as a proxy for effort undertaken to protect the environment across the country. However, similar to organic food sales, waste recycling rates serve at best as a proxy for a country's environmental consciousness. The associated hypothesis is that a country that recycles a high proportion of its waste is a better target market for more environmentally sensitive vehicles, because consumers who actively recycle are more environmentally concerned.

H2b: Auto companies operating in countries with higher recycling rates will be more eco-competitive than competitors operating in countries with lower recycling rates.

Table 6: Waste Recycling

	Waste Recycling Rates[7]
France	55%
Germany	83%
Italy	40%
Japan	78%
Korea	67%
United States	42%

The waste recycling data, similar to many of the following indicators, was gathered through the 2005 Environmental Sustainability Index (ESI) (Esty 2005). The ESI is an effort through the Yale Center for Environmental Law and Policy and Columbia's International Earth Science Information Network to rank the environmental performance of each country in the world. The authors have made a specific effort to make the data available and their methods transparent, and for many of my data categories, the ESI provides the best available statistics. Also, using the ESI data provides maximum comparability since the same methodology was used for each country. Waste recycling, specifically, is defined in the ESI as "any reuse of material in a production process that diverts it from the waste stream, except reuse as fuel" (Esty 2005 285). For OECD countries, this is measured as the percentage of glass, paper and cardboard recycled as a percentage of total consumption; all of the countries in my set are

[7] Source: ESI (Esty 2005)

OECD members. If separate rates were available for glass and "paper and cardboard," the higher rate was used.

Indicator 3: Renewable Energy as Percentage of Total Consumption

Indicators 3 and 4 model a more general notion of market opportunities: the eco-efficiency of a country's economy. The first measure of economic eco-efficiency is renewable energy production. Energy generation from fossil fuel sources is environmentally damaging and carbon intense, but generally cheaper than environmentally friendly, renewable resources. Higher percentages of renewable energy represent national resolve to decouple economic growth from greenhouse gas emissions. Each country in my set has an economy historically based on fossil fuel production, so renewable energy rates more accurately describe current development away from fossil sources for the sake of environmental protection.

H2c: Auto companies operating in countries that utilize more renewable energy will be more eco-competitive than competitors operating in countries with lower renewable energy rates.

Table 7: Renewable Energy

	Renewable Energy Production as % of Total Consumption[8]
France	5.95%
Germany	3.54%
Italy	7.17%
Japan	4.87%
Korea	0.43%
United States	3.72%

[8] Source: ESI (Esty 2005)

This data also comes from the ESI and originally came from the US Energy Information Agency. The definition of renewable energy includes hydroelectric, biomass, geothermal, solar and wind power.

Indicator 4: Carbon Emissions per Million USD GDP

Similar to Indicator 3, this indicator attempts to represent economy-wide eco-efficiency. While renewable energy production represents actions taken to avoid excess carbon dioxide emissions, this indicator represents the baseline, or norm of the economy. In other words, while renewable energy production represents efforts to decouple economic growth from increased carbon dioxide output, carbon emissions per million US dollars indicates the extent to which they are coupled to begin with. In this spirit, I assume that countries with lower normalized emissions are more eco-efficient, thus more likely to demand eco-efficient automobiles.

H2d: Auto companies operating in countries with less carbon intense economies will be more eco-competitive than competitors operating in countries with more carbon intense economies.

Table 8: Electricity Sources and Carbon Dioxide Emissions

	CO_2 emissions per million US dollars GDP[9]	Percentage Electricity derived from Nuclear Power (2004)[10]
France	55.81	78%
Germany	79.76	28%
Italy	96.74	0%
Japan	56.88	28%
Korea	187.84	40%
US	170.72	21%

[9] Source: ESI (Esty 2005)

[10] Source: Energy Information Agency (EIA 2005/2006) for all except Korea, which is from Uranium & Nuclear Power Information Centre (UIC 2007)

The data ranges widely, with South Korea and the United States featuring the dirtiest economies and France and Japan with the cleanest. One aspect of this comparison that must not be overlooked is nuclear energy. Nuclear energy is a form of clean energy, in terms of not emitting greenhouse gases, but carries with it a host of environmental concerns. As you can see above, France and Italy have highly divergent nuclear portfolios compared with the rest of the set. This difference contributes heavily to Italy's relatively high and France's relatively low carbon intensity. While debating the merits of nuclear power is well outside of this thesis's purview, it is important to state that the nuclear power element limits the effectiveness of this indicator to measure the eco-efficiency of the economy. The carbon dioxide emissions data also comes from the ESI, and originally comes from the Carbon Dioxide Information Analysis Center and country data. The emissions have been normalized to constant 1995 US dollars.

Hypothesis 3: Stakeholder Pressure

A second competing hypothesis is that instead of environmental regulations or market opportunities, companies with higher EV'21 ratings are responding to different levels of stakeholder pressure.

Indicator: Number of IUCN Organizations

In general, a "stakeholder" is any person or group with an interest in the activities of a business, and since the automobile industry creates products that play a key role in degrading the environment, everyone on Earth can be considered a stakeholder. Regarding this pressure, we are most interested in environmental groups that apply pressure either directly to companies or indirectly through government or public relations channels.

The IUCN, or World Conservation Union is the oldest international environmental membership organization. The group boasts 1,043 members, composed of national NGOs (736), government agencies (110), state members (83), international NGOs (82), and affiliate members (32) (IUCN.org). All six countries in my set are state members to the IUCN. To model stakeholder pressure, I use the number of IUCN memberships divided by the country's population. This data comes from the ESI, and originally from the IUCN.

H3: Auto companies operating in countries with more IUCN organizations will be more eco-competitive than competitors operating in countries with fewer IUCN organizations.

Table 9: Stakeholder Pressure

	IUCN Member Orgs per Million Population[11]
France	0.66
Germany	0.28
Italy	0.38
Japan	0.15
Korea	0.10
United States	0.25

Hypothesis 4: Internal Factors

Another alternate hypothesis dismisses all of these external factors and focuses on the internal qualities of specific companies. While it is clear that internal factors

[11] Source: ESI (Esty 2005)

contribute heavily to EV'21 ratings, it is unclear which aspect of a company is the most important. In this analysis I will measure three indicators: company size, multi-nationality, and R&D expenditures.

Indicators 1 & 2: Company Size

One possibility is that bigger companies have generally more resources to devote toward environmental responsibility. This argument is somewhat compelling for traditional corporate social responsibility, as transparency and large-scale programs require substantial resources. However, the EV'21 rating is more concerned with which products are brought to market than transparency and eco-programs. This, as we see, does not necessarily advantage large companies. That being said, larger companies tend to have larger scale R&D programs, thus higher capacity to bring new technologies to market. Either way, it is important to test the company size hypothesis to determine whether there is a connection between size and EV'21 performance. I use two measures of company size: employees and net sales. Generally companies with more employees have higher net sales, but the rankings work slightly differently with both measures, so I will test both.

H4a: Companies with more employees are more eco-competitive than companies with fewer employees.

H4b: Companies with higher net sales are more eco-competitive than companies with lower net sales.

Table 10: Company Size[12]

	Net Sales (millions USD)[13]	Employees
BMW	$50,807	104,157
DaimlerChrysler	$170,521	382,125
Fiat	$55,999	178,988
Ford	$172,544	316,928
GM	$188,430	341,333
Honda	$75,007	134,941
Hyundai	$49,534	52,616
Nissan	$70,166	146,088
Peugeot	$62,960	202,508
Renault	$46,017	132,190
Toyota	$158,030	266,950
Volkswagen	$106,455	338,588
Average	$100,539	216,451

I am including both the most recent year (2005) and the average for the past five years to smooth single year shocks. My analysis will use a weighted average to preference recent performance over past performance. The sales and employees data come from Thomson Financial (Thomson 2007).

Indicator 3: Multi-Nationality

Multi-nationality of a company is calculated by dividing the number of vehicles sold in foreign markets by total vehicles sold. The higher the multi-nationality, the less dependent a company is on its domestic market. In terms of environmental performance, the hypothesis is that more multi-national companies must abide by more environmental standards, thus will tend to adopt uniform internal controls to meet the highest standard in order to sell to the maximum number of markets while minimizing costs associated with

[12] Net Sales and Employees figures were calculated by taking the average of 2005 figures and average figures for the period 2001-2005, thus weighting the average toward current figures. This weighting scheme was designed to smooth out fluctuations while leaving the heaviest significance with 2005, which matches the Innovest data.
[13] Source: Thomson Financial (Thomson 2007) for both net sales and employee numbers

differing standards across the company. Similar to the company size hypothesis, this hypothesis is stronger in terms of process rather than product regulation, since "standards" are more appropriately affixed to processes rather than product development.

H4c: More mutli-national auto companies are more eco-competitive than less multi-national companies.

Table 11: Multi-Nationality

	Multi-Nationality[14]
BMW	40%
DaimlerChrysler	28%
Fiat	33%
Ford	45%
GM	43%
Honda	79%
Hyundai	67%
Nissan	76%
Peugeot	24%
Renault	16%
Toyota	70%
Volkswagen	27%
Average	46%

Data on multi-nationality was calculated using company annual reports. While most companies report number of vehicles sold to different geographic markets, these mechanisms are not consistent, and sometimes revenue was used in lieu of vehicles sold. This is a more important data limitation when comparing sales in specific national markets rather than the proportion of domestic sales to exports, thus this data is considerably reliable. For E.U. countries, the E.U., not the member state, was considered 'domestic.' This was done both for data availability and regulatory purposes; since most

[14] Source: various corporate annual reports

European regulations relating to automobiles are on the E.U. level, the concept of meeting a mélange of standards does not apply internally in the E.U.

Indicator 4: R&D Expenditure as Percentage of Net Sales

The final internal indicator to consider is R&D expenditures normalized by net sales. The associated hypothesis is that companies that devote a higher percentage of revenues to research and development are more 'innovative,' and more innovative companies are more environmentally responsible. As we saw in Chapter 3, the connection is not very strong between R&D expenditures and Innovest ratings, but it should be considered formally within the fuzzy set framework. R&D expenditures were taken from Thomson Financial (Thomson 2007).

H4d: Companies that invest more capital in R&D are more eco-competitive than companies that invest less in R&D.

Table 12: R&D Expenditures[15]

	R&D as percentage of Net Sales[16]
BMW	5.1%
DaimlerChrysler	3.9%
Fiat	3.1%
Ford	4.5%
GM	3.4%
Honda	5.3%
Hyundai	0.9%
Nissan	4.5%
Peugeot	3.5%
Renault	4.6%
Toyota	3.8%
Volkswagen	3.1%
Average	3.8%

[15] Calculated same way as company size, see footnote above.

[16] Source: Thomson Financial (Thomson 2007)

Conclusion

This chapter presents my primary and alternate hypotheses regarding the drivers of firm eco-competitiveness as well as my rationale for including these hypotheses. My primary hypothesis is that more stringent product-based environmental regulatory regimes lead to stronger corporate eco-competitiveness as modeled by the Innovest EV'21 rating. I also explore a number of competing hypotheses that attempt to explain variation in EV'21 ratings. These are broadly categorized as market opportunities, stakeholder pressure, and internal factors. For each of these I have explained the underlying reason why it might influence EV'21 ratings and presented the indicators that will be used to operationalize my hypotheses as well as descriptive statistics. Chapter 5 will present my data analysis and results for each hypothesis.

Chapter 5: Data Analysis & Results

Introduction

This chapter seeks to answer the research question posed in Chapter 1: Do more stringent national environmental regulations make automobile companies more competitive? I approach this by conducting two analyses: (1) which causal factors lead to more eco-competitive companies? and (2) does being an eco-competitive company enhance financial performance?

Having established my operationalizations and indicators in previous chapters, this chapter will focus on analysis and results. I start by guiding the reader through the fuzzy set methodology, using examples along the way to demystify the method. My attention then turns to the results, for which I display both scatter plots and the fuzzy set analysis. Following the results I explain each outcome, providing possible reasons for unexpected findings.

Fuzzy Set Methodology

From Indicator to Fuzzy Measure

As opposed to regression statistics, fuzzy set methodology (Ragin 2000) does not use direct quantitative measures to test hypotheses. Rather, quantitative data are converted to values between 0 and 1 based on degree of membership to a specific set. Each researcher can choose values based on any combination of qualitative and quantitative methods according to specialized knowledge of the data. As distinguished from statistical coefficients that assume linear relationships, fuzzy outcomes seek to explain phenomena based upon necessary or sufficient conditionality (Katz et al. 2005).

The first step in performing fuzzy set analysis is converting data values to fuzzy set values. There are a number of different ranges of potential values. Some studies choose to use only three values, 0, 0.5, and 1, to describe non-membership, neither in nor out, and perfect membership in a specified set. The other end of the spectrum uses continuous values that are entirely quantitatively computed once the 0 and 1 values are defined. I chose to use a five-value system (0, 0.25, 0.5, 0.75, 1). This decision was based on the number of cases and the underlying data; a three-value system would fail to capture the case diversity, while a seven-value system would amplify immaterial differences.

After choosing a five-value system, the next step was to select the maximum 0 value and the minimum 1 value for each indicator. In order to aid the explanation of this process, I will use the EV'21 rating process as a representative example. Note that this process followed the same steps for each indicator outlined in Chapter 4.

Table 13: Creating a Fuzzy Indicator

Company	EV'21 Total	Fuzzy EV'21
Honda	79	1
Toyota	77	1
Renault	69	0.75
Volkswagen	67	0.75
Peugeot	65	0.75
Fiat	58	0.5
Nissan	58	0.5
BMW	56	0.25
Hyundai	55	0.25
DaimlerChrysler	49	0
Ford	45	0
General Motors	42	0

Based on the data, I decided that the maximum 0 value would be 50, which means that any company scoring below a 50 on the EV'21 scale receives a fuzzy value of zero. I made this decision because I believe that DaimlerChrysler, Ford and General Motors show similar values of non-membership to the environmentally responsible set. With the 0 value determined, I chose the lowest value for the 1 value, which I set at 71. Clearly, Honda and Toyota are ideal set members, and any company scoring above 71 would be considered an ideal member relative to the set.

From these baselines, I calculated the incremental difference based on equal distribution between the endpoints. Mathematically, the increment was calculated by subtracting the 0 value from the 1 value and dividing by 3 to cover the other three values. In this case, (71-50)/3 = 7. Thus any score between 50 and 57 was considered a 0.25, between 57 and 64 a .5 and between 64 and 71 a 0.75. This allows for a more "objective" quantitative distribution of the scores rather than relying entirely on the researcher's opinion.

Although this rule provides some mathematical rigor to the variable attribution process, it is important that the results are consistent with the researcher's qualitative knowledge. Indeed, the researcher has considerable control over the results of this process by controlling the perceived zero values. For example, had I chosen 75 as the minimum 1 value, which would not have changed the results distinguishing Honda and Toyota from the 0.75 companies, the result farther down would have been for Fiat and Nissan to become 0.25 rather than 0.5 companies. I thought it was important that the score of 58 define the 0.5 value, since in the Innovest framework, those companies are considered "neutral," thus loosely corresponding to the 0.5 value of neither in nor out.

The tradeoff was a questionable separation between Fiat and Nissan on the one hand and BMW and Hyundai on the other. Although all four companies earned BBB ratings from Innovest, which should correspond to a 0.5 rating, the full Innovest universe contains more companies than my set. The result is that there are a number of companies that score lower than General Motors; in fact, General Motors (as well as DaimlerChrysler and Ford) is a BB company compared to the full Innovest set. Since my set is smaller, and Innovest BB companies have been recomputed as 0 value companies, I have more room to draw variation among companies that may have earned the same overall Innovest rating. It is based on this that I decided to separate BBBs into higher and lower performing companies and attributed different values to them.

In the case of the country variables, I recoded the data in a similar way, also using a five-value system. However, in order to perform the analysis, I needed to attribute the country values to specific companies. Thus, every auto company was attributed fuzzy ratings for the independent variables, such as fuel economy or waste recycling, based on their home country's fuzzy score. Without this step, it would be impossible to use fuzzy-set analysis because it requires a consistent number of cases.

As you can see, this process is complicated and is highly dependent on the individual researcher. While this appears to be a weakness in the framework of pure quantitative analysis, it is actually a key strength in a more confined case selection process with significant qualitative factors involved. I performed similar analysis for all of the other indicators. My fuzzy set values are described in Table 14 below.

Table 14: Fuzzy Set Values for Each Indicator

Company	Country	fueleconomy	fueltaxes	co2	recycling	renewables	organics
BMW	Germany	0.75	1	0.75	1	0.25	1
DaimlerChrysler	Germany	0.75	1	0.75	1	0.25	1
Fiat	Italy	0.75	1	0.75	0.25	1	0.50
Ford	United States	0	0	0	0.25	0.25	1
General Motors	United States	0	0	0	0.25	0.25	1
Honda	Japan	1	0.50	1	1	0.75	0
Hyundai	Korea	0	0.75	0	0.75	0	0.25
Nissan	Japan	1	0.50	1	1	0.75	0
Peugeot	France	0.75	1	1	0.50	1	0.25
Renault	France	0.75	1	1	0.50	1	0.25
Toyota	Japan	1	0.50	1	1	0.75	0
Volkswagen	Germany	0.75	1	0.75	1	0.25	1

Company	Country	employees	netsales	r&d	multi-nationality	ev21	roa
BMW	Germany	0.25	0.25	1	0.50	0.25	0.50
DaimlerChrysler	Germany	1	1	0.50	0.25	0	0
Fiat	Italy	0.50	0.25	0.25	0.25	0.50	0.25
Ford	United States	1	1	0.75	0.50	0	0.25
General Motors	United States	1	1	0.50	0.50	0	0
Honda	Japan	0.25	0.50	1	1	1	1
Hyundai	Korea	0	0.25	0	0.75	0.25	0.75
Nissan	Japan	0.50	0.50	0.75	1	0.50	1
Peugeot	France	0.75	0.25	0.50	0.25	0.75	0.25
Renault	France	0.25	0.25	0.75	0	0.75	0.75
Toyota	Japan	1	1	0.50	1	1	0.75
Volkswagen	Germany	1	0.75	0.25	0.25	0.75	0

Fuzzy Analysis: Comparing Causal Factors with Outcome Factors

The next step is comparing causal factors with outcome factors to determine whether necessary or sufficient conditions exist between the factors. In this thesis I am conducting two separate sets of analysis: the effect of different causal factors on the eco-competitiveness rating, and the effect of the eco-competitiveness rating on financial performance. Before reporting the results, it is important to understand how to interpret the results and why they are meaningful.

As previously mentioned, fuzzy-set analysis rests upon the concept of necessary and sufficient conditionality. If a cause is a necessary condition of the outcome, this implies that the outcome is a subset of the cause. To aid this discussion, I will use company size as an example of a causal factor and eco-competitiveness as the outcome factor. If being a large company is a necessary condition for being highly eco-competitive, this means that every highly eco-competitive company is also a large company. However, there may be some large companies that are not highly eco-competitive. Because this relationship is defined as the outcome being a subset of the cause, in fuzzy analysis, this translates into the fuzzy score for eco-competitiveness being greater than or equal to the associated fuzzy score for company size.

Sufficient conditionality, in contrast, implies that the cause is a subset of the outcome. Sticking with our example, if being a large company is a sufficient condition for high eco-competitiveness, this means that each large company will be highly eco-competitive, but there may be some eco-competitive companies that are not large. In fuzzy-set methodology, this translates into the outcome factor being greater than or equal to the causal factor, following the same logic as the necessary conditionality test.

However, with the sufficient condition test, a wrinkle arises if a company has a 0 fuzzy rating, it is not counted as a case. This is because a 0 rating, in principle, means that a company is a non-member of the set, thus not exhibiting the causal factor. In other words, in order for every cause to exhibit the outcome, the cause needs to be present.

Table 15: Conducting Fuzzy Analysis

Company	ev21	employees	ev21 ≤ employees (Necessary)	ev21 ≤ employees (Sufficient)
BMW	0.25	0.25	+	+
DaimlerChrysler	0	1	+	-
Fiat	0.50	0.50	+	+
Ford	0	1	+	-
General Motors	0	1	+	-
Honda	1	0.25	-	+
Hyundai	0.25	0	-	n/a
Nissan	0.50	0.50	+	+
Peugeot	0.75	0.75	+	+
Renault	0.75	0.25	-	+
Toyota	1	1	+	+
Volkswagen	0.75	1	+	-
Total			9	7
Percentage			75.00%	63.64%

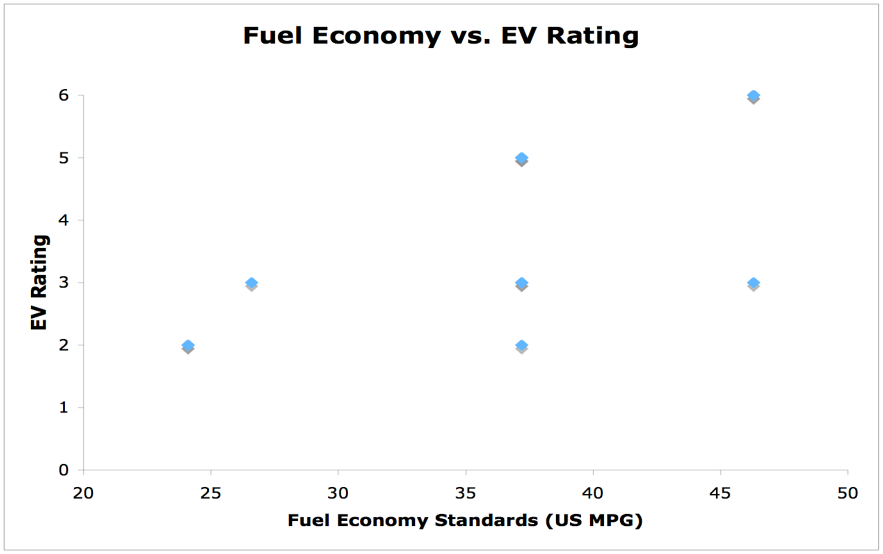
The description above presents necessary and sufficient conditionality requiring that all cases fit the pattern of the cause being either greater or less than the outcome. This is known as *veristic* analysis, where no significant results can be determined unless each case shows the pattern. Another way of conducting the analysis is using a *probabilistic* approach, where a certain percentage of cases must fit the pattern to establish necessary or sufficient conditionality. In a necessary conditionality (or sufficient conditionality) analysis, a benchmark of .8, or 80% of the cases, can be interpreted as "almost always necessary," .65 as "usually necessary," and .5 as "more often than not necessary" (Ragin 2000).

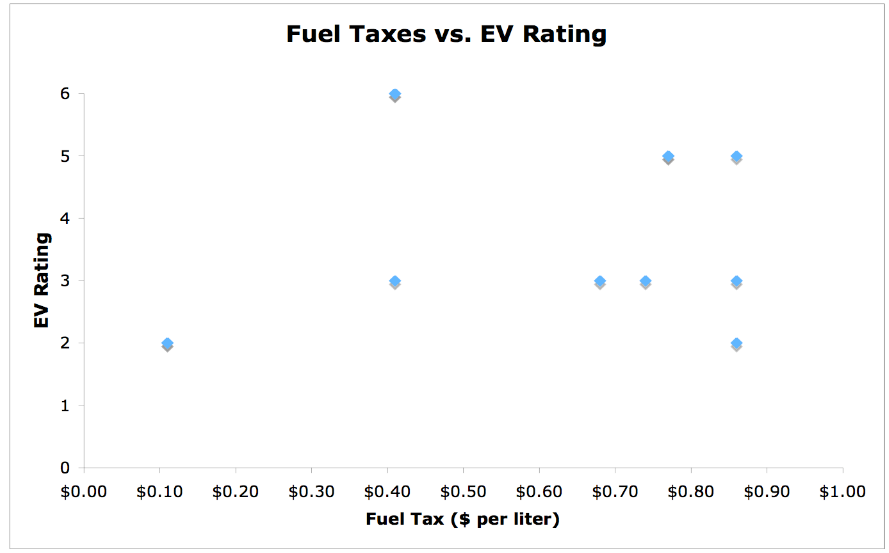
Although these standards appear to be very easy to meet, just as with regression statistics the results may or may not be significant. Ragin (2000) established a guiding table that displays the number of consistent cases needed to pass the different probabilistic benchmarks for different number of cases to achieve different levels of significance. For my twelve-case analysis, eleven cases need to be consistent to claim significance at the .05 level at the benchmark of .65. Thus, unless all of my cases are consistent, the strongest claim I can make is that a cause is "usually" necessary or sufficient. Thus we see that although fuzzy set analysis when compared to regression analysis is a more appropriate methodology for a small number of cases, the small number of cases makes it distinctly difficult to claim significant and meaningful results.

Results: Which Factors are Necessary or Sufficient for Eco-Competitive Corporate Behavior?

I employed the above analysis to identify which, if any, of my indicators are necessary or sufficient conditions for eco-competitive ratings. In addition to each hypothesis, I tested the negation of that hypothesis. The negative values are simply calculated by subtracting the fuzzy set value from 1. This indicates that if a company is a .75 in employee numbers, then it is also a .25 in the ~ employee set. Although all of my indicators were crafted so that the positive version of the hypothesis is the expected outcome, testing the negation of the hypothesis allows the researcher to identify relationships flying counter to expectations. This section will present the results for each indicator grouped by hypothesis. I will present both the fuzzy results and scatter plots to aid in building intuition about the data.

Primary Hypothesis (H1): Environmental Regulations Lead to High Eco-Competitiveness

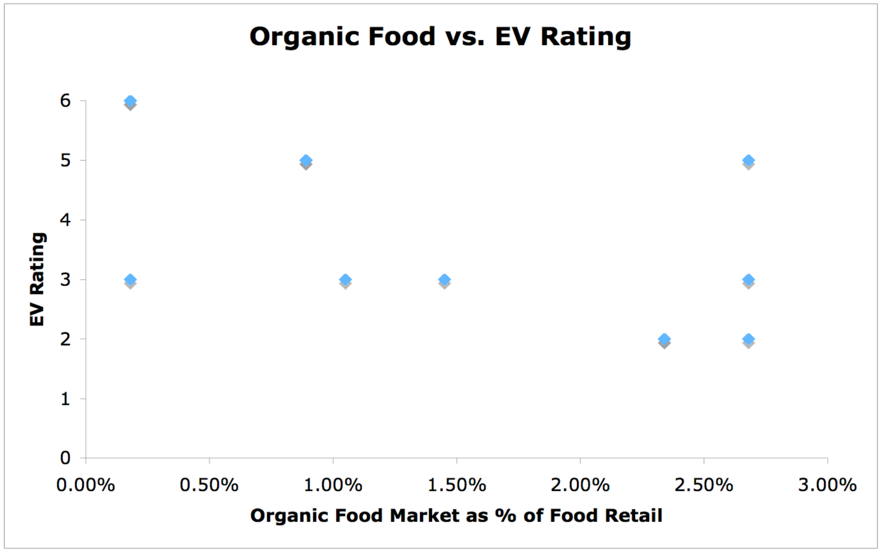


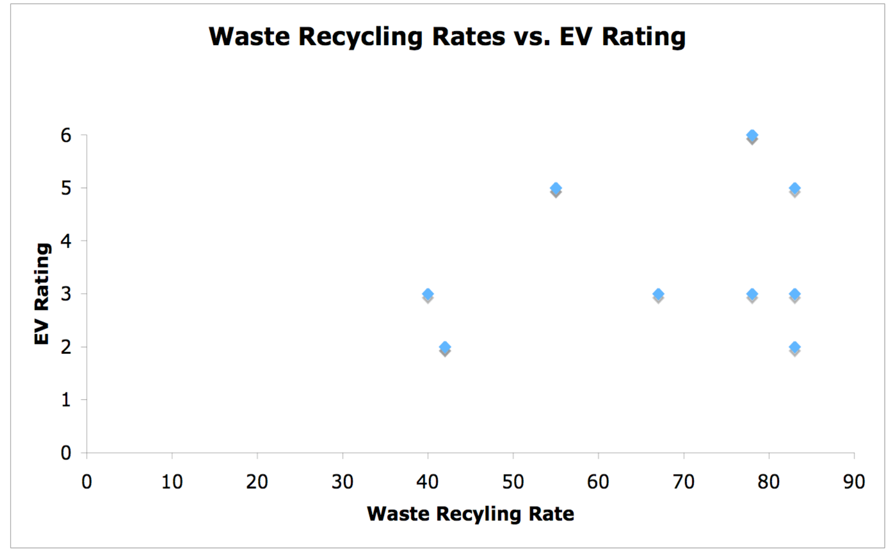


Fuzzy Set Analysis		
Causal Factor	Proportion of Cases: Cause ≥ EV'21 Rating[17] (Necessary Condition Test)	Proportion of Cases: Cause ≤ EV'21 Rating (Sufficient Condition Test)
Fuel Economy	0.9167(**)	0.5556
~ Fuel Economy	0.4167	0.5556
Fuel Tax	0.8333(*)	0.3000
~Fuel Tax	0.4167	0.6667

[17] **: Indicates significant results at the .05 level for .65 benchmark, which translates to "usually necessary"
*: Indicates results that narrowly miss .1 level significance at .65 benchmark

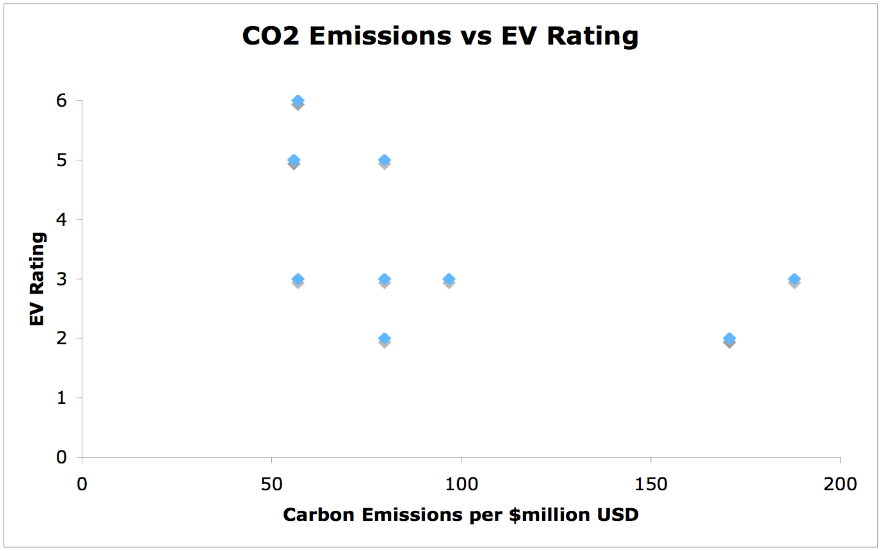
Hypothesis 2: Market Opportunities Lead to High Eco-Competitiveness

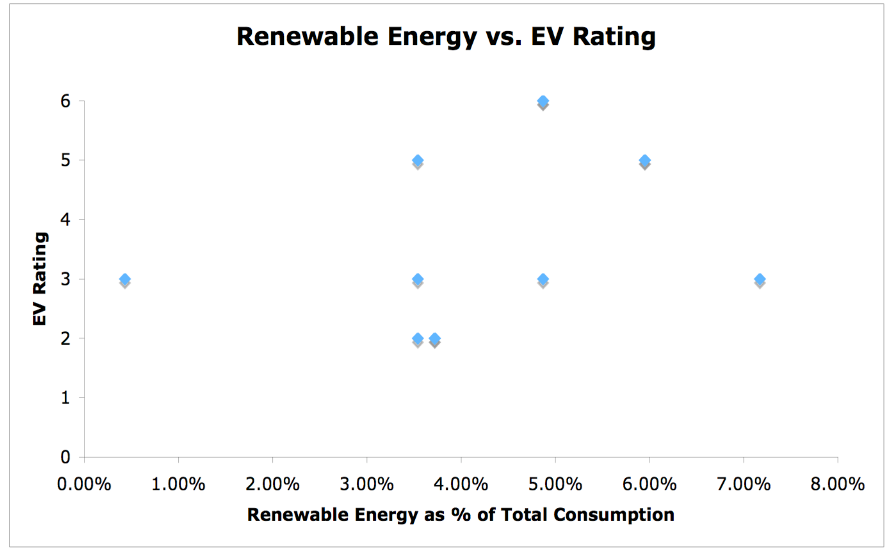




Fuzzy Set Analysis		
Causal Factor	**Proportion of Cases: Cause ≥ EV'21 Rating (Necessary Condition Test)**	**Proportion of Cases: Cause ≤ EV'21 Rating (Sufficient Condition Test)**
Organic Food	0.5833	0.4444
~Organic Food	0.8333(*)	0.8333
Recycling	0.75	0.4167
~Recycling	0.4167	0.6000

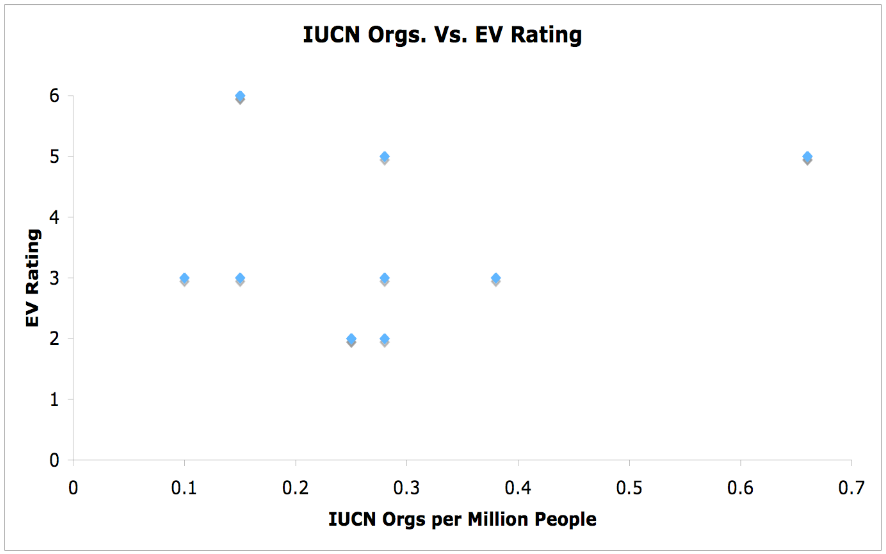
Hypothesis 2a: Eco-Efficient Economies Lead to High Eco-Competitiveness





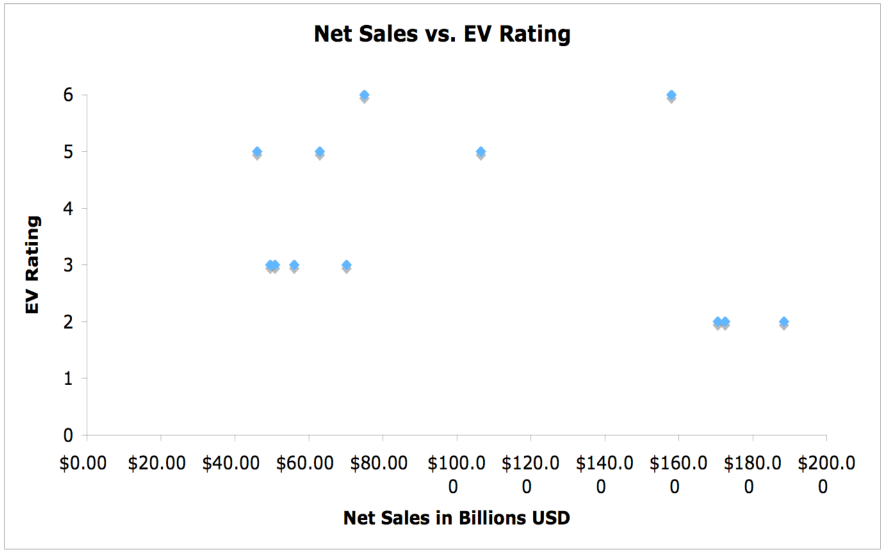
Fuzzy Set Analysis		
Causal Factor	**Proportion of Cases: Cause ≥ EV'21 Rating (Necessary Condition Test)**	**Proportion of Cases: Cause ≤ EV'21 Rating (Sufficient Condition Test)**
CO2 Emissions	.9167(**)	0.3333
~CO2 Emissions	0.4167	0.3750
Renewables	0.6667	0.3636
~Renewables	0.5000	0.4000

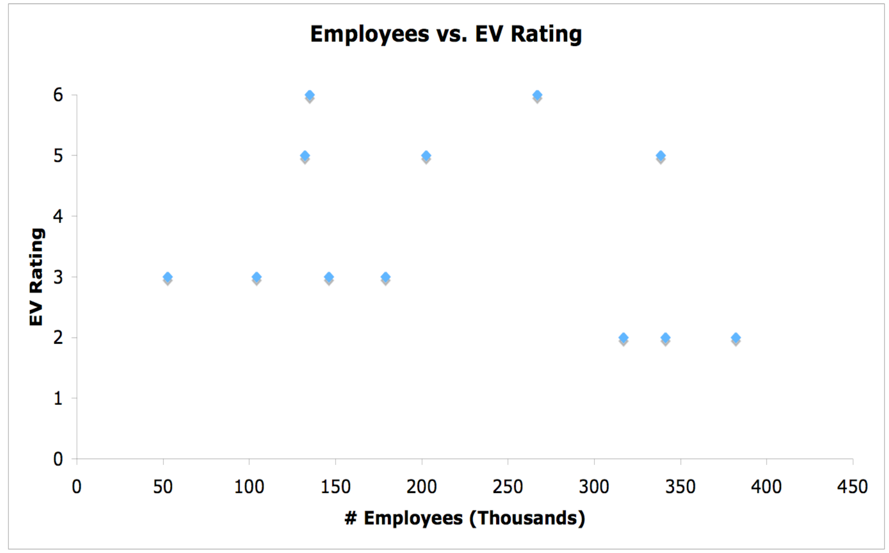
Hypothesis 3: Stakeholder Pressure Leads to High Eco-Competitiveness



Fuzzy Set Analysis		
Causal Factor	**Proportion of Cases: Cause ≥ EV'21 Rating (Necessary Condition Test)**	**Proportion of Cases: Cause ≤ EV'21 Rating (Sufficient Condition Test)**
IUCN	0.5833	0.3750
~IUCN	.8333(*)	0.3636

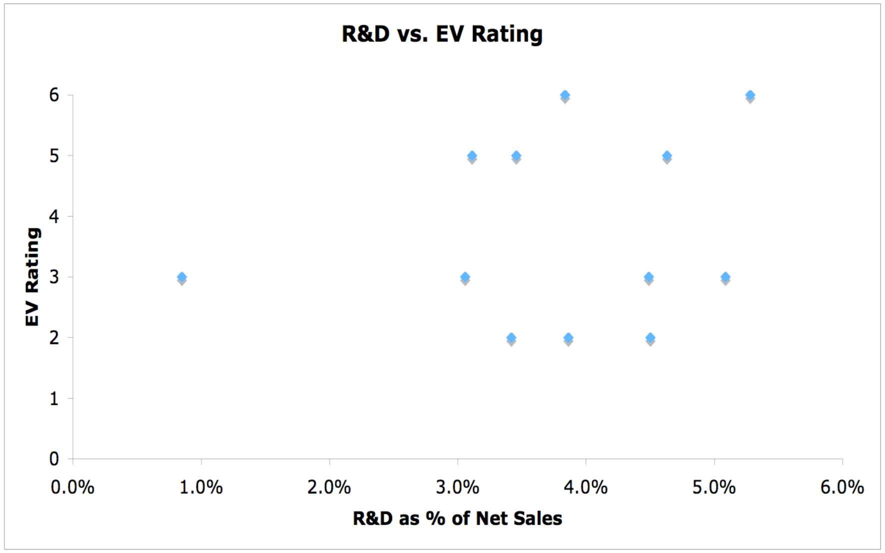
Hypothesis 4: Internal Factors Lead to High Eco-Competitiveness

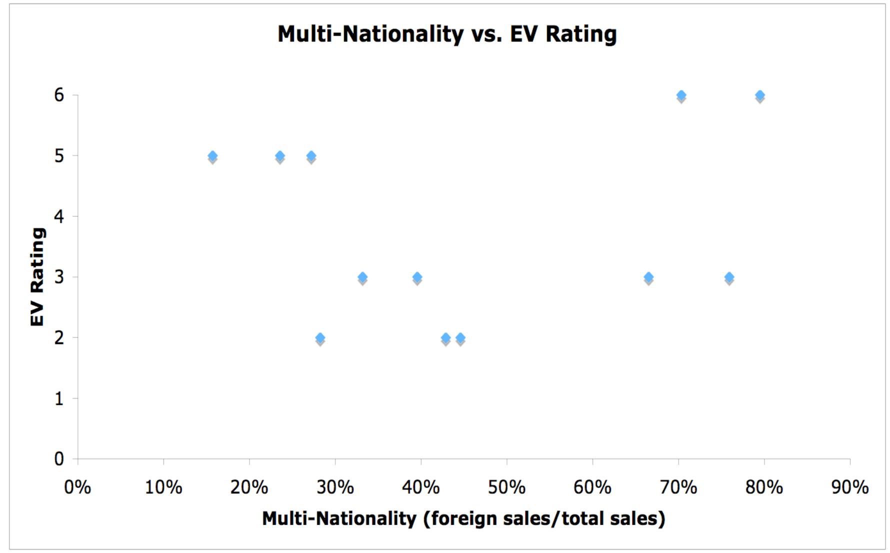




Fuzzy Set Analysis		
Causal Factor	Proportion of Cases: Cause ≥ EV'21 Rating (Necessary Condition Test)	Proportion of Cases: Cause ≤ EV'21 Rating (Sufficient Condition Test)
Net Sales	0.6667	0.75
~Net Sales	0.7500	0.625
Employees	0.7500	0.6364
~Employees	0.6667	0.7143

Hypothesis 4: Internal Factors Lead to High Eco-Competitiveness





Fuzzy Set Analysis		
Causal Factor	Proportion of Cases: Cause ≥ EV'21 Rating (Necessary Condition Test)	Proportion of Cases: Cause ≤ EV'21 Rating (Sufficient Condition Test)
R&D	0.5833	0.5455
~R&D	0.5000	0.5
Multi-Nationality	0.6667	0.4545
~Multi-Nationality	0.75	0.3333

Discussion: Which factors lead to high eco-competitiveness?

The fuzzy set analysis leads to some meaningful and interesting results. In this section I will discuss the results for each hypothesis, highlighting significant results and addressing the lack of significant results in certain areas.

H1: Stringent Environmental Regulatory Regimes Lead to More Eco-Competitive Companies

The primary hypothesis tested was that countries with more stringent fuel economy standards and higher fuel taxes will also have more eco-competitive auto companies. The fuzzy set analysis generally supports this hypothesis, yielding significant results for fuel economy standards' impact on eco-competitiveness and nearly significant results for fuel taxes.

The results for fuel economy standards can be interpreted as, "Operating in a country with high fuel economy standards is usually necessary for being highly eco-competitive." As I have previously argued, this result is due to the fact that companies that are able to meet higher fuel economy standards without losing ground to other companies that do not are inherently more competitive. Eco-competitive companies operating in highly regulated areas are able to turn the apparent obstacle of meeting strict regulations into a competitive opportunity to gain competence in fuel efficiency technology and use it to increase global sales and reputation. This strategy should become more and more viable as environmental concerns and fuel prices continue to increase in the future, a trend that has already to some extent crippled G.M. and Ford.

Similarly, the fuel tax results can similarly be interpreted as, "Operating in a country with high fuel taxes is usually necessary for being highly eco-competitive," however the results narrowly miss statistical significance. The argument for this result follows similar logic, except as opposed to fuel economy standards, high fuel taxes increase the user costs of driving inefficient automobiles. Companies understand that the cost of driving is an important factor for consumers, and if those costs are very high, it is less likely that companies will choose to sell fuel inefficient autos. In countries with cheap gasoline, such as the U.S., it is relatively easy for companies to market and sell sport utility vehicles and other fuel inefficient cars. However, despite the low fuel tax, rising fuel prices in the U.S. have devastated G.M. and Ford, which have both sustained heavy losses within the past two years.

It is also intuitive that fuel economy standards lead to a more significant result than fuel taxes. Fuel economy standards act directly on a company, forcing it to produce more efficient cars or pay fines. Fuel taxes, on the other hand, act directly on consumers, thus becoming only one of many factors to consider when purchasing an automobile. This can help explain how Japanese companies are more eco-competitive than their European counterparts despite having significantly lower fuel taxes; Japanese companies operate under more stringent fuel economy standards.

H2a: Market Opportunities Lead to More Eco-Competitive Companies

My second hypothesis was that market opportunities, not regulations, promote eco-competitiveness. I modeled market opportunities by using waste recycling rates and organic food sales as a percentage of the food retail sector. The surprising result shows that not having a large organic food market is usually a necessary condition for eco-competitive companies.

Organic food was chosen as an indicator to model the extent to which consumers are willing to pay extra for eco-friendly products. Organic food is generally more expensive than conventional food products, but is better for the environment by not using herbicides, pesticides and other “unnatural” agents. I hypothesized that countries with larger organic food markets would have citizens who are generally willing to pay extra for eco-friendly products, thus providing a market opportunity for eco-competitive companies much in the same way as countries with high recycling rates. The data however, did not match this hypothesis. In fact, it appears that the opposite is the case, although the results narrowly miss significance. The primary reason for this, as I mentioned in the previous chapter, is that the “eco-premium,” or extra amount that a consumer is willing to pay for a product based on its environmental friendliness, is much smaller for organic food than for automobiles; willingness to consistently pay $1 more for certain food products is not equivalent to paying potentially thousands of dollars more for a more eco-friendly automobile. Furthermore, as a capital investment, many more factors influence which automobile an auto shopper will buy than which tomato a food shopper will buy.

Waste recycling was chosen as an indicator to model the extent to which a country’s citizens are involved in environmentally friendly activities. Recycling is an activity that requires an individual or institution to exert effort to preserve the environment. At a more abstract level, recycling, whether mostly voluntary or part of a large program, such as in Germany, promotes environmental awareness, and may be an indicator of consumer eco-consciousness, which could factor into automobile purchase decisions. This awareness presents a market opportunity for more eco-competitive companies to market and sell their advantage over less eco-competitive companies. According to the data, this generally appears to be the case, although the results do not suggest necessary or sufficient conditionality.

H2b: Eco-Efficient Economies Lead to More Eco-Competitive Auto Companies

In addition to the more specific measures of consumer market opportunities, I also tested more general measures of overall economic efficiency and eco-friendliness. These measures involve the interaction among government, business and consumers contributing to eco-efficient economies. In order to test the more general hypothesis that companies operating in cleaner national economies will be more eco-competitive, I used the indicators carbon intensity and percentage of energy derived from renewable sources.

I modeled the carbon intensity of the economy using carbon dioxide emissions per million USD GDP. The hypothesis that companies operating in less carbon-intensive economies will be more eco-competitive was borne out by the data. The results suggest that operating in a carbon efficient economy is usually a necessary condition for auto companies to be eco-competitive.

It is not easy to establish a clear causal mechanism to explain this significant result, because many factors contribute to the eco-efficiency of an economy, of which transport is a large one. One possible explanation is that eco-efficient economies are the result of a combination of resource constraint and strong government intervention in the market, which would feed through all environmentally intensive sectors. This would include, but not be limited to regulating the transportation sector through fuel economy standards and fuel taxes. Indeed, the data shows that the only case not to match the pattern, Hyundai, which is the same company that does not match the pattern of fuel economy standards. In other words, Hyundai is more eco-competitive than Korea's fuel economy standards and general economic eco-efficiency would suggest. Since the necessary conditionality test results are exactly the same for these two indicators, it appears that they may be measuring the same concept on different levels, thus lending increased credibility to both results as necessary conditions.

The other indicator I use is energy derived from renewable sources as a percentage of total consumption. The hypothesis that companies operating in countries that use more renewable energy will be more eco-competitive is not supported by the data. This is interesting in that this indicator is supposed to measure the same concept as carbon intensity, the eco-efficiency of the economy. However, it is clear from the data that renewable energy sources are only one aspect of the eco-intensity of an economy, and not the one most related to auto companies' eco-competitiveness.

H3: Stakeholder Pressure leads to More Eco-Competitive Companies

My third hypothesis was that stakeholder pressure promotes eco-competitiveness. I modeled stakeholder pressure through the number of World Conservation Union (IUCN) organizations normalized by population for each country. The associated hypothesis is that companies operating in a country with a large number of environmental organizations will be more eco-competitive. Not only did the data not support this hypothesis, the inverse hypothesis proved to be a necessary condition, although not at a significant level. These results imply that operating in a country with *a small number* of environmental organizations is usually necessary for being highly eco-competitive.

There are two interpretations of this result: first, this could be a legitimate finding, or second, it is a finding based on an insufficiently accurate indicator. Supporting the interpretation that this result is legitimate is the argument that environmental organizations arise in a vacuum of government responsibility. This makes intuitive sense, and leads us to conclude that measuring the number of environmental organizations is essentially the inverse of measuring government regulation. Since fuel economy standards and fuel taxes both seem to be necessary conditions for eco-competitiveness, it makes sense that the ~IUCN hypothesis would also be a necessary condition.

Despite the elegance of this logic, the raw data does not support this interpretation. The European countries have the most IUCN organizations, followed by the U.S. and then Japan and Korea. In order for the argument that environmental groups spawn as a result of weak government action to be convincing, we would not expect the European countries to head the list. Rather, it appears more likely that number of IUCN organizations is a rough indicator, and not particularly effective in measuring actual stakeholder pressure. There are many factors, such as favorable tax laws that may foster the creation of environmental organizations in some countries while hindering progress in other countries.

H4: Internal Factors Lead to More Eco-Competitive Companies

My final hypothesis was that internal factors are more important in determining a company's eco-competitiveness compared to external factors, such as the regulatory environment, market opportunities or stakeholder pressure. In this spirit I tested company size, research and development (R&D) programs, and multi-nationality for relationships with eco-competitiveness. The results show that none of these indicators demonstrate necessary or sufficient relationships with eco-competitiveness.

For company size, I hypothesized that larger companies, either in terms of number of employees or net sales, will be more eco-competitive. This hypothesis is predicated on the idea that larger companies have more resources to invest in advanced technology and corporate responsibility. However, this relationship is not supported by the data. The lack of a significant finding could be explained by the fact that eco-competitiveness attempts to model the extent to which companies see environmental challenges as a source of opportunity rather than negative risk. Thus the size of a company is not particularly relevant to the rating, and two of the biggest companies in the sector, G.M. and Ford, have the lowest eco-competitiveness ratings.

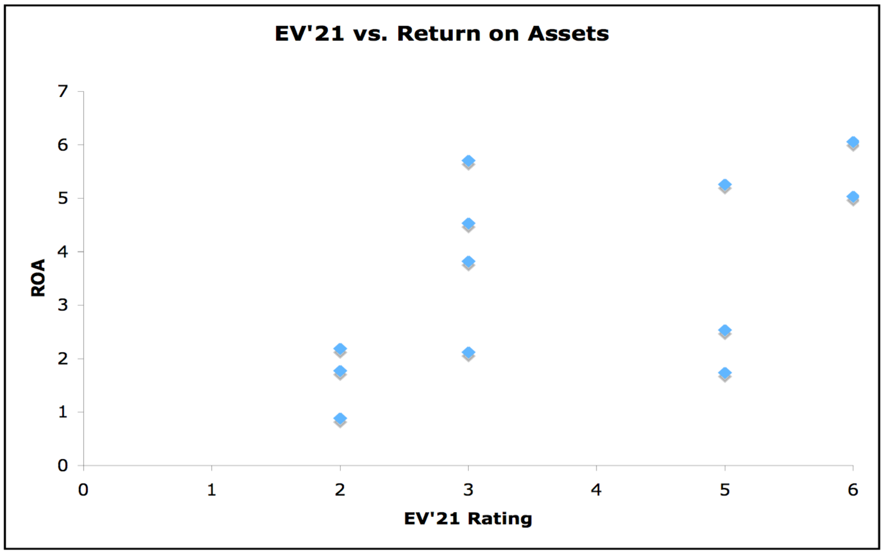
R&D expenditure as a percentage of net sales is a commonly used measure of innovativeness in the literature. Assuming that eco-competitive companies are more innovative than their peers, it makes sense to hypothesize that eco-competitive companies will have a higher percentage of their sales devoted to R&D activities. The data, however, does not show this relationship. Eco-competitiveness is focused on innovations and product developments that are more efficient and environmentally benign than current technology. This means that even if a company spends relatively little in R&D, if it consistently markets efficient products and devotes R&D attention to environmental technology, it will be more eco-competitive.

The last indicator I test is multi-nationality, which is simply the percentage of sales in foreign markets. The logic behind this measure is that companies operating more substantially in foreign markets will be more eco-competitive to account for the patchwork of product-based environmental standards governing automobiles. As with the other internal factors, the hypothesis that more multi-national companies are also more eco-competitive is not supported. It appears that the regulatory stringency of the home market is a more important driver of eco-competitiveness than the extent to which a company sells autos in foreign markets.

Results & Discussion: Is Eco-Competitiveness Necessary or Sufficient for High Profitability?

Having established which causal factors are necessary for a high eco-competitiveness rating, I turn to the question of whether a high eco-competitiveness rating is necessary or sufficient for high profitability. Although the primary ambition of this thesis is to demonstrate that more stringent environmental regulations lead to more eco-competitive companies, being able to show superior financial returns as a result of eco-competitiveness in the auto sector would increase the significance of my argument. The scatter plot and fuzzy data results are reported below.

Results: Is Eco-Competitiveness Necessary or Sufficient for High Profitability?



Fuzzy Set Analysis		
Causal Factor	Proportion of Cases: Cause ≥ EV'21 Rating (Necessary Condition Test)	Proportion of Cases: Cause ≤ EV'21 Rating (Sufficient Condition Test)
ev21	0.6667	0.5556
~ev21	0.5000	0.5556

Discussion: Eco-Competitiveness and Financial Competitiveness

Based upon the Innovest literature, my hypothesis was that eco-competitiveness could function as a mechanism to connect environmental regulations with superior financial competitiveness. Although the increased financial performance of eco-competitive companies has been demonstrated in the literature, I attempt to demonstrate this effect in the auto industry.

As the data above shows, being highly eco-competitive does not appear to be a necessary condition for high profitability performance. There are a couple of explanations for why the data failed to demonstrate this hypothesis. The first is that this relationship legitimately does not exist. Since the Innovest literature tests the full range of Innovest companies against financial performance, it is unclear whether the automobile companies fit the pattern. Perhaps the auto industry defies the pattern and eco-competitive firms do not show enhanced profitability.

Another possibility is that Innovest performance more accurately measures stock performance than profitability. The most significant results on Innovest ratings related to stock valuation, which includes more intangible factors than profitability. That being said, Guenster (2006) tests both ROA and stock valuation performance for the full basket of Innovest rated companies. The study finds that when running a linear regression modeling the EV'21 rating's effect on ROA, the coefficient is positive and significant at the .01 level. The study proceeds to separate companies into "high eco-efficiency" (their term for eco-competitive is eco-efficient) and "low eco-efficiency" baskets and run a second regression. The results suggest that the highly eco-competitive companies demonstrate superior ROA performance, but that this result is weak; however, the least eco-competitive show significant underperformance in terms of profitability.

This result suggests another reason for the absence of a significant relationship in this study, my sample selection. The Innovest rating is meant to span the whole sector and judge companies' eco-competitiveness in relation to one another. My sample contained the incomplete Innovest universe, twelve of nineteen, and none of the worst performing companies. Indeed, my worst performers are BB companies in the Innovest methodology, which excludes three companies rated lower than G.M. While there are good reasons to exclude certain companies to examine which factors lead to increased eco-competitiveness, this selection may have undermined the connection between eco-competitiveness and operational performance.

To test this claim, I used the entire universe of Innovest auto sector companies, and attributed fuzzy scores for eco-competitiveness and ROA using the same methodology. The introduction of seven new companies to the rating, including three less eco-competitive companies than GM, previously my lowest ranked company, altered a few of the original fuzzy ratings. In conducting the analysis, I find that when using the full Innovest universe, high eco-competitiveness is usually necessary for high financial performance, and the results are significant at the 0.10 level. This result lends credence to my assumption that eco-competitiveness can serve as a valuable mechanism linking environmental regulation with enhanced profitability specifically in the auto sector.

Chapter 6: Conclusion

Introduction

I now return to the original statement that motivated this thesis, “If the U.S. had strong regulations and Japan had weak ones, G.M. would be Toyota and Toyota would be G.M.” To test the sentiment of this statement, I asked whether a more stringent product-based environmental regulatory context leads to more eco-competitive auto companies. From there I tested whether eco-competitiveness leads to better financial performance for auto companies. This two-part question is built on literature that supports the relationship between eco-competitiveness, as modeled by the Innovest EV’21 rating, and superior financial returns, both in terms of stock performance and profitability.

With this literature in mind, I focus on the more original question of whether environmental regulations influence eco-competitiveness in auto companies. This question is distinct in two ways from other literature that tests the connection between environmental regulations and performance. First, I focus on product-based rather than process-based regulations. Process-based environmental regulations lead to a limited universe of corporate strategic options: violate the law, comply with the law, site a plant in another country, or adopt an even higher internal standard. Most of the literature in this field addresses this decision, trying to explain what factors companies consider when choosing among these options. Beyond-compliance literature, especially, focuses on why companies would adopt a more stringent internal standard rather than choose one of the other options.

In contrast, product-based standards lead to a much more diverse set of corporate responses. When making product decisions, companies must consider myriad competitive factors, especially in a global marketplace, of which regulation is merely one. As with process-based standards, companies also choose whether to comply or violate product-based standards (depending on the penalty of non-compliance and the nature of the law), but after that decision is made, the number of ways in which a company can achieve compliance are endless. This thesis attempts to model to what extent companies choose the eco-competitive path, in which stringent national regulations in a global marketplace are used as an opportunity to gain competitive advantage rather than a risk that only leads to increased costs.

Second, my hypothesis and research design focuses on eco-competitiveness as the mechanism that connects environmental regulations with financial performance. Because Porter hypothesis literature focuses on process-based regulation and its effect on manufacturing, the main causal mechanism connecting stringent environmental regulation and superior financial performance is the cost savings from eco-efficient production. This is based on the logic that companies learn to use resources more efficiently when they are permitted to pollute less, and since resources cost money, resource efficiency will cut costs. In my product-based analysis, eco-efficiency is a subset of eco-competitiveness. In addition to cost savings from eco-efficiency, I also look to revenue generation from eco-inventiveness, a company's ability to design and commercialize products that are superior in terms of environmental performance.

By covering both the cost-savings of eco-efficiency and the revenue potential of eco-inventiveness, eco-competitiveness is a more robust mechanism than those used previously. Understanding eco-competitiveness helps clarify why strict national regulations can lead to increased financial performance. As companies attempt to decide among different strategic paths, strict national regulation can nudge managers in the eco-competitive direction, which based on the literature is a legitimate path toward superior financial performance.

Summary of Results

Which Factors Lead to Eco-Competitiveness?

In order to answer my research question, I tested multiple hypotheses for different factors that lead to eco-competitiveness using the fuzzy set methodology to identify necessary and sufficient conditional relationships. My primary hypothesis is that stringent national product-based environmental legislation leads to increased eco-competitiveness in global auto companies. The results generally supported this hypothesis. Operating in a country with high fuel economy standards is shown to be usually necessary for high eco-competitiveness, at a statistically significant level. Fuel taxes also showed a necessary conditionality relationship, but the results were not statistically significant. These results support the claim that environmental regulations lead to more eco-competitive companies.

The second hypothesis, derived from the ecological modernization literature, is that market opportunities have a stronger impact on eco-competitiveness than environmental regulations in the auto industry. I operationalized market opportunities by using two indicators at the economy-wide level (normalized CO_2 emissions and renewable energy production) and two indicators at the consumer level (organic food market and waste recycling). The results show that operating in a low carbon emissions country is usually necessary for being eco-competitive, and the result is statistically significant. Operating in a country with a small organic food market also appears to usually be necessary for eco-competitiveness, but like fuel taxes, the result narrowly misses the significant level. Renewable energy production shows no strong relationships with eco-competitiveness, and waste recycling shows a positive, but insignificant relationship with eco-competitiveness. These mixed results lead to complicated interpretations, which I discuss below.

The third hypothesis I tested is that stakeholder pressure leads to high eco-competitiveness. Modeling stakeholder pressure by number of environmental organizations in each country, I found that not only does stakeholder pressure not lead to high eco-competitiveness, but that the inverse hypothesis, that the lack of stakeholder pressure is usually necessary for strong eco-competitiveness, turned out to be the result (although, as previously mentioned, is not statistically significant). I discuss this result in detail in Chapter 5, but in summary, stakeholder pressure does not seem to be a strong component of eco-competitiveness.

Finally, I tested the internal factors of company size, R&D expenditures, and multi-nationality. These factors proved to be important in the beyond-compliance literature for explaining corporate decisions related to the environment. However, in this analysis, none of these were strongly related to eco-competitiveness. It can still be argued that there are internal factors that lead to eco-competitive behavior, in fact, there must be, because only internal factors can adequately explain the diverging eco-competitiveness of companies that operate in the same country. However, these factors may be more related to personal preferences of top level managers, thus difficult to model in a study as general as this one.

Does Eco-Competitiveness Lead to Financial Performance?

While the main research question has certain policy significance, corporations are more interested not in what influences their decisions, but rather whether choosing an eco-competitive strategy will lead to enhanced financial returns. This thesis depends on literature that has exhibited the connection between eco-competitiveness, as I measure it, and superior financial returns, in terms of profitability and share price performance. This literature finds a statistically significant relationship using the entire set of approximately 1200 corporations; however, my thesis is only concerned with twelve auto companies. Thus, using the fuzzy set methodology, I tested whether being an eco-competitive company was a necessary or sufficient condition for high profitability.

Initially the results suggest that this connection does not exist for these companies. Having knowledge of the Innovest rating structure, I decided to test all nineteen of the Innovest rated auto companies. After adding the extra seven companies and recoding the sector both in terms of eco-competitiveness and profitability, I retested the hypothesis. Using this universe of companies I found that a high eco-competitiveness rating is usually necessary for high profitability. Because incorporating the other companies forced me to recode my variables, the connection between environmental regulations and financial performance is weakened. However, in a more general sense, this result lends increased legitimacy to the eco-competitiveness rating as a predictor of profitability, and thus a strong mechanism to link environmental regulation with strong financial performance.

Practical Implications

What do these results mean for policy makers and for businesses? For policy makers, this research can be seen as justification to enact higher environmental standards for products in different industries. However, this is a touchy argument. Simply raising fuel economy standards will make it more difficult for the less eco-competitive U.S. companies to compete with the Japanese companies in the short term. This is essentially a first-mover argument – the Japanese companies are more technologically advanced and can easily meet a higher U.S. fuel economy standard, whereas the U.S. companies have been less able to commercialize environmental technology and would initially suffer from higher standards.

However, to survive in the long term, U.S. companies need to be competitive in the race to develop game-changing technologies. Low fuel economy regulations at home have allowed U.S. companies to choose the short-term profit-maximizing strategy of developing mostly SUVs and "crossover" vehicles to Americans. Over the past couple of years this strategy has backfired, due partly to high fuel prices, and the U.S. companies have lost significant ground to the Japanese competitors. Exacerbating this problem is the long-term view, where the largest growth markets are in emerging countries. Currently, China's fuel economy standards are higher than those in the U.S., which will make it difficult for U.S. companies to compete with Japanese companies for market share.

Despite these obstacles, the future does not have to be so dim. The race to develop next generation automotive technology has only just begun, and the Japanese companies have merely won the first round. As discussed in Chapter 3, hybrids are short-term environmental technologies, and the battle over the medium and long-term environmental technologies, such as biofuels and hydrogen fuel cells is far from decided. If policy makers want U.S. companies to win this battle, they need to cooperate and invest heavily in infrastructural developments that would allow widespread distribution of biofuels or hydrogen. G.M. may commercialize the world's first hydrogen fuel cell vehicle, but if consumers cannot fill the tank, they will not buy the car. Thus government needs to take a proactive role in providing the regulatory and infrastructural environment that promotes eco-competitive strategy.

For the auto companies, this research suggests that taking an eco-competitive strategy is a responsible plan for long-term growth. Instead of fighting against raising fuel economy standards, auto companies should instead concentrate on how to turn these regulations into competitive advantages. It has worked already for Japanese companies, and with the massive resources and R&D capabilities of the U.S. companies, there is no reason they cannot catch up. Even lacking more stringent regulations, companies can still set higher internal standards and aim to make inroads in markets that operate under more stringent standards.

In addition to these implications for the automobile sector this research can be applied to other industries as well. Before suggesting implications for other sectors, however, it is important to re-establish the scope of my research. The results apply to multi-national companies operating under a patchwork of environmental product-based standards. One issue that comes to mind is chemicals. Historically, chemical companies have been highly regulated and subject to international environmental agreements, such as the Montreal Protocol, which essentially banned CFC use. Currently, Europe is taking a global lead on chemicals regulation with directives such as the Restriction on Hazardous Substances (RoHS), which phases out a number of hazardous chemicals, and REACH, a regulation that requires manufacturers to gather information about the substances they use.

The REACH directive is intended to promote eco-competitiveness in the EU chemicals, among other goals related to the protection of human health and the environment. The introduction to REACH on the EU website specifically mentions that "innovative capability and competitiveness of the EU chemicals industry should be enhanced" (Europa REACH). This directive should give European chemicals companies an eco-competitive advantage moving forward, and competitors in other parts of the world will be forced to catch up without the aid of regulatory oversight.

Areas for Further Study

This thesis provides a sector level analysis of how various causal mechanisms affect company eco-competitiveness. Further research can generally either serve to broaden this research to include other sectors or narrow it to look more closely at the mechanisms I suggest. The most intuitive area for further study would be other product-based environmental regulations and how they impact the eco-competitiveness of multi-national corporations. One example, as mentioned above, would be the chemicals industry. But researchers can also look to industries such as electronics, which are increasingly governed by product-based regulations.

In addition to looking to multi-national corporations operating under a variety of standards, one could conduct similar analysis within the U.S., looking at different state regulations and how they affect national companies. One potential example is fast food.

Although it may be premature to structure a research question around fast food regulatory regimes, large fast food companies are increasingly focusing on the health impacts of their products. Similar to auto companies establishing a “green” image, fast food companies are attempting to create a “healthy” image.

Another avenue for further research is to dig down into my results. I mentioned above that there must be internal company factors that contribute to eco-competitive strategy, which would act to differentiate companies in a single country. Testing this claim would require a closer inspection, probably in a comparative case format of diverging eco-competitiveness performance in a single country. This research may help elucidate the connections between internal company factors and eco-competitiveness that my thesis was unable to establish.

Yet another avenue for research along similar lines would be to conduct a more qualitative analysis of how managers respond to different regulations. How great a role do fuel economy standards and fuel taxes play in upper management’s decision making? Research in this area can also help flesh out the connection I establish between environmental regulations and eco-competitiveness.

Additionally, my findings suggested some limitations in two of the indicators I used. First, using number of IUCN organizations as a measure of stakeholder pressure led to a counter-intuitive finding. Although this finding may be legitimate, it is likely that a more accurate measure of stakeholder pressure can lead to a stronger result. Second, using organic food market share failed to translate into an indicator of willingness to pay an eco-premium. Despite the finding, I do believe that willingness to pay extra for environmentally friendly products can be an effective indicator of market opportunities for environmentally friendly automobiles.

Conclusion

Having traced through my research question, hypothesis and results, I turn to perhaps the most important question: what does it all mean? My research shows that fuel economy regulations, low carbon intensity, and fuel taxes all serve as necessary conditions for strong eco-competitiveness. Although these indicators are all supposed to measure different aspects of regulatory and market conditions, it seems possible that they all derive from the same macro-level source. The division separating government regulations from market conditions are not crisp, and all three of these measures indicate on a large scale the extent to which a country is eco-conscious.

The key point is that a researcher cannot fully separate consumer behavior, market conditions and government regulations. Carbon intensity is determined not only by industrial performance, but also by government regulations spanning sectors and citizen consumption patterns. Fuel economy standards and fuel taxes also spill into this notion of carbon intensity of the economy. Similarly, waste recycling is not only a measure of consumer behavior, but also includes government programs to incentivize recycling. All of these programs and impacts are interconnected, and while researchers can draw lines and use these indicators to measure different things, the results are not so simple to interpret.

This interconnectedness does not undermine my hypothesis and results that having high fuel economy standards are usually necessary for companies to be eco-competitive, but it is important to remember that high fuel economy standards do not occur in a vacuum. They are among the many tools that governments use to improve the environment and prevent catastrophic climate change. Thus in order for companies to truly embrace eco-competitiveness, governments need to do more than raise fuel economy standards; they need to demonstrate that preserving the environment is a top priority and that they are willing to work with industry to find the best way to do it. Rather than a tremendous and risky cost drain, the essence of my research suggests that a large-scale national shift toward more environmentally advanced thinking can lead to significant competitive advantages for companies operating in a global marketplace.

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