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Green Index: Integration of Environmental Performance, Green Innovativeness and Financial Performance

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Green Index: Integration of Environmental Performance, Green Innovativeness and Financial Performance

by

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Abstract

The integration of sustainability performance of companies is becoming increasingly important. The recent global requirements (i.e. the Kyoto Protocol) for significant reduction of the negative impact of companies on the environment over the next 6 years have been putting pressure on the companies, requiring them to lower the negative environmental impact of market performance. This requirement challenges the profitable growth of the companies' business functions, given the change needed for business operations to improve on their environmental impact.

In this dissertation a new corporate sustainability performance index, called: The Green Index, for measuring and assessing the integrated sustainability performance of companies is developed. The Green Index integrates Environmental Performance, Green Innovativeness and Financial Performance, by quantifying the expert opinions toward their integration. Development of the Green Index is a holistic approach in defining and measuring "green" performance for companies, integrated into their market performance. Green Index, for the first time in the literature, introduces Green Innovativeness in defining and measuring Green Performance of companies, in integration with Environmental and Financial Performance.

In the literature and business practices, there are various sustainability indices used, and methodological approaches in measuring corporate sustainability performance with more than hundred performance indicators. The Green Index, uniquely refers to the collective expert opinion of management researchers, executive managers of corporations, high-tech companies' R&D managers, financial managers, corporate social responsibility managers, in defining a shorter list of 29 performance measures under the three core performance dimensions. Hierarchical Decision Modeling is used for the development of Green Index based on experts' collective decisions. At the next level, desirability levels for each one of the 29 performance measures are scaled by a group of angel investors and investors. And their collective desirability quantifications are used toward the application of the Green Index to quantify the Green Index value for a set of scenario analyses for alternative company performance states.

Green Index fills a major gap in the scholarly literature and business practices. It meets the needs prioritized in the near future strategy of World Business Council on Sustainable Development (WBCSD) towards development of new performance metrics and business models for industries that are financially successful while innovating with green products as they are reducing their negative environmental impact (WBCSD Annual Report 2010, 2011).

Dedication

I dedicate this dissertation to the living memory of Her Holiness Shri Mataji Nirmala Devi, who gave the key to the True Knowledge Within to humankind, that is the highest.

This dissertation is a gift of gratitude to Mother Earth, to all the primordial teachers*; who taught humankind the mastery of living on Earth, Jesus Christ and Virgin Mother Mary; who taught of Knowledge of the Self, in surrender to GOD Divine.

Green Index is a gift of offering to all those children of the Mother Earth who are innocent in their minds, hearts and deeds, who work dedicatedly for making Earth a better place to live in, for all of us.

www.shrimataji.org

* Primordial teachers: Shri Raja Janaka, Shri Abraham, Shri Zoroaster, Shri Moses, Shri Lao-Tsu, Shri Confucius, Shri Socrates, Shri Mohammed, Shri Guru Nanak, Shri Shirdi Sai Baba

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I would like to thank the members of my dissertation committee: Dr. Robert Harmon, Dr. Charles Maria Weber IV., and Dr. Maurizio G. Zollo for their scholarly guidance over the years, and especially over the last year toward completion of the dissertation. Their insight on the theoretical contribution and impact of the Green Index is invaluable.

I would also like to express my gratitude to the experts, whose names are kept anonymous, and who gave their invaluable time and opinion for the creation of the Green Index. Their contribution to the development of Green Index has enabled the development of a new approach defining and measuring the environmental impact of corporate activities through the lens of profitability.

Last but not least, I would like to extend my full hearted gratitude to my family, friends and all the Sahaja Yogis of the World, for their invaluable support during my Ph.D. study over the years.

Above all, my utmost gratitude goes to Almighty God for the divine intervention during this academic endeavor and in my life.

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CHAPTER 1

Introduction and Research Scope

1.1 Introduction

The integration of sustainability performance of companies is becoming increasingly important. The recent global requirements (i.e. the Kyoto Protocol) for significant reduction of the negative impact of companies on the environment over the next 6 years have been putting pressure on the alignment of the Triple Bottom-Line performance for companies.

In this dissertation, a new corporate Green Performance index, called the Green Index is developed. The Green Index integrates Environmental Performance, Green Innovativeness and Financial Performance. The Green Index has a holistic approach and scope in measuring sustainability performance for companies.

Environmental performance and financial performance are the tangibles of the Triple-Bottom line. With this dissertation a new performance dimension: Green Innovativeness is introduced. The dissertation is in alignment with the near future strategy of World Business Council on Sustainable Development (WBCSD) to develop new performance metrics and business models for industries which is both environmentally oriented and innovative in the market with environmentally focused product innovations (WBCSD Annual Reports 2010, 2011).

WBCSD emphasizes that environmental protection generally pays off and thus improves the firms' bottom line (WBSD Annual Reports in 2007, 2008).

This research study presents a research design for addressing the gaps that exist in the literature on the integration of Environmental Performance, Green Innovativeness and Financial Performance for industrial corporations by referring to:

(1) The recent trends which have been increasing the environmental performance constraints on the companies,
(2) The gap that exists in the literature for integration of environmental performance, green innovativeness and financial performance, and
(3) The Hierarchical Decision Model which has a lot to offer by bringing in the tacit expert knowledge from the academia and the industry.

The objective of the dissertation is to develop the Green Index by using a Hierarchical Decision Model (HDM) and to apply it to a company for demonstration.

The scope of this research is limited to the assessment of environmental performance, green innovativeness and financial performance dimensions of companies. The Green Index model developed in the research is generalizable to any company in any industry, yet it is specifically demonstrated for the companies in semiconductor manufacturing industry.

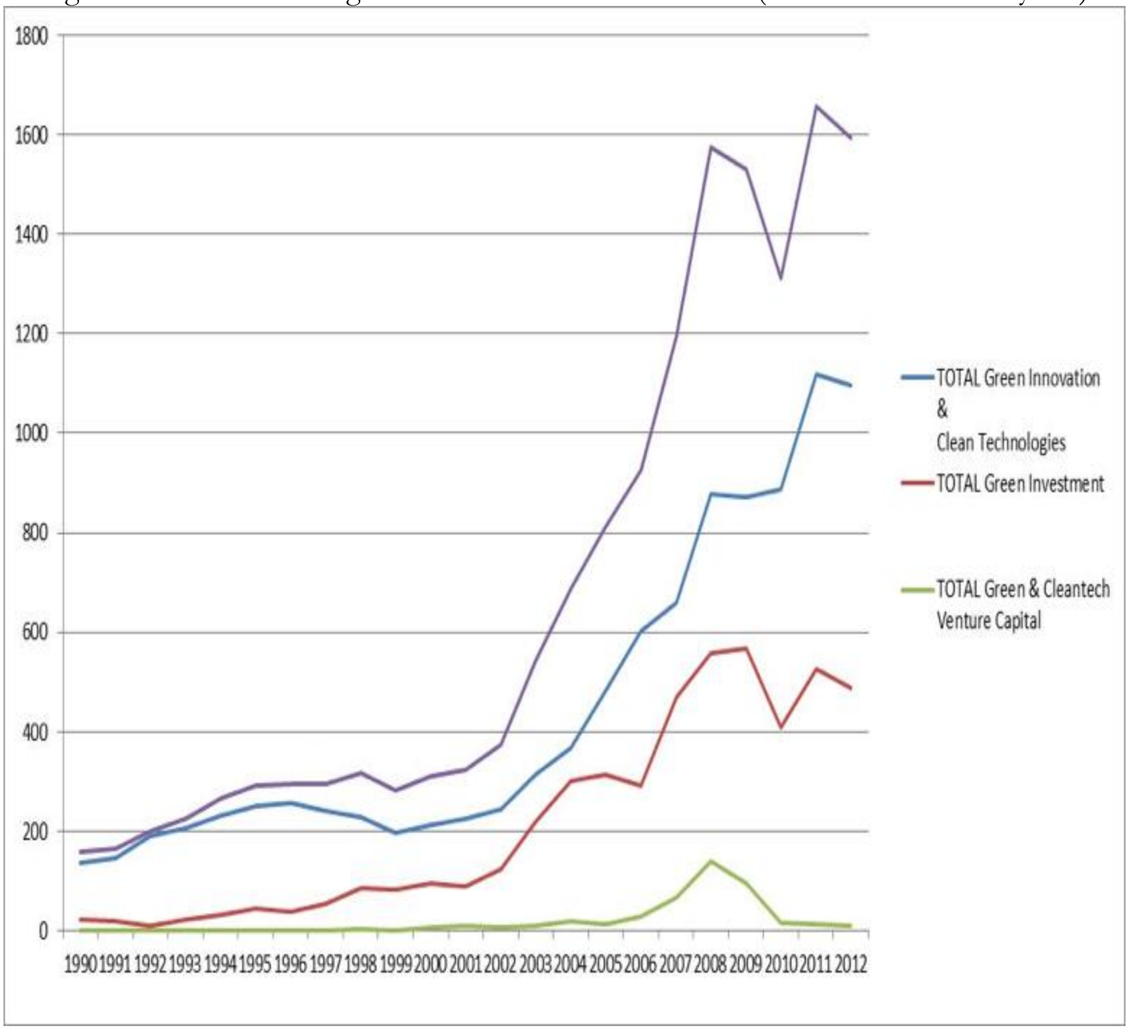
1.2. Research Scope

The results of an earlier bibliometric analysis conducted in the literature by using four search engines (EBSCO, Compendex, SCI, Google Scholar, Google) for on business-oriented scholarly publications, engineering-oriented scholarly publications, overall scholarly publications, and general publications including professional journals, news, blogs and for all other published materials are used to identify the research scope.

The bibliometric analysis modeling by Fisher-Pry model showed high potential growth trends in the areas of Green Innovations, Green Investments, and Green Venture Capital. This finding supports the need for addressing the integration and the nature of relationship between environmental performance, green innovativeness and financial performance for companies, holistically.

The literature search verifies the growth trend in sustainability-related topics in both scholarly and general publications over the past 23 years, between 1990 and 2012. When overall general publications including economics, business and engineering professional journals, are studied, it is observed that the cumulative number of publications on Green Innovations & Clean Technologies have been highest in number in comparison to Green Investments and Green & Cleantech Venture Capital in the World from 1990 to 2012. The impact of the 2008 global financial crisis is also recognizable from the cumulative numbers after 2009. The pace of growth is slowed down since 2008. The cumulative number of publications on Green Business grows from 158 in 1990 grows to more 1594 as of 2012 (Figure 1.1).

Figure 1.1. Publications' growth trend from 1990 to 2012 (cumulative over the years)



The growth trends in financial investments and technological innovations in sustainability show the Rapid Development stage as of 2012, emphasizing the high potential for scholarly work for at least the next 8 to 10 years. The details on this Fisher-Pry Model analysis is available in Tekin and Kocaoglu (2013).

The findings of Tekin and Kocaoglu (2011, 2013) can be classified into three main groups by referring to the stages at which they currently as:

a. Green Innovations are at the very early stages of Rapid Development as of 2012 both for the scholarly and general publications literature with a goodness of fit higher than 99%.
b. Green Investments are at the very early stages of Rapid Development as of 2012 both for the scholarly and general publications literature with a goodness of fit higher than 98%.
c. Green Venture Capital is at the very early Emerging Stage as of 2012, for the scholarly publications literature, with a goodness of fit higher than 99%, while for the general publications it appears to be at a very late stage of Rapid Development with a goodness of fit 99.7%.

These findings provided the motivation to develop a holistic approach to study the environmental, green innovativeness and financial performance of companies.

In the following sections of this dissertation Literature Review and Research Gaps are summarized in Chapter 2, Research Approach and Methodology are introduced in Chapter 3, Research Results are presented in Chapter 4, and Conclusions and Research Contributions are presented in Chapter 5.

CHAPTER 2

Literature Review and Research Gaps

2.1. Introduction

This chapter is a review of the literature on the integration of the three performance dimensions: "environmental performance", "green innovativeness" and "financial performance" as it relates to the development of the Green Index. The literature review shows the lack of such an integrated index, as well as the lack of studies that address the integration. There are some research studies, which focus on the two dimensional relationship among the three, and at some points they show conflicting results with each other.

Being competitively innovative has been the challenge for companies so as to sustain themselves as high performers. However, how the boundaries of the firms' operations change, evolve when the environmental performance requirements either by the regulations or the customers come into play, is still yet to be discovered. There are no generalized and verified metrics to define the critically important performance indicators for addressing such interactive dynamics. This dissertation will contribute to the current state of literature for the integration of environmental performance, green innovativeness and financial performance of the firm.

In the following sections Triple Bottom Line concept is briefly summarized and the gaps in the literature that show the need for the holistic integration of environmental performance, green innovativeness and financial performance are introduced.

2.2. Literature review

There are several indices on measuring sustainability performance and financial performance of companies but not one on green innovativeness. Moreover the integration of environmental performance, green innovativeness and financial performance into a single index is not available.

In this section the literature review of the existing scholarly publications is presented in five sections as: the triple bottom line, relationship between environmental performance and financial performance & sustainability and financial performance, relationship between innovativeness & green innovativeness and financial performance, methods applied for addressing the relationships, and overall research gaps in the literature for the integration of the three performance dimensions.

2.2.1. A Focused look into the Triple bottom line

Often referred to as the Triple Bottom Line, companies today must concern themselves not only with their economic profits but also with social and environmental profits (Elkington, 1984). Triple Bottom Line approach has three domains: people, planet and profit. The People domain refers to the social benefits delivered to the society and to the employees of the companies, the Planet domain refers to engaging in environmentally responsible, sustainable business practices. The Profit domain, refers to the economic and financial welfare of the businesses. Building on the three domains, the definition of sustainability was first developed by the UN's Brundtland Commission (led by the former Norwegian Prime Minister GroHarlem Brundtland) in 1987, as: "Business practices that meet the needs of the current generation without compromising the ability of the future generations to meet their needs".

World Business Council for Sustainable Development declared in its 2008 Annual Report: "What a way to run the World" that "green solution" can be found to both economic and ecological challenges, creating new jobs and markets by investing in new forms of energy, redesigning or retrofitting buildings and equipment, and managing forests and other ecosystems sustainably." (WBCSD Annual Report, 2008).

The global financial crisis in 2008 was addressed by WBCSD's Chairman, Samuel DiPiazza Jr. as: "Economic crises must remind us that sustainable development is not just about environmental or social issues but also about sound economic development." In fact, the financial crisis has not been causing firms or governments to abandon sustainable development. Many in business and government suggest that a "green solution" can be found to both economic and ecological challenges, creating new jobs and markets by investing in new forms of energy, redesigning or retrofitting buildings and equipment, and managing forests and other ecosystems sustainably.

With the recent limitations and pressures brought to the markets with the climate change requirements[1], the environmental impact requirements for the companies have been becoming tighter with the requirements such as the stabilization of global emissions by 2015, and cutting of emissions 40-45% by 2020.

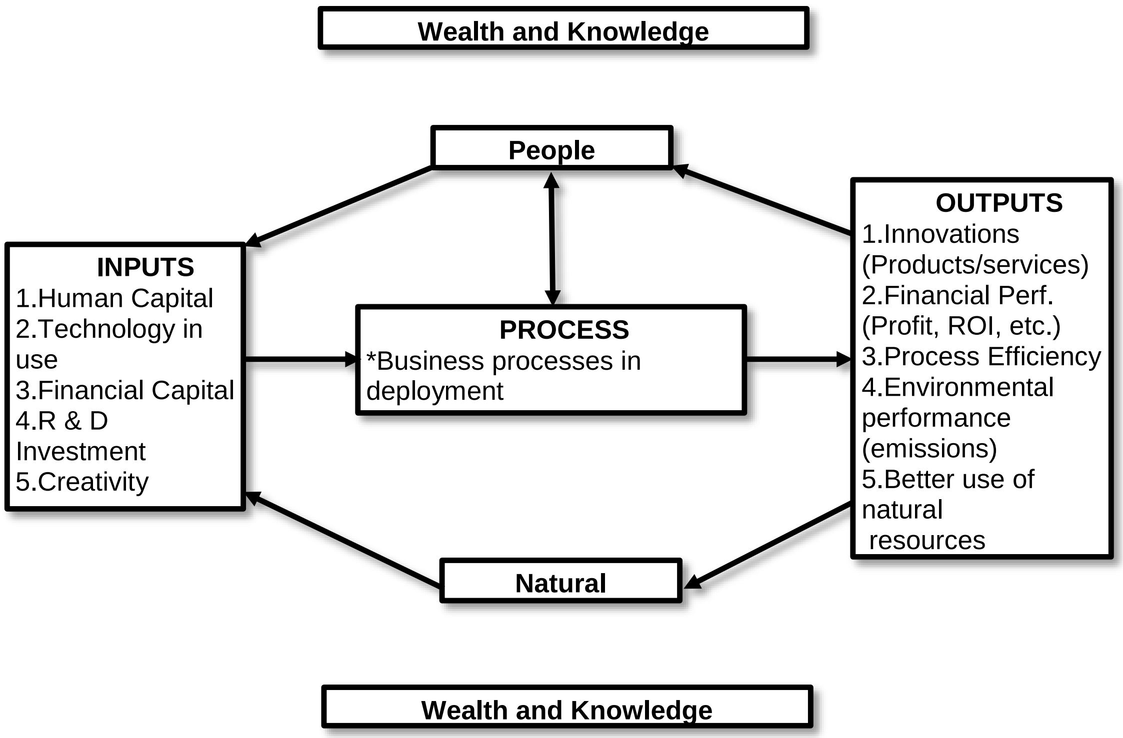
It is widely accepted that environmental actions are associated with an increase in costs for businesses imposed by the government (Lanoie et al, 2007). Over the last decade, this view has been challenged by the researchers, certain business practitioners and analysts. They have identified various ways for firms to offset the costs of sustaining the environmental higher profits.

It is shown by Lanoie et al., in their 2007 report that a better environmental performance can lead to *firstly,* an increase in revenues through certain channels such as: better access to certain markets, the possibility to differentiate products, the possibility to sell pollution-control technology; *secondly*, cost reductions in the categories of: regulatory costs, cost of material energy and services, cost of capital, cost of labor. The study discusses that the expenses incurred to reduce pollution can sometimes be partly or completely compensated by gains elsewhere.

[1] Goals for Industrial Nations, Kopenhagen 2010, & USA Presidential Climate Action Project, 2010.

This dissertation is within the boundaries of the "Living Organism" and it has the firm central to it. The Living Organism concept and how a company manages and sustains the evolutionary chain of Living Organism in the context of this research is presented in Figure 2.1. below.

Figure 2.1. The living organism of the firm



In this framework the firm is acting as a living organism while working with the inputs and utilizing the resources of nature & people and through its processes it is creating outputs in various forms. These outputs are feeding into the natural resources and people at large as they apply. This "living organism" is evolving around the firm, while at the same time it is being managed & maintained by the firm itself.

As briefly defined and introduced, the focus of this study is to address the holistic integration of the three main "tangible" outputs of a firm, which are listed in the outputs box defined in Figure 2.1. as green innovations, environmental performance and financial performance.

In the literature, there is considerable amount of research on addressing the impact of the "people" domain on that of the "profit" and vice versa. The "people" domain is kept out of the scope of this research, given the focus of this research being on the tangible outcomes of the firm to the markets. The integration of the environmental performance, green innovativeness and financial performance dimensions is nonexistent in the literature. The body of knowledge in the literature on environmental performance, financial performance and the relationship between the two is presented in the following sections. Given the organic, inseparable relationship between competitiveness and financial performance, innovations being the core driver of success in competition in the markets, also falls into the scope of this research . Starting from the importance of innovations for companies, the "green innovativeness" concept is discussed for the Green Index research and it is introduced as the "third' major performance dimension for addressing the integration and measurement of tangibles for the Triple Bottom Line of the firm from a completely "environmental", in other words "Green" perspective. Building further on, the financial performance dimension is discussed based on the literature, and at the research development stage, it is further expanded to cover the environmental perspective within the measurement of financial performance.

There is large volume of literature showing that being innovative contributes to the performance of the firm positively and works for its competitive advantage (Avlonitis and

Gounaris, 1999; Atuahene-Gima, 1996; Capon et al., 1992; Deshpande´ et al., 1993; Han et al., 1998; Li and Calantone, 1998; Manu and Sriram, 1996; Mavondo, 1999; Va´zquez et al., 2001). Currently, there has been increasing attention towards being green and managing business within the environmental regulations, and there is a lot to be explored in this area Russo and Fouts (1997), Khanna et al. (1998), Dasgupta and Laplante (2001), King and Lenox (2001).

With these three major pillars: environmental performance, green innovativeness and financial performance, the research discusses:

(1) the current level of knowledge on addressing the integration among three performance dimensions,

(2) the development of a new measurement approach to model the integration,

(3) the development of a strategic decision making tool which will build upon the synthesis of the literature

2.2. Relationship between environmental performance and financial performance

Some studies in the literature use the term "sustainability" covering tangible environmental impact as well as intangibles. Some studies solely use the term "environmental performance" for the environmental impact, and / or environmental footprint.

With these difference in the wording of environmental performance, this section is an assessment of all the concepts in use: when the studies refer to the term sustainability rather than "environmental performance" the terminology of the referred study/(ies) is used, and "environmental performance" is mentioned in parenthesis. The assessment in this section is structured into two perspectives:

(1) the use of indicators that are external to the firm

(2) the use of those that are internal to the firm

The first assessment is from the perspective of looking into the body of literature where proxies for the Environmental Regulations (ERs), that are external to the firm, are introduced and utilized for studying the relationship between environmental performance and firm performance.

In this context, the impact of Environmental Regulations (ERs) appears as a key factor. This perspective and the key articles are summarized in section 2.2.1 All the papers introduced and discussed in this section build upon the main Porter Hypothesis (PH) assumptions as explained on pages 19 thru 21. The second assessment is from the perspective of the use of internal indicators for sustainability and financial performance within the firm and Section 2.2. is dedicated for the assessment of the studies on the interaction between the two.

2.2.1. External indicators for environmental performance: Environmental Regulations (ERs)

This review section summarizes the studies where proxies for the environmental regulations, which are *external* to the firm, are used to study the relationship between environmental performance and firm performance. An in-depth assessment of the literature, dealing with the environmental regulations as *external* indicators for the impact studies of environmental performance are as follows.

Berman and Bui, (2001) states that since the early seventies, the scope of Environmental Regulations (ERs) in most developed economies has been considerably broadened, resulting in increased pollution control expenditures. For example, in the US, pollution abatement investments increased by 137% over the 1979-1994 period. The estimated total annual abatement expenditure represents between 1.5% and 2.5% of the US GDP The same trend has been observed in Canada where environmental protection expenditures by business increased by 27% from 1995 to 2002 (Lanoie et. al, 2007). Given the growing concern for environmental quality and the threat of climate change, significant increases in ERs and pollution control expenditures are very likely to continue in the near future. ERs are especially relevant for the energy sector for they include several "pollution intensive" industries such as petroleum or power generation (Ambec and Barla, 2006).

Gradually starting with Brundtland Report in 1987 and continuing with the Earth Summits in Rio de Janeiro (1992) and Johannesburg (2002), Sustainable Development has become one of the foremost initiatives with strong attention throughout the World. In Brundtland Report, sustainable development is defined as "Business practices that meet the needs of the current generation without compromising the ability of the future generations to meet their needs"[2].

Laoine et al (2007), state that "Given the increasing reactions of the nature in the forms of natural disasters, acid rains, ozone layer problems, the environmentalists in particular, and the general population, more broadly believe that the consequences of business as usual are frightening. Many corporations accept the same conclusion, but the environment is often just one more thing to worry about. It looms in the future at a time when they are beset with many other, more important concerns. How then, can firms be induced to participate in society's fight to manage the impact of human activity on the environment? - *only by showing them that it is possible to offset the costs of sustaining the environment with higher profits"*. This study claims that an environmental revolution demands a "paradigm shift" from one set of assumptions to another. Technology sets the parameters of the possible; it creates the potential for an environmental revolution. Hence, initiating any environmentally sound major paradigm shift according to the CIRANO [3] report , will depend largely on convincing business leaders of the potential for profit. (Burgundy Report[4] 2007).

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[2] Brundlant Report of UN, http://www.un-documents.net/our-common-future.pdf

[3] CIRANO is a private non-profit organization incorporated under the Québec Companies Act. Its infrastructure and research activities are funded through fees paid by member organizations, an infrastructure grant from the Ministère du développementécxonomique et régional and grants and research mandates obtained by its research teams.

[4] The Burgundy Reports are written by CIRANO Fellows on issues of general interest, and aims to encourage discussion and debate.

Lankoski (2006), shows the positive links between environmental and economic performance such as: green buying power, potential to differentiate products, and selling pollution-control technologies having potential to increase revenues and regulatory costs, cost of material, energy and services, cost of capital and labor have potential to reduce costs. These impacts are summarized in Table 2.1 on the following page.

Table 2.1. The Economic Impacts of Environmental Regulation *(Ref: Lankoski, 2006)*

Potential to increase revenues	**Potential to reduce costs**
Green buying power	Regulatory costs
Potential to differentiate products	Cost of material, energy and services
Selling pollution-control technologies	Cost of capital and labor

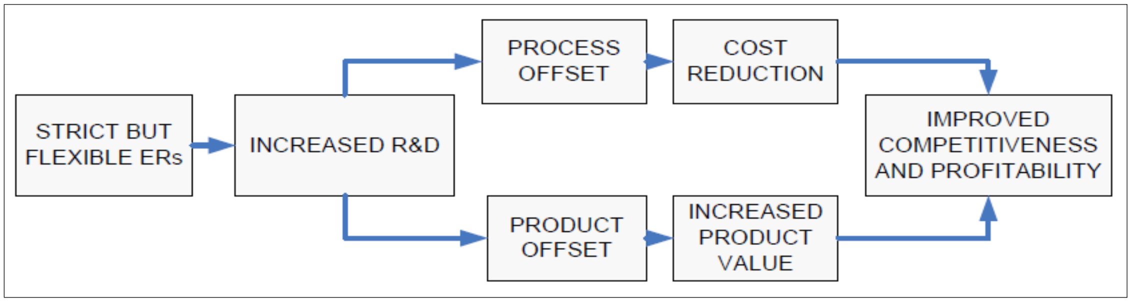
The link between performing well environmentally and being a financially successful company has been a topic of high interest in the corporate environmental management literature. (see e.g. Jaggi and Freedman, 1992; Walley and Whitehead, 1994; Feldman et al., 1996; White, 1996; Hamilton, 1995; Hart and Ahuja, 1996; Johnson, 1995; Klassen and McLaughlin, 1996; McGuire et al., 1988; Morris, 1997; Russo and Fouts, 1997; Wagner and Wehrmeyer, 2001). These papers have addressed the relationship from several perspectives.

Some scholars assume that environmental protection is a net cost to a company, whereas others believe that environmental protection generally pays off and thus improves the firms' bottom line (e.g. Porter and van der Linde, 1995; WBCSD, 1997,2007, 2008). The limited, however diverse, empirical studies in the literature provide arguments for both sides. Wagner (2000), states that there are many studies supporting the hypothesis that good environmental performance is not punished, and that bad performance does not pay off. The traditional view among economists, that the environmental regulations impose costs on regulated industries, was challenged by Porter (1991) and Porter and van der Linden (1995). As it is referred now as the Porter Hypothesis (PH) this hypothesis states that stringent, well-designed environmental regulations lead not only to social benefits but may very often also result in private benefits for regulated companies.

Critics of the PH argue that success stories for the case are not the norm and that overall, improving environmental quality is not without high costs, given that those regulations require firms to allocate labor and capital resources to pollution reduction, which are unproductive from a business perspective. For Porter and van der Linden (1995), the traditional view has a narrow static perspective on firms' reaction to ERs. The study states that when faced with the prospect of higher abatement costs, firms will invest in innovation activities to find new ways to meet new regulatory requirements. The resulting new production process or new product specifications would reduce pollution and at the same time lower production costs, or increase product market value. These benefits will very often offset and even exceed the costs initially imposed by regulations.

Porter summarizes the links involved in the PH as presented in Figure 2.2. as follows: Strict & flexible ERs, result in increased R&D which lead to cost reduction via process offset and increased product value via product offset, both of which improves competitiveness and profitability.

Figure 2.2. Schematic representation of the Porter Hypothesis *(Ref: Ambec et Barla 2006)*



Following PH, several studies have been conducted to explore the impact of ERs on financial performance highlight with conflicting results, and they are classified into two main groups.

The first group of articles: Russo and Fouts (1997), Khanna et al. (1998), Dasgupta and Laplante (2001), King and Lenox (2001), conclude that the relationship between financial performance and environmental regulations is positive, whilst the second group of articles: Brannlund et al. (1995), Filbeck and Gorman (2004), Gupta and Goldar (2005) conclude that there is a negative relationship between the two. The focus of these two groups of papers, the industries they look into and the countries they cover are different. Their results are ungeneralizable and deliver conflicting conclusions. The papers which conclude a negative relationship are using firm's performance indicators as specifically driven from stock market performance whilst the other group is, in fact, not referring to stock market performance, but looking into the ROA, ROI and similar firm specific performance indicators and introducing constructs for a better definition and measurement of environmental performance and financial performance.

These papers' key findings and methods are briefly summarized below, as adapted from Ambec et Barla 2006.

Group 1: There is a positive relationship between ER & performance

Four papers from 1997 to 2001 show a positive relationship between ER and firm performance:

Russo and Fouts (1997), in their study of 243 firms from a wide range of industries, over 1991-1992 period, show that environmental performance and economic performance are positively related and industry growth moderated the relationship, with the returns to environmental performance higher in high-growth industries.

Khanna et al. (1998), in their study on 91 US chemical firms, over 1989 – 1994 period, show that there are negative abnormal returns during one-day period following disclosure, abnormal losses are higher for firms which do not reduce emissions or whose performance worsens compared to other firms and that abnormal losses push firms to increase wastes transferred off-site.

Dasgupta and Laplante (2001), in their study of 126 events, involving 48 publicly-traded firms in Argentina, Chile, the Philippines and Mexico, show that 20 out of 39 positive events lead to positive abnormal returns (+20% in firm value over a 11 days window), 20 out of 39 positive events lead to positive abnormal returns (+20% in firm value over a 11 days window).

King and Lenox (2001), in their study of panel of 652 US manufacturing firms over 1987-1996 period, show that ERs have positive impact on financial performance but only significant in one specification as well as a positive link between financial and environmental performance.

Group 2: There is a negative relationship between ER & performance

Three papers from 1995 to 2005 report a negative relationship between ER and firm performance:

Brannlund et al. (1995), in their study on 41 Swedish pulp and paper mills, from 1989 to 1990, show that average reduction in profits due to regulation is between 4% and 17%, and that between 66% and 88% of mills are unaffected by regulation.

Filbeck and Gorman (2004), in their study of 24 US electrical utilities over 1996-1998 period, show that there is negative relationship between returns and environmental regulation compliance.

Gupta and Goldar (2005), in their study of 17 Indian pulp and paper plants, 15 auto firms and 18 chlor alkali firms, over 1999-2001 period, show that there is a negative relationship between abnormal returns and environmental rating.

The common characteristic of these two groups of papers which conclude with opposite results is that, each individual study has its own perspective, methodological approach, theoretical ground and focus area. The groups of papers advocate conflicting research findings.

2.2.2. Internal indicators for sustainability: environmental and financial performance

In this section, the studies that explore the internal indicators of sustainability (in the form of environmental performance) and financial performance for the firm are summarized. For the proposed Green Index development, the goal is to develop a model of integration. The literature findings show that studies which deliver such integration models do not exist. The case studies provide detailed information on the verified internal indicators for the firm within the context of environmental and financial performance relationship. These indicators in the literature provide a list of potential indicators which can be used for the Green Index. In this section these potential indicators of financial performance and environmental performance for the firms are discussed. The studies which address the interaction between the two performance dimensions are summarized.

As for the main indicators, those for corporate financial performance and corporate environmental performance cited in several papers in the following two sections are presented. A list with the relevant citations is also presented in Table 2.2. and Table 2.3.

Dowell et al. (2000) uses Tobin's q, Hart and Ahuja (1996) and Russo and Fouts (1997) use Return on Assets, Return on Investment and Return on Equity as variables while addressing the relationship between environmental performance and financial performance. The detailed explanations for these variables as used in the corresponding papers are listed in Table 2.2, below.

Table 2.2. Corporate financial performance studies *(ref: King & Lenox, 2001)*

Measure	*Description*	*Examples*
Tobin's *q*	Firm market valuation over replacement value of assets	Dowell et al. (2000)
Return on Assets	The ratio of income to total assets	Hart and Ahuja (1996), Russo and Fouts (1997)
Return on Equity	The ratio of income to firm equity	Hart and Ahuja (1996), Russo and Fouts (1997)
Return on Investment	The ratio of operating income to book value of assets	Hart and Ahuja (1996), Russo and Fouts (1997)

Table 2.3. Corporate environmental performance *(ref: King & Lenox, 2001)*

Measure	*Examples*
Capital expenditures on pollution control technology	Spicer (1978) Nehrt (1996)
Emissions of toxic chemicals (typical source: TRI)	Hamilton (1995) Hart and Ahuja (1996)
Spills and other plant accidents	Karpoff et al. (1998)
Lawsuits concerning improper disposal of hazardous waste	Muoghalu et al. (1990)
Rewards or other recogition for superior environmental performance	Klassen and McLaughlin (1996)
Participation in environmental management standards	White (1996) Dowell et al. (2000)
Rankings of superior environmental performers (e.g., CEP)	White (1996) Russo and Fouts (1997)

Spicer (1978), Russo and Fouts (1997) Dowell et al. (2000), Cohen et al. (1995), White (1996) support a proposed positive relationship between pollution reduction and financial gain by relying on correlation studies on environmental and financial performance.

In the field of industrial ecology, Nelson (1994); Panayotou and Zinnes (1994); Esty and Porter (1998); Reinhardt (1999), argue that there are situations where beyond-compliance behavior by firms is a win-win for both the environment and the firm. Porter and van der Linde (1995); Reinhardt (1999) assume the Porter Hypothesis conditions and suggest that corporations shall be both green (be successful environmental performers) and competitive.

For the study of internal indicators for sustainability via environmental and financial performance, the literature is grouped, in terms of the methodological approaches these studies have as (1) Longitudinal and quantitative studies, (2) Qualitative studies, and (3) Event studies.

Group 1: Longitudinal and quantitative studies

All the papers in this group, use different indicators and the sample sets they use, the industries they focus on are different. They both conclude that there is a positive relationship between environmental performance and financial performance. These papers are listed and summarized below:

- A series of studies conducted by the **Council on Economic Priorities (CEP)** in the 1970s states that expenditures on pollution control are significantly correlated with financial performance among a sample of pulp and paper firms (Spicer, 1978).
- **Russo and Fouts (1997)** concludes a significant positive correlation between various financial returns and an index of environmental performance developed by the CEP.
- **Cohen et al. (1995)** uses several measures of environmental performance derived from U.S. Environmental Protection Agency (U.S. EPA) databases to construct two industry-balanced portfolios of firms and they show no penalty for investing in the green portfolio and a positive return to green investing.
- **White (1996)** states a significantly higher risk-adjusted return for a portfolio of green firms using the CEP ratings of environmental performance.

- **Dowell and colleagues (2000)** show that firms which adopt a single, stringent environmental standard worldwide have higher market valuation (Tobin's q) than firms that do not adopt such standards.
- **King and Lenox (2001)** argues that early studies often lacked the longitudinal data needed to fully test the relationship and that several years of data are needed if one wants to rule out rival explanations for the apparent association or show that environmental improvement "causes" financial gain. This study uses longitudinal data of 652 US firms, and empirical tools, to explore the publicly traded US manufacturing firms' corporate data from Standard & Poor's Compustat database and environmental performance data from US EPA's Toxic release Inventory (TRI) over 1987-1996 period. Tobin's q is used as financial performance measure, where it measures the market valuation of a firm's relative to the replacement costs of tangible assets as cited in Lindberg and Ross (1981). The results show evidence of an association between pollution reduction and financial gain, however the direction of the causality of all the relationships defined and explored are not verified, as is the case in correlation studies. The indicators used are: total emissions, relative emissions and industry emissions. The key results of this study are listed in Table 2.4 below.

Table 2.4 The emission variables used by King & Lenox (2001)

Variable	*Description*	*Result*
Total emissions	Log of total emissions of facilities	Associated with financial performance, but direction of the relationship uncertain
Relative emissions	Emissions relative to other facilities of similar sector and size	Associated with financial performance, but direction of the relationship uncertain
Industry emissions	Emissions per employee for the sectors in which the firm operates	Apparent but possibly spurious association with financial performance; direction of relationship uncertain

King & Lenox (2001) points out that the empirical literature does not clarify whether the apparent association is generated by a firm's choice to operate in cleaner industries or to operate cleaner facilities. The existing research cannot answer whether it pays to be green or whether it pays to operate in green industries. King and Lenox (2001) shows support for a connection between some means of pollution reduction and financial performance, but it also suggests that the reason for this connection is yet to be established.

- Proponents of a causal link between environmental and financial performance have argued that pollution reduction provides future cost savings by increasing efficiency, reducing compliance costs, and minimizing future liabilities (Porter and van der Linde 1995, Reinhardt 1999). Porter and van der Linde (1995) theorizes that opportunities for profitable pollution reduction exist because managers often lack the experience and skill to understand the full cost of pollution.

Such correlative studies are informative, but they tell nothing about causality or integration. Market analysts, for example, increasingly gather environmental performance data as an indicator of future capital market returns (Kiernan 1998). For their purposes, it matters little whether environmental performance leads to financial performance or simply provides an indicator of firms that have high financial performance (King & Lenox 2001). From the perspective of corporate managers and policy analysts, however, the distinction is critical. The prescription that often follows from the "pays to be green" literature is that managers should make investments to lower their firm's environmental impact (Hart and Ahuja 1996). To fully demonstrate that it pays to be green, current literature cannot demonstrate that environmental improvements produce financial gain.

Group 2: Qualitative studies

Qualitative research studies such as Denton (1994); Deutsch (1998); Graedel and Allenby (1995); Porter and Van der Linde (1995); King (1995) identify numerous examples of profitable pollution prevention opportunities. Hart (1997) argues that discretionary improvements in environmental performance often provide financial benefit. It proposes that excess returns (in other words profits above the industry average) result from differences in the underlying environmental capabilities of firms. Managers may possess unique resources or capabilities that allow them to employ profitable environmental strategies which are difficult to imitate.

Though some of the papers listed above show positive relationship between better environmental performance and better financial performance, King and Lenox (2001) paper argues that these early studies often lack the longitudinal data needed to fully test the relationship and that several years of data are needed if one wants to rule out rival explanations for the apparent association or show that environmental improvement actually "causes" financial gain.

Group 3: Event studies

Event studies, which show greening indeed causes financial gain, look at the relative changes in stock price following some environmental event. The limitation with event studies is that they often study the effect of events that are only partially environmental in nature.

Klassen and McLaughlin (1996), White (1996), Karpoff et al (1998), and Jones & Rubin (1999) studied the effect of published reports of events and awards on firm valuation and found a relationship between the valence of the event (positive or negative) and the resulting change in market valuation.

Blacconiere and Patten (1994) estimates that Union Carbide lost $1 billion in market capitalization, or 28%, following the Bhopal chemical accident, in 1984. Muoghalu et al. (1990) shows that firms named in lawsuits concerning improper disposal of hazardous waste suffered significant losses in capital market value. Each of these events has environmental elements, but each is affected by other firm attributes. King and Baerwald (1998) argues that size, market power, and unique firm characteristics influence how events are reported and interpreted , and that a firm with good public relations may be able to put a positive spin on negative news.

Research done so far to explore the relationship between environmental performance and financial performance of the firm, is promising and there is potential for further exploration. Most of the studies use the three research methods summarized above. The positive relationship between environmental performance and financial performance has been verified: however there is lack of consistency in clearly defining what really indicates environmental performance for the alternate assessments. This points out the potential for further academic research and the use of other research methods.

Internal indicators for innovation and green innovativeness, have not been used in the three groups of papers for the exploration of the relationship between environmental performance and financial performance.

In the following section 2.2.3., the approaches deployed by the industry and business are introduced. It can be concluded that the academic literature has been dealing with the addressing of environmental performance in various diverse ways, given the complexity of defining the indicators for environmental performance for a firm, and how to assess it. When it comes to how environmental performance and financial performance interact with each other, the results are conflicting with opposing findings. The interest on the issue has been growing. The unstructured, ungeneralizable research growth over the years leaves room for the future research agenda. Green innovativeness, and its interaction and integration with environmental performance and financial performance has not yet been addressed in the literature. The business practices for defining and measuring environmental and financial performance are introduced in the following section: 2.2.3.

2.2.3. Business practices for measuring environmental and financial performance

The current business practices in defining and measuring environmental performance and financial performance are summarized in this section. Some of these measures are introduced by international organizations to the markets and some are specific measures which the companies choose to measure independently for their business operations. In the industry, environmental performance is heavily referred to as sustainability performance.

Currently, there are two Corporate Social Responsibility (CSR) Indexes deployed for financial markets as a tool for investment decisions for the investors: the Dow Jones Sustainability Index (DJSI) established in 1999 and the FTSE4Good established in 2001. These indices have an environmental sustainability component to them along with social responsibility and economic sustainability indicators and they are relating the overall performance of a corporation to the composite CSR Index. Yet there is no specifically Environmental Sustainability Index in use that relates the value of such an environmental performance index to the overall financial performance of the firm.

If such a globally generalizable sustainability performance index had been developed, an in depth research to assess the relationship between the environmental performance and the financial performance of firms would have been possible. Such an index would potentially respond to all the inconsistencies that exist in assessing the nature of the relationship between environmental performance and financial performance. That clarification would potentially lead the industries, and the firms accordingly, as well as the governments and regulatory institutes.

There are some generalized, official standards, codes and indicators for environmental sustainability which are in use by the companies due to governmental regulations. Currently there is lack of a standardized measure of green innovativeness for companies. The standards defined for sustainability by international organizations for companies with short summaries are briefly introduced and summarized below:

ISO standards

The International Standardization Organization (ISO) is a member agency of the United Nations System. It is a network of national standards institutes in 148 countries with headquarters in Geneva and it has established a number of international standards in the areas of social and environmental performance (ISO 14000 series). These standards are based on the three main elements of sustainable development: the economy, society and the environment.

Many companies monitor these three parallel standards on the basis of their assessments in order to guide product, process and personnel development and to secure their position in the rapidly changing climate of environmental legislation and stakeholder expectations.

ISO 14001

ISO 14001 is one of the most frequently adopted standards in the area of corporate responsibility and is widely recognized as an international standard for environmental management. ISO 14001 was developed in 1996 by ISO. ISO standards are developed by technical committees made up of experts on loan from the industrial, technical and business sectors which have asked for the standards and subsequently put them to use.

AA1000 Assurance Standard

AA1000 is an assurance standard that covers an organization's disclosure and associated sustainability performance. Its goal is to secure the quality of sustainability accounting, auditing and reporting. It is continually under development by Accountability, an international membership-based professional institute established in London in 1996. AA1000 is used worldwide by a variety of organizations such as businesses, service providers, NGOs, public bodies and advocacy groups.

SA8000

SA8000 is the first global certification system for supply chain labor standards, which is a voluntary standard developed by Social Accountability International (SAI). It is based on ILO conventions and linked to UN norms. It is significant as an example of a stand-alone certification solution for managing aspects of corporate responsibility and as a global, certifiable standard that is delivering auditable compliance for manufacturers and purchasers in the supply chain.

In addition to these standards, there are two major critical sources of information regarding environmental performance/sustainability from the perspective of private sector: The study conducted by Sze´kely and Knirsh (2005) on Responsible Leadership and Corporate Social Responsibility explores the practices carried on by a group of 19 global corporations from a wide range of industries. It gathers information on the metrics in deployment in those corporations by referring to the economic, environmental and social performance and the main concept of Triple Bottom Line concept which is established by John Elkington of SustainAbility, in 1998. In 1998 John Elkington, chairman of SustainAbility, institutionalized the concept of the triple bottom line. According to him, business in the twenty-first century needs to focus on enhancing environmental quality and social equity just as it strives for profits. It must also put the same effort into this cause. Thus it must weigh the three sustainability spheres equally (Sze´kely and Knirsh, 2005).

On pages 34 thru 37, in Table 6, the indicators for economic and environmental sustainability used by Sze´kely and Knirsh (2005) are presented. It specifically highlights the economic and "environmental sustainability" indicators in use by the corporations[5]. There is also a social responsibility section of the same collection of indicators used in the Sze´kely and Knirsh (2005), however that section is not included in this research given the objective of this being on the integration of the three performance dimensions for the firm.

In Sze´kely and Knirsh (2005), there are more than 30 indicators for "environmental sustainability" and more than 20 indicators for "economic sustainability" in use by the corporations. It is not possible to say that there is a clear consensus on the indicators for measuring, tracking and managing "environmental sustainability" consistently across several organizations and industries. Companies adopt international standards and codes and use assurance providers for a number of reasons: to meet legal compliance requirements, to build trust and credibility, to gain certification, to gain or restore stakeholder confidence, and to improve management systems through the use of standards and processes.

Two major takeaways of Table 2.5. are the "diversity of the indicators" and the "variation in what the companies pay attention to" in different industries. The industries' nature and

[5] This research uses the terms "environmental performance" and "financial performance", however, as the reference study is summarized in this part, the terminology that is used in their study is kept as it is in this section.

attention brings about different indicators to be deployed, and thus the ways and methods they develop building environmentally and financially successful business practices vary a lot.

These findings represent the need for better means of addressing the environmental performance and financial performance of companies, via certain, common, core value indicators, that are comparable across industries and countries, above and beyond the country and industry specific environmental and financial regulations.

Table 2.5.
The indicators for economic and environmental sustainability by Sze´kely and Knirsh (2005)

Company	Economic sustainability metrics	Environmental sustainability metrics
1. **Allianz** Sustainability Report 2004	• total income • earning before tax • net income • ROC after tax • Earnings per Share	• % of employees in environmental management • energy consumption (MJ/employee/year) • total water consumption (Liters/employee/year) • emission of greenhouse gases (kg/employee/year) • waste (kg/employee/year) • paper consumption (kg/employee/year) • business travel (km/employee/year)
2. **Axel Springer** Sustainability Report 2003 Only available online	• revenue (total and by country) • total expenditure on purchased goods, services, materials • share of orders paid for in accordance with contract convention • equivalent monetary value of all benefits to staff • interest on liabilities, dividends • change in retained income in the reporting period • taxes paid to all tax-levying authorities • state subsidies and assistance • donations to the community, civil society and others (cash and in kind)	• total material consumption • processing of material that is treated or untreated waste from other sources • direct energy consumption by type • total water consumption • emission of greenhouse gases • emission of gases harmful to the ozone layer • emissions into the atmosphere • waste (quantity, type of depositing, incineration) • significant quantities of spilled chemicals, oils and fuels • acceptance of return of used products • fines and sanctions for non-compliance with applicable international declarations, conventions and treaties, as well as with national, regional and local regulations relating to environmental issues
3. **BASF** Corporate Report 2003	• sales (total and per - division) • net income • earnings per share • cash flow	• emissions of greenhouse gases (1000metric tons) • reduction of greenhouse gas emissions • emissions to water • reduction of emissions to water
4. **Beiersdorf** Sustainability Report 2003 No figures in report—online links	• sales • net income • earnings per share • investment R&D	• energy consumption (GWh) • water consumption • wastewater
5. **BMW** Sustainability Report 2003/04	• revenue • capital expenditure • cash flow • net profit • total no. of vehicles produced • vehicle deliveries to customers	• energy consumption in GWh and GWh/unit produced • emissions of greenhouse gases (tons and tons/unit) • water consumption (m3 and m3/unit) • wastewater (m3 and m3/unit) • waste (tons and kg/unit)
6. **Boehringer Ingelheim Pharma KG** ESH 2000	• sales • expenditure on EHS	• energy consumption total • emissions of greenhouse gases (1000 tons) • water consumption (mill m3) • wastewater (tons) • waste (tons) • % of waste recycling

_Table 2.5.. (cont'd.)

Company	Economic sustainability metrics	Environmental sustainability Metrics
7. **Daimler Chrysler** CSR Report 2004 No figures in report—online links	• sales • net income • R&D investment	• total spending environmental protection • energy consumption (GWh) • CO_2 emissions (tons) • water consumption (mill m3) • wastewater (mill m3) • waste (tons)
8. **Deutsche Bank** CSR Report 2003	• net revenue • income taxes • earnings per share • total spending for culture and society	• energy consumption (GWh) • CO_2 emissions (tons) • water consumption (m3) • paper (tons) • waste (tons and kg/unit) • business travel (CO_2 emission)
9. **Deutsche Post** Environmental Report 2003 Figures supported by online links	• total revenue • net income • cash flow • earnings per share	• energy consumption (GWh) • CO_2 emissions (tons) • water consumption (tons) • additional input/output balance
10. **Deutsche Telekom** HR and Sustainability Report 2004	• earnings before interest, tax, amortization and depreciation • operating free cash flow • net income • net revenue • no. of sustainability indices/funds in German speaking countries in which shares are listed	• energy consumption (GWh) • CO_2 emissions (relative to energy consumption) • water (% recycled) • wastewater (mill m3) • paper (1000 tons) • annual Fleet Service CO_2 emissions relative to mileage • percentage of waste recycled
11. **EON-Ruhrgas** Environmental Report 2004	• sales • profit after tax • subscribed capital	• energy consumption in GWh • emissions of greenhouse gases (tons) • waste (tons)
12. **Henkel** Sustainability Report 2003	• sales (total and per division) • operating profit • production volumes	• energy consumption in 1000mWh as % of production volume • emissions of greenhouse gases (1000metric tons) and % of production volume • dust emissions (metric tons) and % of production volume • emissions of volatile organic compounds in metric tone and % of production volume • water consumption and volume of wastewater • COD and heavy metal emissions to water • waste for recycling and disposal in 1000metric tons • complaints from neighbors

Table 2.5. (cont'd.)

Company		Economic sustainability metrics	Environmental sustainabilitymetrics
13.	**Lufthansa** Environmental Magazine 2003	• total income • net income • cash flow	• energy consumption (fuel tons) • CO_2 emissions (tons) • water consumption (m3) • wastewater (m3) • waste (tons) • plus a number of air transport specific indicators concerning noise levels and emissions
14.	**Munich Re** Environmental Report 2003	• net income • earnings per share	• energy consumption (GWh) • CO_2 emissions (tons & kg/E) • water consumption (m3 & l/E) • wastewater (m3) • waste (tons) • recycling (tons) • paper (kg) • business travel (km/E/Y) • additional input/output balance
15.	**Robert Bosch AG** Environmental Report 2003/2004	• sales • net income • R&D investment	• energy consumption (GWh) • CO_2 emissions (in 1000 m3) • water consumption (mill m3) • wastewater (mill m3) • waste (mill tons3) • environmental protection costs and investment • additional input/output balance
16.	**RWE** Corporate Responsibility Report 2003	• revenue • net income	• CO_2 emissions (in 1000 m3) • water consumption (1000 m3) • waste (1000 t) • paper and glass recycled • expenditure for environmental protection (mill €)
17.	**Schering** Environmental Report 2003	• sales • investment R&D • earnings per share • cash flow	• energy consumption (GWh) • CO_2 emissions (tons) • water consumption (mill m3) and Wastewater (t COD burdens) • waste (tons) • environmental protection spending • input/output • transport modes (ship, airplane, truck/car)
18.	**Siemens** Corporate Responsibility Report 2003	• sales • net income • earnings per share • investment R&D total and % of sales • personnel costs (wages, salaries, social welfare contributions, pension plan expenses, employee benefits)	• energy consumption (GWh) • CO_2 emissions (tons) • water consumption (mill m3 & l/E) • wastewater (mill m3) • waste (tons & t/E) • business travel (total km) • environmental protection spending (total and €/Employee)

Table 2.5. (cont'd.)

Company		Economic sustainability metrics	Environmental sustainability metrics
19.	**Thyssen-Krupp** No CSR Reports From website	• sales • net income • ROC after tax • Earnings per share	
20.	**Volkswagen** Environmental Report 2003/2004	• sales revenue • operating profit • appropriation of funds to shareholders (dividends), to employees (wages, benefits), to the state (taxes, levies), to creditors (interest) and to the company (reserves)	• energy consumption (mill GWh) • CO_2 emissions (tons) • water consumption (mill m3) • wastewater (mill m3) • industrial and hazardous waste (tons) • environmental protection spending (mill €) • recycling (tons)

2.3. The relationship between innovativeness and financial performance

Successful financial performance has the impact of "innovation" embedded in it. The outputs of innovation are integral part of the market performance of companies, thus their financial performance. Innovation is the most critical business driver for the competitive advantage for firms, and with quality as main contributor to business success (Schumpeter et al., 1983; Buzzell and Gale, 1987; Garvin, 1988; Nonaka, 1991; Han et al., 1998; McGovern et al., 2004). The limitation though is that the case studies and anecdotal examples have not been complemented with a large-scale data analysis; thus, the exact nature of the relationship between innovativeness, quality, and firm performance is not clear and generalizable yet. Currently, in the literature, there is no single, generally accepted definition of what "innovativeness" is, and furthermore how it can be measured. Thus, addressing of integration with financial performance and environmental performance is not available yet. The direct and secondary links and interactions between being innovative and successful environmental performers, for firms, have not been studied, yet to date.

A brief summary of the literature addressing the relationship between "innovativeness" and financial performance is presented and the "green innovativeness" perspective is also introduced as little as it exists in the scholarly work, less than a year old.

For this research , innovativeness is specifically addressed from the perspective of The Theory of Resource-based View of the firm (RBV). RBV is briefly introduced and its implications on the firm's knowledge when it comes to assessing its innovations and innovativeness are discussed in the following section.

2.3.1. Resource-based view of the firm (RBV)

Penrose (1959) and Wernerfelt (1984) are the main building blocks of the theory of the Resource-Based View of the firm. Penrose in her book: the Theory of the Growth of the Firm, argues that although markets set price signals that influence resource allocation, those within the firm make decisions on what activities the firm is involved in, how those activities is performed, what resources are required, which resources are allocated to different activities and, ultimately, which resources are used. As a consequence, internal processes and insights rather than external market prices and cost signals will greatly influence a firm's growth. However, decisions about internal processes are burdened with a considerable degree of uncertainty since decision makers often do not have full information upon which to act. What makes the contribution of Penrose (1959) important is that, she endeavored to consider what goes on inside a firm, something not traditionally accounted for by mainstream economists (Nelson, 1991; Sautet, 2000). TI also contributes to the foundations for what is now called the Resource-Based View of the firm, one of a number of theories of the firm (Sautet, 2000;Wernerfelt, 1984).

According to the RBV, the sustainable competitive advantage results from the inimitability, rarity, and non-tradability of intangible resources (Barney, 1991, 1997; Grant, 1991; Penrose, 1959; Peteraf, 1993). The key message of these studies is that: "A firm should possess certain intangible resources that competitors cannot copy or buy easily. Thus, the firm possessing intangible resources can gain competitive advantage in the market", which is also quite in line with the Blue Ocean Strategy of Kim and Maubourgne in 2005. Hall, 1992; Penrose, 1959; Wernerfelt, 1984 list examples of resources a firm could possess. For example, Wernerfelt (1984) lists brand names, in-house knowledge of technology, employment of skilled personnel, trade contracts, machinery, efficient procedures, and capital. Hall (1992), considering intangible resources as the firm's competencies, listed the culture of the organization and the know-how of employees, suppliers, and distributors as resources. Cho & Pucik (2005), define the firm's intangible resource as its capability of being innovative and at the same time delivering high-quality products or services to customers.

Central to Penrose's seminal paper in 1959, and therefore to the Resource-Based View of the firm, are decisions about the acquisition and use of resources. But what exactly are resources? Resources are generally categorized as tangible assets (or resources) and intangible assets (or resources). Examples of tangible assets include financial resources, types of capital equipment, land and buildings, location and the qualification profile of employees. Intangible assets are more difficult to describe. One typology of intangible assets is presented by Hall (1993) and used by Fernandez et al. (2000). Here, intangible assets are either people dependent (e.g. human capital) or people independent and include organizational capital (e.g. culture, norms, routines and databases), technical capital (e.g. patents) and relational capital (e.g. reputation, brands, customer and employee loyalty, networks within the distribution channel, the ability of managers to work together, relationships between buyers and sellers, etc.). Moving from the Penrose's definition of tangible and intangible assets and resources, this research for the Green Index, uses the tangible outcomes of the firm for the three performance dimensions.

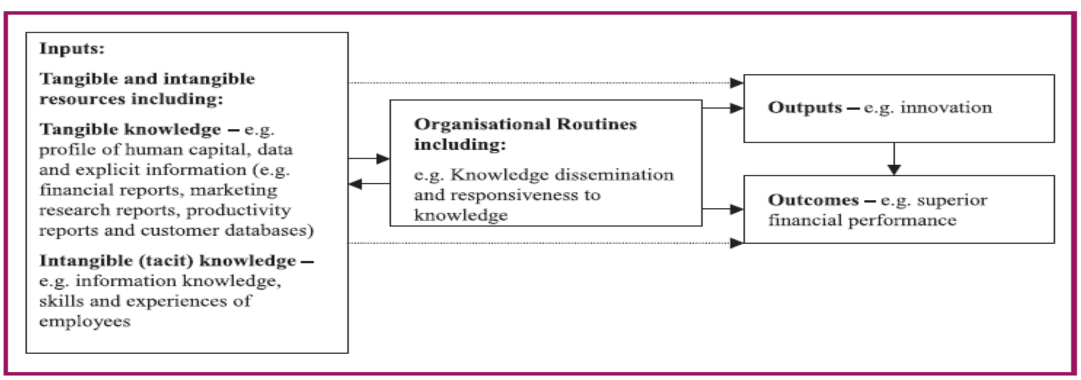
This categorization has been widely accepted in the extant literature. Moreover, explicit information such as databases, market research reports, financial data and reports and patents are best categorized as tangible assets since, theoretically, they can be bought or sold. For the definition of green innovativeness and financial performance dimensions, and the output indicators for each, the Green Index research builds on the use of such tangible outputs as well. Darrock 2005 suggests that the term intangible assets be reserved for assets that have a significant tacit knowledge component, such as organizational culture, relationships with suppliers and customers and the experience and intellectual capital of employees. She suggests that this reclassification then enables intangible assets to more rightly lay claim to being difficult to measure and concludes that by contrast, tangible assets are generally easier to measure and manage (Darroch, 2005).

Penrose's definition of resources is as follows on the following page:

"Strictly speaking, it is never the resources themselves that are the "inputs" into the production process, but only the services that the resources can render. The services yielded by resources are a function of the way in which they are used – exactly the same resources when used for different purposes or in different ways and in a combination with different types or amounts of other resources provides a different service or set of services." (Penrose 1959, p. 25).

Darroch 2005, argues that effective knowledge management, a capability in its own right, is also critical to the long run survival of the firm because it underpins the development of other capabilities. Thus Penrose (1959) while providing theoretical foundations from which the Resource-Based View of the firm was spawned, also provides an important contribution to the new discipline of knowledge management. The chart by Darroch 2005, is given in Figure 2.4. and it is representative of the inner mechanism for the flow of inputs, through organizational routines and how innovations as outputs and superior financial performance as outcomes are expressed.

Figure 2.4. The Knowledge flow mechanism within the firm: from inputs thru organizational routines, to outputs and outcomes (Darroch, 2005).



This flow chart with its indication of outputs and outcomes also support the metrics that are proposed for the performance dimensions of this research . According to this flow chart, the main outputs of a firm are its innovations while financial performance is an outcome not necessarily only a reflection of innovation but also of the organizational routines, for which there are diverse "intangible" resources and routines involved uniquely by each firm. This research focuses on the outputs of environmental performance, those of green innovativeness as an extension of innovativeness, and those of financial performance for their integration for development of the Green Index, and that is presented in detail in the section on the research model and design.

2.3.2. Innovation

Drucker (1993) defines innovation as "An application of knowledge to produce new knowledge". According to Edwards and Gordon (1984), innovation is a process that begins with an idea, proceeds with the development of an invention, and results in the introduction of a new product, process or service to the marketplace. In the original Booz Allen Hamilton (1982) typology of innovation, innovations are categorized as new to the world, new products to the firm, additions to existing product lines, improvements or revisions to existing product lines, cost reductions to existing products, or repositioning of existing products. New to the world innovations are typically characterized as radical innovations while the other categories are incremental innovations.

Innovation is thought to provide organizations with a means of creating a sustainable (maintainable) competitive advantage that is imperative in today's turbulent environment. Innovation is positioned as a driver of economic growth. Different scholars state that innovation is a mechanism by which organizations can draw upon core competencies and transition these into performance outcomes critical for success (Reed and DeFillippi 1991; Barney 1991).

Morris (2008), states that "The method of innovation is to develop ideas, refine them into a useful form, and bring them to fruition in the market where they will hopefully achieve profitable sales or in the operation of the business where they will achieve increased efficiencies. Even though different scholars give different definitions for innovation, the core of innovation is creating something that did not previously exist and taking it all the way to commercialization. Innovation definitely creates business value. The value manifests itself in different forms, e.g. there could be value from radical innovation leading to entirely new products, as well as from incremental innovation leading to improvement in existing products. Moreover, Gupta 2007, argues that sustainable and profitable growth in a company requires "sustainable" innovation activities. History has proven that only companies that innovate will survive and companies that do not innovate will hardly make it, let alone to compete in the rapidly changing market (Morris, 2008).

Innovative activity, on the other hand, which can be initiated by individuals or organizations, reflects a firm's entrepreneurial orientation (Lumpkin and Dess, 1996; Naman and Slevin, 1993). According to Miller (1983), an entrepreneurial firm is one that engages in product-market innovation, undertakes somewhat risky ventures, and is first to come up with proactive innovations, beating competitors to the punch. Entrepreneurship research has also been defined as the scholarly examination of how, by whom, and with what effects opportunities to create future goods and services are discovered, evaluated, and consequently exploited. (Shane and Venkataraman, 2000).The literature is quite rich with studies that illustrate the importance of knowledge, innovation, and creativity for superior firm performance.

Their importance for the survival and success of organizations is widely accepted among organizational researchers (Damanpour, 1996; Wolfe, 1994) and building on them for example Gopalakrishnan and Damanpour, (1997) developed theories on innovation. Most organizational innovation researchers, however, have agreed that understanding innovative behavior in organizations has remained relatively undeveloped, inconclusive, and inconsistent (Fiol, 1996; Gopalakrishnan and Damanpour, 1997; Wolfe, 1994). A reason for inconclusive and inconsistent findings in the literature is addressed by the fact that there exist different definitions of innovation or innovativeness across disciplines (Cho & Pucik, 2005). Having cited Cho & Pucik, 2005, Bloch 2005 defines four types of innovation as:

i. Product Innovation: Introduction of new or improved goods or services in terms of technical specifications, user friendliness, components, materials, or other functional characteristics.
ii. Process Innovation: Introduction of new processes which consist of significant improvement in techniques, equipment, etc.

iii. Marketing Innovation: Introduction of new methods in marketing area such as those in the price, distribution channel, product promotion, product placement, etc.

iv. Organizational Innovation: Introduction of new organizational techniques on how work can be organized. The innovations take place in practices, workplace organization or relationship with external parties.

For the "green innovativeness" performance dimension of the proposed Green Index, the product innovation (i) from above is used.

Following the classification by Bloch 2005, Kingsland 2007, defines two types of innovation based on the degree of novelty as:

i. Incremental Innovations: Innovations that are usually small, easy to implement and not much risky, all with short timelines and are part of / related to several projects within the organization.

ii. Breakthrough (radical) Innovations: Innovations that are usually big in size, complicated to implement and involve high risk, all with long timelines and are part of / related to few projects within the organization. If successful, they will "disrupt" the market and provide high return on investment, result in high amount of growth.

While the importance of this domain has not gone unnoticed, there seems to be a lack of clarity and consensus on the drivers and performance implications of innovation. Furthermore, scholars have pointed out that past research in this arena has primarily been inconclusive, inconsistent, and lacking explanatory power (Wolfe, 1994). **Vincent et al (2008), claim that the major culprit of this lack of consistency and power is that there is no one theory of innovation present within the literature**. They argue that, no one set of antecedent variables has emerged that can differentiate between organizations that are successful innovators from those that struggle with innovation and conclude that it is difficult to build a strong theoretical understanding of the nature of this phenomenon.

2.3.2.1. Green innovation

Tseng et al. 2012, is the most recent study that clearly talks about green supply chain and how it affects the company's performance. This study states that improvements in firm's environmental performance and compliance with environmental regulations can contribute to a company's competitiveness. The implementation of green supply chain through internal and external environmental management contributes substantial benefits by enhancing firm's competitiveness and improving environmental performance. However, the limited understanding of environmental and no-environmental criteria have hampered the development of a widely accepted framework that would characterize and categorize firm's green innovation activities. There are a few recent studies in the literature for seeking the drivers of firm's green innovation (Lin et al., 2011; Tseng 2011; Ming-Lang Tseng et al., 2012), but not yet any that addresses the impact of "green innovativeness" on firm's overall financial performance. Firms must do their best in green innovation to strengthen their competitiveness due to the ever-changing green technology and short life cycle of products. Unfortunately, green innovation involves high uncertainty and risk and many resources are consumed in the process. Hence, understanding green innovation is feasible for firms to acquire the necessary techniques and assistance. (Ming-Lang Tseng et al., 2012).

Sharma (2002) and Wu(2009) argue that the different environmental strategies or practices are found to be associated with managerial interpretations which can be seen as threats or as opportunities for tackling various environmental issues. Hamel (2006) argues that in today's management, innovation may represent one of the most important and sustainable sources of competitive advantage for firms due to its context specific nature among others. Eiadat et al. (2008) discusses that the innovative environmental strategies is partly explained by managerial environmental concern.

Building up on this point of view, firms have been implementing proactive environmental strategies and practices by using management initiatives for mitigating the impact of firms innovation activities on the environment (Melnyk et al., 2003; Tseng, 2010; Lin et al., 2011), yet there is none that specifically addresses the impact of green innovations, nor that of green innovativeness on the environment.

Among the limited number of studies that exists in the literature; Klassen and Whybark (1999), talks about application of environmentally friendly equipment and technologies, whereas Klassen and Vachon (2003), Buysse and Verbeke (2003) discusses the investment on environmental protection measures in focal electronic manufacturing firms. Tseng et al., (2009), Yung et al., (2011) discuss that well-designed environmental standards can increase manufacturer's initiatives to innovate green products and technologies to differentiate their products and lower the cost of production through products and process innovations where necessary. However, again, none of these studies look at the importance of green innovations in the large pool of innovations by themselves, nor the impact of such green products and green process on the overall firm financial performance. The current state of scholarly knowledge in understanding the dynamics of green innovativeness within the context of firm performance is not clear in definition yet.

Ming-Lang Tseng et al. (2012), classifies green innovation into four main categories:

(1) Green managerial innovation
(2) Green product innovation
(3) Green process innovation
(4) Green technological innovation.

The only study that singles out in addressing the impact of <u>(2) Green product innovation</u> and <u>(3) Green process innovation</u> is Chen et al. (2006), which presents that both of these innovations are positively associated with firm's competitive advantage.

Chen (2008) introduces the concept of "green core competencies" as the collective learning and capabilities about green innovation. The study states that environmental management has a positive influence on firm's ability to develop green product and process innovations.

Chio et al. (2011) presents an empirical verification that encourages firms to implement green supply chain and green innovation in order to improve their environmental performance and to enhance their competitive advantage in the market. The studies: Chen et al. (2006), Chen (2008), Chio et al. (2011) present green innovation specifically on environmental performance as drivers in the manufacturing firms and supply chain.

Ming-Lang Tseng et al. (2012), specifically emphasizes that this evaluation requires identification of appropriate measures in order to complete robust study and to advance the body of knowledge in the field both academically and practically. Malhotra and Grover (1998), and Lee et al. (2003) argue that, academically, greater attention needs to be put on:

(1) Employing multi-criteria,
(2) Assessing the criteria for content validity, and purifying them through extensive literature reviews to effectively and empirically advance theory within this field.

Practically, firms can benefit from the development of reliable and valid aspects and criteria to practices through case firms (Tseng et al. 2012).

(Tseng et al. 2012) talk about the weighing of priorities and aspects for green innovation: " The practitioners apply several criteria for benchmarking and continuous improvement when seeking to harmonize environmental and innovation goals. The top managers may keep multiple aspects and criteria for forging green innovation but different priorities in mind, thus positioning the weighting on aspects and criteria also reveals the priority of the resources distribution. This implies that the priority of aspects and criteria and the relative weights set for the aspects and criteria interact with each other." In this study, they apply multi-criteria decision making (MCDM) in considering expert opinion regarding environmental concerns. They evaluate the ability of different drivers forcing electronic manufacturing firms to adopt green innovation practices to address two specific study questions:

(1) What are the key drivers of green innovation practices?
(2) What role do suppliers play in the adoption of green innovation practices?

With the fuzzy logic modeling deployed, the study defines four aspects with twenty-two criteria to address the Green Innovation within the company. The four aspects are defined as:

(1) Management Innovation
(2) Process Innovation
(3) Product Innovation
(4) Technological Innovation

These four aspects and twenty-two criteria are presented in Table 7., on the following page. The criteria that are of relevance to the proposed Green Index, are highlighted as the gray cells and are specifically touched upon in the detailed breakdown of the four aspects, as follows.

Among the criteria related to Management Innovation: (C3) Reduction of hazardous waste, emission, etc., (C4) Less consumption of e.g. water, electricity, gas and petrol, (C5) Install environmental management system and ISO 14000 series, are found of relevance for this research . Specifically, (C3) and (C4) contribute in defining Green Index as for indicators of environmental performance for this research .

Among the criteria related to Process Innovation: (C7) Low energy consumption such as water, electricity, gas and petrol during production/use/disposal, are found of relevance and contribution in defining Green Index for this research . Even though criterion (C7) is listed under Process Innovation in Tseng et al. 2012, given their study is in the scope of supply chain management, the measurements themselves are output indicators of energy consumption. In this context (C7) is found of relevance and contribution in defining Green Index as for indicators of environmental performance for this research.

Among the criteria related to Product Innovation: (C13) Degree of new green product competitiveness understand customer needs, (C14) Evaluations of technical, economic and commercial feasibility of green products, (C16) Using eco-labeling, environment management system and ISO 14000, are found of relevance for this research . Specifically, (C13) and (C14) contribute in defining Green Index as for indicators of green innovativeness performance for this research.

Among the criteria related to Technological Innovation: (C18) Investment in green equipment and technology, (C22) Advanced green production technology, are found of relevance to defining Green Index. (C22) Advanced green production technology contributes in defining Green Index as for an indicator of green innovativeness performance for this research .

Table 2.6. Aspects for green innovation and criteria (Tseng et al. 2012)

Aspects	Criteria	
Management Innovation (AS1)	C1	Redefine operation and production processes to ensure internal efficiency that can help to implement green supply chain management
	C2	Re-designig and improving product or service to obtain new environmental criteri or directives
	C3	Reduction of hazardous waste, emission, etc.
	C4	Less consumption of e.g. water, electricity, gas and petrol
	C5	Install environmental management system and ISO 14000 series
	C6	Providng environmental awareness seminars and training for stakeholders
Process Innovation	C7	Low energy consumption such as water, electricity, gas and petrol during production/use/disposal
	C8	Recycle, reuse and remanufature material
	C9	Use of cleaner technology to make savings and prevent pollution (such as energy, water, waste)
	C10	Sending in-house audiotr to appraise environmental performance of supplier
	C11	Process design and innovation and enhance R&D functions
	C12	Low cost green provider: unit cost versus competitors' unit cost
Product Innovation	C13	Degree of new green product competitiveness understand customer needs
	C14	Evaluations of technical, economic and commercial feasibility of green products
	C15	Recovery of company's end-of-life products and recycling
	C16	Using eco-labeling, environment management system and ISO 14000
	C17	Innovation of green products and design measures
Technological Innovation	C18	Investment in green equiopment and technology
	C19	Implementation of comprehensive material saving plan
	C20	Supervision system and technology transfer
	C21	Advanced green production technology
	C22	Management of documentation and information

The recent literature shows current interest and newly developing analytical approaches in addressing the Green Innovations aspects in managing a company's green innovativeness. The new criteria identified are used in developing the proposed indicators for green innovativeness performance dimension of the Green Index.

2.3.3. Innovation for financial performance

In this research , innovativeness is treated as a strategic tool and indicator —a firm-level behavior that is an "output" of firm and industry-level characteristics as well as a determinant of firm performance and literature search is conducted within this context. Hence, this approach integrates mainly the elements of industry structure and resource-based theory.

The industrial organization (IO) perspective of strategic management (Bain, 1956; Harrigan, 1981) emphasizes the importance of context while the resource-based view (RBV) (Barney, 1991; Rumelt, 1984; Wernerfelt, 1984) places central importance within the firm. In the latter view, competitive advantage is a function of the resources a firm has at its disposal and the capabilities it has to deploy its strategic assets (Amit and Schoemaker, 1993). Knowledge is a valuable, rare, difficult to imitate and organization-specific resource (Barney, 1991; Kogut and Zander, 1996; Spender, 1996).

Innovation is a critical one source of competitive advantage for a firm. A positive relationship between innovation and performance is established in the literature (Avlonitis and Gounaris, 1999; Atuahene-Gima, 1996; Capon et al., 1992; Deshpande´ et al., 1993; Han et al., 1998; Li and Calantone, 1998; Manu and Sriram, 1996; Mavondo, 1999; Va´zquez et al., 2001).

Innovators are, by definition, first movers. Significant theoretical and empirical work has gone into the study of first movers, fast followers and late followers (Lieberman and Montgomery, 1988). Competitive advantage may flow from first mover status if supporting assets are, or soon become, available or if experience leads to learning that presents barriers to followers (Lieberman and Montgomery, 1988; Tushman and Anderson, 1986). Innovation may be viewed as successful to the extent that it leads to a competitive advantage and consequent superior profitability (Roberts, 1999; Roberts and Amit, 2003).

Innovation is a key element of entrepreneurial style or posture and numerous studies have linked entrepreneurial style to performance (e.g., Covin et al., 2000; Naman and Slevin, 1993; Miller, 1983; Zahra and Covin, 1995). Although the rates of innovation may be greater in dynamic environments, innovative firms frequently perform well wherever they are found. Innovative firms are likely to enjoy revenue growth, irrespective of the industry in which they operate and also firm knowledge, industry dynamism and innovation interact in the way they influence firm performance (Thornhill, 2005).

Firms must be innovative if they are to maintain the pace of change, much less get ahead of the curve (Brown and Eisenhardt, 1997). Firms that confront uncertainty where it exists, via innovation, typically outperform those that ignore its presence (Garg et al., 2003). Challenging competitive conditions may compel new ventures to become innovative and have entrepreneurial (Miller, 1983; Zahra, 1993; Zahra and Covin, 1995) behaviors which can subsequently lead to growth and profitability (Wiklund, 1998; Zahra and Neubaum, 1998).
The industry's level of differentiation may also affect firm performance, as competition in a highly-differentiated industry is unlikely to be price-based and, thus, is likely to be profitable for all concerned (Porter, 1980, 1996). Some industries, however, lend themselves to higher levels of differentiation than others, and there is evidence that industry level factors, such as

overall levels of differentiation, impact performance (McGahan and Porter, 1997). Also it is verified that firms do better in industries in which companies allocate more resources to differentiation activities (McWilliams and Siegel, 2000), thus it can be expected that industry differentiation, innovations shall impact firm performance. Despite the theoretical seminal works of Porter, Thornhill (2005) verifies a slight contradictory finding that innovative firms are likely to enjoy revenue growth, irrespective of the industry in which they operate and also firm knowledge, industry dynamism and innovation interact in the way they influence firm performance (Thornhill, 2005).

Furthermore, another study by Darroch in 2005 from a sample of New Zealand firms of 50 or more employees does not verify a positive directional relationship between innovation and performance, and this result contradicts research reported in the area as well. Darroch, hypothesizes that a possible reason for the apparent contradiction with the extant literature is that other innovation-performance studies reported earlier did not consider categories of innovation but instead, considered the general characteristics of the innovating firm (e.g. Atuahene-Gima, 1996; Capon et al., 1992; Manu and Sriram, 1996; Mavondo, 1999, Va´zquez et al., 2001), the number of innovations (e.g. Han et al., 1998; Va´zquez et al., 2001) or the advantages of the new product (e.g. Li and Calantone, 1998). Thus, direct comparisons are less relevant given the different operationalization of constructs. However, in spite of the contradicting results reported here (Veryzer, 1998) says that “Without innovation, firms risk losing their competitive position by falling behind”.

Innovation is hypothesized as one possible mechanism by which organizations can gain a competitive advantage in the marketplace through unique organizational resources (Barney 1991).

Product innovation is defined as a source of competitive advantage to the innovator and at the same time that it can lead to a sustainable increase in firm profits (Geroski, Machin and VanReenen 1993; Chandy and Tellis 1998). Research also supports the argument that innovation serves as a key mediator between antecedents of innovation and performance (Conner 1991; Damanpour and Evan 1984; Han et al 1998). In particular, innovation mediates the relationship between environmental uncertainty and performance. Firms faced with intense competition and turbulent environments often rely upon innovation as the primary driver of organizational performance (Gronhaug and Kaufman 1988). Innovation provides organizations with a means of adapting to the changing environment and often is critical for firm survival. The relationship between organization level variables and performance are also mediated by innovation. Organization structure provides the internal configuration, including communication and resource flows, necessary for innovation to occur (Russell, 1990). Organizational capabilities provide organizations with the inputs required for innovation that in turn can provide the organization with superior performance (Eisenhardt and Martin, 2000).

2.3.4. Comprehensive literature assessment for the overall innovation and financial performance

An important research report that was found is the publication by Vincent et al. in 2005. In this report, the limitations and the "Pandora's box" of innovation dynamics (product & organization) and interactions between innovation & performance are assessed within their comprehensive research of the field.

The study focuses on the 23 years of innovation research from 1980 to 2003 and delivers in depth objective understanding of the innovation field from economic, strategy and marketing literatures. In this study they cover only the studies that actually measure innovation and its impacts.

The study sample was overall, eighty-three empirical studies which measured organizational innovation. The sample set was analyzed in this analysis and one hundred and thirty-four independent samples were coded for the analysis. The average sample size ranged from a high of 40,808 to a low of 16 with a mean of 917.49 and standard deviation of 3,895.75. The sample size for the meta-analysis across all studies was 122,943 observations. Sixty-five studies examined innovation in a manufacturing context and forty-three in service industries. Twenty-six studies aggregated innovation scores across multiple industries for the analysis. Ninety-five of the studies were cross sectional in nature while only thirty-nine utilized a longitudinal research design.

The summary of the characteristics of this sample set is as follows:

1. Seventy-one studies used a frequency count of innovation as the measure for innovation
2. Thirty studies used a binary (1/0) adopt versus nonadopt measure of innovation.
3. Six studies used R&D intensity to represent organizational innovation
4. Eleven studies operationalized innovation as a series of steps taken by organizations to promote innovation.
5. Sixteen studies that used a scale of radicalness, or newness of the innovation, as the measure of organizational innovation
6. The dual core typology was also examined in several studies with seventeen examining administrative innovations
7. Twelve studies focusing on technical innovations (Daft 1978).

Vincent et al's comprehensive detailed study provides several facts from the two perspectives for innovation as a moderator and as a mediator as follows:

Innovation as a moderator:

1. The antecedents / inputs of innovation can be broadly grouped into Environmental, Organizational Capabilities, Organizational Demographics, and Organizational Structural variables (Russell, 1990)
2. The consequences, or outcomes of innovation, have been categorized into three distinct types:

    1. Financial performance,
    2. Efficiency gains,
    3. Self-report subjective measures of innovation performance

3. Competition and environmental turbulence have a relatively small impact on innovation. Additionally, a union influence is negatively related to innovation, while the urbanization surrounding a company promotes innovation.
4. Organizational capabilities act as the drivers of innovation. Overall results suggest that an organization's past innovation has the strongest relationship with innovation. Furthermore, an organization's communication, customer and competitor orientation, network ties, and resource levels are all positively related to innovation. Managerial openness to change is positively correlated with innovation, as well as the presence of an innovation champion and team communication.
5. The results of the overall analysis suggest that both organizational age and size are positively related to innovation. In addition individual antecedents also impact organizational innovation. Management education level and professionalism are positively correlated with innovation.
6. The link between innovation and performance is well established in the literature (Han et al. 1998). The overall analysis supports this expectation. Results suggest that innovation is positively related to all of the performance outcomes in this analysis and has the strongest relationship with efficiency gains in an organization and the weakest relationship with financial performance.

Innovation as a mediator:

Innovation is not a key mediator for all environmental and organizational antecedents included in the model, but does play a significant role in financial performance.

1. Competition, age, and resource level have both a direct and indirect (through innovation) relationship with performance.
2. Innovation is a partial mediator but it cannot be concluded that product innovation is the only mechanism through which superior financial performance is achieved.
3. There is strong support for the role of innovation as a mediator for turbulence, age, diversification and size with that of performance. Marginal support is found for the role of innovation as a mediator in the competition-performance and resource-performance relationships.

Innovation plays a role in organizational performance and serves as a link between certain antecedents and financial performance, thereby supporting the partial mediation model and the resource-based view of the firm.

The impact of innovation on firm performance is well addressed in the literature. However, when it comes to innovativeness and what is called an innovation of quality and value, what makes a company more innovative than its competitors. There are no clear answers yet when it comes to the integration of innovativeness to environmental sustainability of the firm and how companies integrate being innovative while at the same time performing well environmentally and financially. It has not been addressed in the literature yet. The Resource Based View of the firm provides an important theoretical grounding in the management literature for addressing the importance of resources for such an integration of the three performance dimensions. The assessment of the performance indicators of innovativeness, as well as environmental performance and financial performance, as a problem of effective management of internal resources of the firm, finds strong theoretical foundation to build an integration model anew. Innovativess is the main value added a firm delivers to its customers and to the markets in general, and if that and its integration to environmental performance concerns can be addressed clearly for firms in environmental performance transition stages, the firms' overall performance would benefit from such contribution.

2.3.5. Summary of the literature review

2.3.5.1. Environmental performance and financial performance

The studies addressing the relationship between environmental performance and financial performance are summarized in Table 2.7. on page 63.

2.3.5.2. Green innovativeness and financial performance

The studies addressing the relationship between green innovativeness performance and financial performance are summarized in Table 2.8. on page 64.

2.3.5.3. Green innovativeness and environmental performance

No studies have been identified in the literature addressing the relationship between green innovativeness and environmental performance.

2.4. Research Gap

There are various statistical approaches and numerous indicators used in research studies to address the relationships between environmental performance and financial performance and between innovativeness and financial performance of the firms. Very few of these studies refer to green innovativeness. There is no research that addresses the integration of the three performance dimensions: environmental performance, green innovativeness and financial performance. This dissertation addresses this gap by referring to the expert judgments in determining the agreed upon indicators and sub-indicators and measuring their weights, to incorporate into a hierarchical decision model to obtain a “Green Index”. The research approach and methodology for this research is explained in Chapter 3.

Table 2.7. Summary of literature on environmental performance and financial performance

Topic	#	Study	Brief note on the study
Environmental and Financial performance	1	Russo and Fouts (1997)	Concludes a significant positive correlation between various financial returns and an index of environmental performance developed by the CEP
	2	Cohen et al. (1995)	Uses several measures of environmental performance derived from U.S. Environmental Protection Agency (U.S. EPA) databases to construct two industry-balanced portfolios of firms and they found no penalty for investing in the green portfolio and a positive return to green investing. Concludes a positive relationship between pollution reduction and financial gain by relying on correlative studies of environmental and financial performance.
	3	White (1996)	States that a significantly higher risk-adjusted return for a portfolio of green firms using the CEP ratings of environmental performance. Concludes a positive relationship between pollution reduction and financial gain by relying on correlative studies of environmental and financial performance.
	4	Dowell et al. (2000)	Reports that firms that adopt a single, stringent environmental standard worldwide have higher market valuation (Tobin's q) than firms that do not adopt such standards. Concludes a positive relationship between pollution reduction and financial gain by relying on correlative studies of environmental and financial performance.
	5	King & Lenox (2001)	Uses longitudinal data of 652 US firms, and empirical tools, to explore the publicly traded US manufacturing firms' corporate data from Standard & Poor's Compustat database and environmental performance data from US EPA's Toxic release Inventory (TRI) over 1987-1996 period, they use Tobin's q as for financial performance measure, where it measures the market valuation of a firm's relative to the replacement costs of tangible assets as cited in Lindberg and Ross (1981).
	6	Hart (1997)	Argues that discretionary improvements in environmental performance often provide financial benefit and proposes that excess returns, in other words profits above the industry average result from differences in the underlying environmental capabilities of firms. Managers may possess unique resources or capabilities that allow them to employ profitable environmental strategies that are difficult to imitate.
	7	Lanoie et al. (2007)	Reports that a better environmental performance can lead to Firstly, an increase in revenues through certain channels such as: (1) better access to certain markets, (2) the possibility to differentiate products, (3) the possibility to sell pollution-control technology. Secondly, cost reductions in the categories of: (1) regulatory costs, (2) cost of material energy and services, (3) cost of capital, (4) cost of labor. Lanoie et al., 2007, discusses that the expenses incurred to reduce pollution can sometimes be partly or completely compensated by gains elsewhere.
	8	Berman and Bui, 2001	Environmental Regulations (ERs) in most developed economies results in increased pollution control expenditures. In the US, pollution abatement investments increased by 137% over the 1979-1994 period. The estimated total annual abatement expenditure represents between 1.5% and 2.5% of the US GDP.
	9	Ambec and Barla (2006)	ERs is especially relevant for the energy sector for it includes several "pollution intensive" industries such as petroleum or power generation
	10	Lankoski (2006)	Shows the positive links between environmental and economic performance
	11 - 20	Jaggi and Freedman (1992) Walley and Whitehead (1994) Feldman et al. (1996) Hamilton (1995) Johnson (1995) Klassen and McLaughlin (1996) Morris (1997) Wagner and Wehrmeyer (2001)	Address the relationship between environmental performance and financial performance from several perspectives
	21	Wagner (2000)	States that there are many studies supporting the hypothesis that good environmental performance is not punished, or turned the other way around that bad performance does not pay off

Table 2.7. Cont.'d. Summary of literature on environmental performance and financial performance

Topic	#	Study	Brief note on the study
Environmental and Financial performance	22	Porter (1991) Porter and van der Linden (1995)	States that stringent, well-designed environmental regulations lead not only to social benefits but may very often also result in private benefits for regulated companies: "When faced with the prospect of higher abatement costs, firms will invest in innovation activities to find new ways to meet new regulatory requirements. The resulting new production process or new product specifications would reduce pollution and at the same time lower production costs, or increase product market value. These benefits will very often offset and even exceed the costs initially imposed by regulations."
	23	Khanna et al. (1998)	In this study on 91 US chemical firms over 1989 – 1994 period, shows that there are negative abnormal returns during one-day period following disclosure, abnormal losses are higher for firms that do not reduce emissions or whose performance worsens compared to other firms and abnormal losses push firms to increase wastes transferred off-site. Concludes that the relationship between financial performance and environmental regulations is positive
	24	Dasgupta and Laplante (2001)	In this study of 126 events involving 48 publicly-traded firms in Argentina, Chile, the Philippines and Mexico, shows that 20 out of 39 positive events lead to positive abnormal returns (+20% in firm value over a 11 days window), 20 out of 39 positive events lead to positive abnormal returns (+20% in firm value over a 11 days window). Concludes that the relationship between financial performance and environmental regulations is positive
	25	Brannlund et al. (1995)	In this study on 41 Swedish pulp and paper mills from 1989 to 1990, shows that average reduction in profits due to regulation is between 4% and 17%. whilst on the other hand between 66% and 88% of mills are unaffected by regulation. Concludes that the relationship between financial performance and environmental regulations is negative.
	26	Filbeck and Gorman (2004)	In this study of 24 US electrical utilities over 1996-1998 period, shows that there is negative relationship between returns and environmental regulation compliance. Concludes that the relationship between financial performance and environmental regulations is negative
	27	Gupta and Goldar (2005)	In this study of 17 Indian pulp and paper plants, 15 auto firms and 18 chlor alkali firms over 1999-2001 period, show that there is a negative relationship between abnormal returns and environmental rating. Concludes that the relationship between financial performance and environmental regulations is negative.
	28	Spicer (1978)	Concludes a positive relationship between pollution reduction and financial gain by relying on correlative studies of environmental and financial performance.
	29 - 35	Nelson (1994) Panayotou and Zinnes (1994) Easty and Porter (1998) Reinhardt (1999) Denton (1994) Deutsch (1998) Graedel and Allenby (1995)	Argue that there are situations where beyond-compliance behavior by firms is a win-win for both the environment and the firm
	36	King(1995)	Argues that the environmental investments in the company are beneficial for the financial performance of the firm
	37	Hart (1997	Argues that discretionary improvements in environmental performance often provide financial benefit and proposes that excess returns. Profits above the industry average result from differences in the underlying environmental capabilities of firms.
	38 - 40	Klassen and McLaughlin (1996) Karpoff et al (1998) Jones & Rubin (1999)	Studies the effect of published reports of events and awards on firm valuation. found a relationship between the valence of the event (positive or negative) and the resulting change in market valuation.
	41	Muoghalu et al. (1990)	Found that firms named in lawsuits concerning improper disposal of hazardous waste suffered significant losses in capital market value. The events have environmental elements, but each is affected by other firm attributes.
	42	Blacconiere and Patten (1994)	Estimated that Union Carbide lost $1 billion in market capitalization, or 28%, following the Bhopal chemical accident in 1984. The events have environmental elements, but each is affected by other firm attributes.
	43	King and Baerwald (1998)	Argues hat size, market power, and unique firm characteristics influence how events are reported and interpreted a firm with good public relations may be able to put a positive spin on negative news.
	44	Szekely and Knirsh (2005)	The study conducted by Szekely and Knirsh (2005) on Responsible Leadership and Corporate Social Responsibility in which they explored the practices carried on by a group of 19 global corporations from a wide range of industries and gathered information on the metrics in deployment in those corporations when it comes to economic, environmental and social performance. These indicators are based on the main concept of Triple Bottom Line established by John Elkington. There are more than 30 indicators for environmental sustainability and more than 20 indicators for economic sustainability in use by the corporations. It is not possible to say that there is a clear consensus on which indicators are most suitable when it comes to understanding, tracking or even trying to manage environmental sustainability consistently across several organizations, industries, etc. One of the key takeaways of the following table is the diversity of the indicators and the variation in the attention of the companies that are operating in different industries.
	45	John Elkington (1998)	In 1998 John Elkingtom, chairman of SustainAbility, institutionalized the concept of the triple bottom line. According to him, business in the twenty-first century needs to focus on enhancing environmental quality and social equity just as it strives for profits. It must also put the same effort into this cause.

Table 2.8. Summary of literature on green innovativeness and financial performance

	Topic	#	Study
Green Innovativeness and Financial Performance	1 - 3	Buzzell and Gale (1987) Garvin (1988) Nonaka (1991)	States innovativeness and quality as main contributors to business success.
	4	Penrose (1959)	According to RBV, the sustainable competitive advantage results from the inimitability, rarity, and non-tradability of intangible resources.
	5	Wernerfelt (1984)	RBV delivers enhanced firm financial performance.
	6 - 9	Barney (1991) (1997) Grant (1991) Penrose (1959) Peteraf (1993)	A firm should possess certain intangible resources that competitors cannot copy or buy easily. Thus, the firm possessing intangible resources can gain competitive advantage in the market
	10	Wernerfelt (1984)	Lists brand names, in-house knowledge of technology, employment of skilled personnel, trade contracts, machinery, efficient procedures, and capital.
	11	Hall (1992)	Considering intangible resources as the firm's competencies, listed the culture of the organization and the know-how of employees, suppliers, and distributors as resources.
	12	Cho & Pucik (2005)	Defines the firm's intangible resource as its capability of being innovative and at the same time delivering high-quality products or services to customers.
	13	Fernandez et al. (2000)	Intangible assets are either people dependent (e.g. human capital) or people independent and include organizational capital (e.g. culture, norms, routines and databases), technical capital (e.g. patents) and relational capital (e.g. reputation, brands, customer and employee loyalty, networks within the distribution channel, the ability of managers to work together, relationships between buyers and sellers, etc.)
	14	Darrock (2005)	Suggests that the term intangible assets be reserved for assets that have a significant tacit knowledge component, such as organizational culture, relationships with suppliers and customers and the experience and intellectual capital of employees.The paper suggests that this reclassification then enables intangible assets to more rightly lay claim to being difficult to measure and therefore manage and concludes that by contrast, tangible assets are generally easier to measure and manage.
	15	Edwards and Gordon (1984)	Innovation is a process that begins with an idea, proceeds with the development of an invention, and results in the introduction of a new product, process or service to the marketplace.
	16	Booz Allen Hamilton (1982)	Brings a typology of innovation: innovations are categorized as new to the world, new products to the firm, additions to existing product lines, improvements or revisions to existing product lines, cost reductions to existing products, or repositioning of existing products. New to the world innovations are typically characterized as radical innovations while the other categories are incremental innovations.
	17-18	Reed and DeFillippi (1991) Barney (1991)	State that innovation is a mechanism by which organizations can draw upon core competencies and transition these into performance outcomes critical for success.
	19-20	Naman and Slevin (1993) Lumpkin and Dess (1996)	State that innovative activity, on the other hand, which can be initiated by individuals or organizations, reflects a firm's entrepreneurial orientation.
	19	Miller (1983)	States that an entrepreneurial firm is one that engages in product-market innovation, undertakes somewhat risky ventures, and is first to come up with proactive innovations, beating competitors to the punch
	20	Gopalakrishnan & Damanpour (1997) Wolfe (1994)	Understanding innovative behavior in organizations has relatively remained undeveloped, inconclusive, and inconsistent.
	21	Cho & Pucik (2005)	Suggests that a reason for inconclusive and inconsistent findings in the literature is addressed by the fact that there exists different definitions of innovation or innovativeness across disciplines.

Table 2.8. Cont.'d. Summary of literature on green innovativeness and financial performance

	Topic	#	Study
Green Innovativeness and Financial Performance	22	Wolfe (1994)	Points out that past researchon different definitions of innovation or innovativeness has primarily been inconclusive, inconsistent, and lacking explanatory power.
	23	Vincent et al. (2008)	Claims that the major reason of the lack of consistency and power in definitions of innovation and innovativeness across disciplines is that there is no one theory of innovation present within the literature.
	24	Barney (1991) Rumelt (1984) Wernerfelt (1984)	The resource-based view (RBV) places central importance within the firm.
	25	Amit and Schoemaker (1993)	Competitive advantage is a function of the resources a firm has at its disposal and the capabilities it has to deploy its strategic assets.
	26 - 34	Avlonitis and Gounaris (1999) Atuahene-Gima (1996) Capon et al. (1992) Deshpande´ et al. (1993) Han et al. (1998) Li and Calantone (1998) Manu and Sriram (1996) Mavondo (1999) Va´zquez et al. (2001)	Conclude a positive relationship between innovation and performance.
	35 - 36	Roberts (1999) Roberts and Amit (2003)	Innovation may be viewed as successful to the extent that it leads to a competitive advantage and consequent superior profitability.
	37 - 41	Covin et al. (2000) Naman and Slevin (1993) Miller (1983) Zahra and Covin (1995)	Innovation is a key element of entrepreneurial style or posture and numerous studies have linked entrepreneurial style to performance.
	42	Thornhill (2005)	Although the rates of innovation may be greater in dynamic environments, innovative firms frequently perform well wherever they are found. Innovative firms are likely to enjoy revenue growth, irrespective of the industry in which they operate and also firm knowledge, industry dynamism and innovation interact in the way they influence firm performance.
	43	Brown and Eisenhardt (1997)	Firms must be innovative if they are to maintain the pace of change, much less get ahead of the curve.
	44	Garg et al. (2003)	Firms that confront uncertainty where it exists, via innovation, typically outperform those that ignore its presence.
	45 - 47	Miller (1983) Zahra (1993) Zahra and Covin (1995)	Challenging competitive conditions may compel new ventures to become innovative and entrepreneurial.
	48 - 49	Wiklund (1998) Zahra and Neubaum (1998)	Becoming innovative and entrepreneurial can subsequently lead to growth and profitability.
	50	Tseng et al. (2012)	How green supply chain affects the company's performance. States that improvements in firm's environmental performance can contribute to firm's competitiveness. Aspects for green innovation and criteria are defined and listed.

Table 2.8. Cont.'d. Summary of literature on green innovativeness and financial performance

	Topic	#	Study
Green Innovativeness and Financial Performance	51	Ming-Lang Tseng et al. (2012)	An exploratory study that is seeking the drivers of firm's green innovation activities . It concludes that understanding green innovation is a feasible for firms to acquire the necessary techniques and assistance. Classifies green innovation into four main categories Specifically emphasizes that this evaluation requires identification of appropriate measures in order to complete robust study and to advance the body of knowledge in the field both academically and practically
	52 - 53	Lin et al., 2011 Tseng 2011	An exploratory study that is seeking the drivers of firm's green innovation
	54	Klassen and Whybark (1999	Application of environmentally friendly equipment and technologies
	55 - 56	Klassen and Vachon (2003) Buysse and Verbeke (2003)	Discuss the investment on environmental protection measures in focal electronic manufacturing firms.
	57 - 58	Tseng et al., (2009), Yung et al., (2011)	Discuss that well-designed environmental standards can increase manufacturer's initiatives to innovate green products and technologies to differentiate their products and lower the cost of production through products and process innovations where necessary
	59	Chen et al. (2006)	Addresses the impact of Green product innovation and Green process innovation and presents that both of these innovations are positively associated with firm's competitive advantage.
	60	Chen (2008)	Introduces the concept of "green core competencies" as the collective learning and capabilities about green innovation. The study states that environmental management has a positive influence on firm's ability to develop green product and process innovations.
	61	Chio et al. (2011)	Presents an empirical verification that encourages firms to implement green supply chain and green innovation in order to improve their environmental performance and to enhance their competitive advantage in the market.
	62 - 64	Chen et al. (2006) Chen (2008) Chio et al. (2011)	Present green innovation specifically on environmental performance as drivers in the manufacturing firms and supply chain.
	65 - 66	Malhotra and Grover (1998) Lee et al. (2003)	Argue that, academically, greater attention needs to be put on (1) Employing multi-criteria and (2) Assessing the criteria for content validity, and purifying them through extensive literature reviews to effectively and empirically advance theory within this field.
	67	Fiol (1996)	Understanding innovative behavior in organizations has relatively remained undeveloped, inconclusive, and inconsistent.

CHAPTER 3

Research Approach and Methodology

3.1. Research Objective, Goals and Questions

The objective of this dissertation is to integrate environmental performance, green innovativeness performance and financial performance into a combined index called the Green Index. Within this objective there are two sub-objectives:

(1) to identify and prioritize the core performance dimensions of environmental performance, green innovativeness and financial performance for a company

(2) to develop an integrated decision model and metrics measurement process to operationalize the deliverables of (1)

These objectives are met by addressing the 7 research goals and the corresponding research questions in the following pages.

Research Goal 1:

RG1: Validate and quantify the relative importance of the core performance dimensions (Environmental Performance, Green Innovativeness and Financial Performance) for the firm's Green Performance and develop a new combined performance measure called the Green Index as the outcome of this research.

Research Question:

R.Q.1 What is the relative importance of each of the performance dimensions (Financial Performance, Green Innovativeness and Financial Performance) for the Green Index?

Research Goal 2:

RG2: Validate and determine the relative importance of indicators and sub-indicators of Environmental Performance for Green Performance of the firm.

Research Questions:

RQ2.1: What are the indicators and measurable sub-indicators for Environmental Performance of the firm?

RQ2.2: What is the relative importance of each of the identified indicators and sub-indicators of Environmental Performance of the firm?

Research Goal 3:

RG3: Validate and determine the relative importance of indicators and measurable sub-indicators of Green Innovativeness Performance for Green Performance of the firm.

Research Questions:

RQ3.1: What are the indicators and measurable sub-indicators for Green Innovativeness Performance of the firm?

RQ3.2: What is the relative importance of each of the identified indicators and sub-indicators of Green Innovativeness Performance of the firm?

Research Goal 4:

RG4: Identify and determine the relative importance of indicators and measurable sub-indicators of Financial Performance for Green Performance of the firm.

Research Questions:

RQ4.1: What are the indicators and measurable sub-indicators for Financial Performance of a firm? (Medium & long term)

RQ4.2: What is the relative importance of each of the identified indicators and measurable sub-indicators of Financial Performance of the firm?

Research Goal 5:

RG5: Develop the Green Index that combines the performance dimensions, indicators and sub-indicators obtained by meeting the Research Goals 1 thru 4.

Research Goal 6:

RG6: Obtain the desirability levels for the performance metrics for each sub-indicator as defined by investors and integrate them to the Green Index.

Research Question:

RQ5: What are the relative desirability values of the various levels of the performance metrics for each sub-indicator of the firm toward Green Index?

Research Goal 7:

RG7: Development of seven scenarios that are representative of various company profiles with respect to 3 performance to demonstrate the Green Index model and assess the results.

3.2. Developing A New Perspective for The Green Index

In the literature there is a clear gap for the integration of environmental performance, green innovativeness and financial performance. Being innovative has been the challenge for the companies so as to sustain themselves as high performers. However, as the sustainability and environmental foot print requirements for companies become tighter over time, with the governmental regulations on the markets, revenue generation and continuous innovation has been becoming a major challenge for companies. The performance dimensions of Environmental Performance, Green Innovativeness and Financial Performance have not been integrated to date, in the literature nor in business practices. The methodological tools and research approaches do not address this integration in the research field nor in business practices. This dissertation delivers this integrated perspective with the development of the Green Index and provides a solution with its solid methodological approach. Green Index is introduced as a new measure for assessing the firm's performance by means of the three performance dimensions and their sub-indicators.

For this research a 4 level Hierarchical Decision Model (HDM) is developed toward the Green Index as follows:

Level 1: Green Index

Level 2: Performance Dimensions

Level 3: Indicators

Level 4: Sub-indicators

- The Performance Dimensions (Environmental Performance, Green Innovativeness and Financial Performance) at Level 2 contribute to the Green Index.
- The Indicators at Level 3 are the key components of each Performance Dimension.
- The Sub-indicators at Level 4 are the measurable metrics constituting each Indicator.

The HDM addresses the research objective, research goals and research questions in Section 3.1. It is generalizable to any company in any industry, but for the purpose of this research it has been demonstrated specifically for the semiconductor manufacturing companies.

The structure of the HDM is presented in Figures 3.1. thru 3.4. as follows on the following pages:

Figure 3.1. Graphical Representation of the HDM Model for Green Index

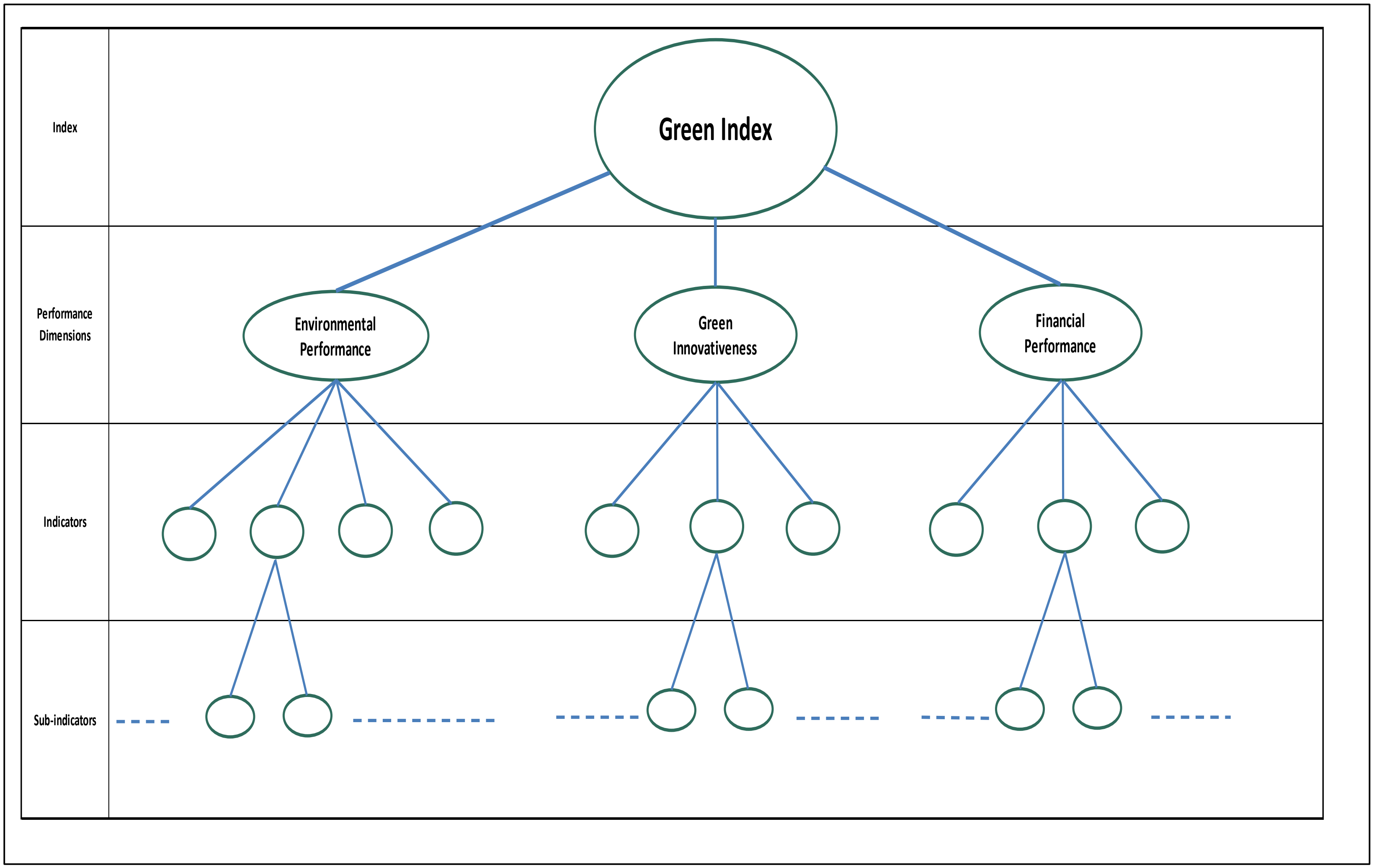


Figure 3.2. Environmental Performance, Performance Dimension Close-Up Graphical Representation of the HDM for Green Index

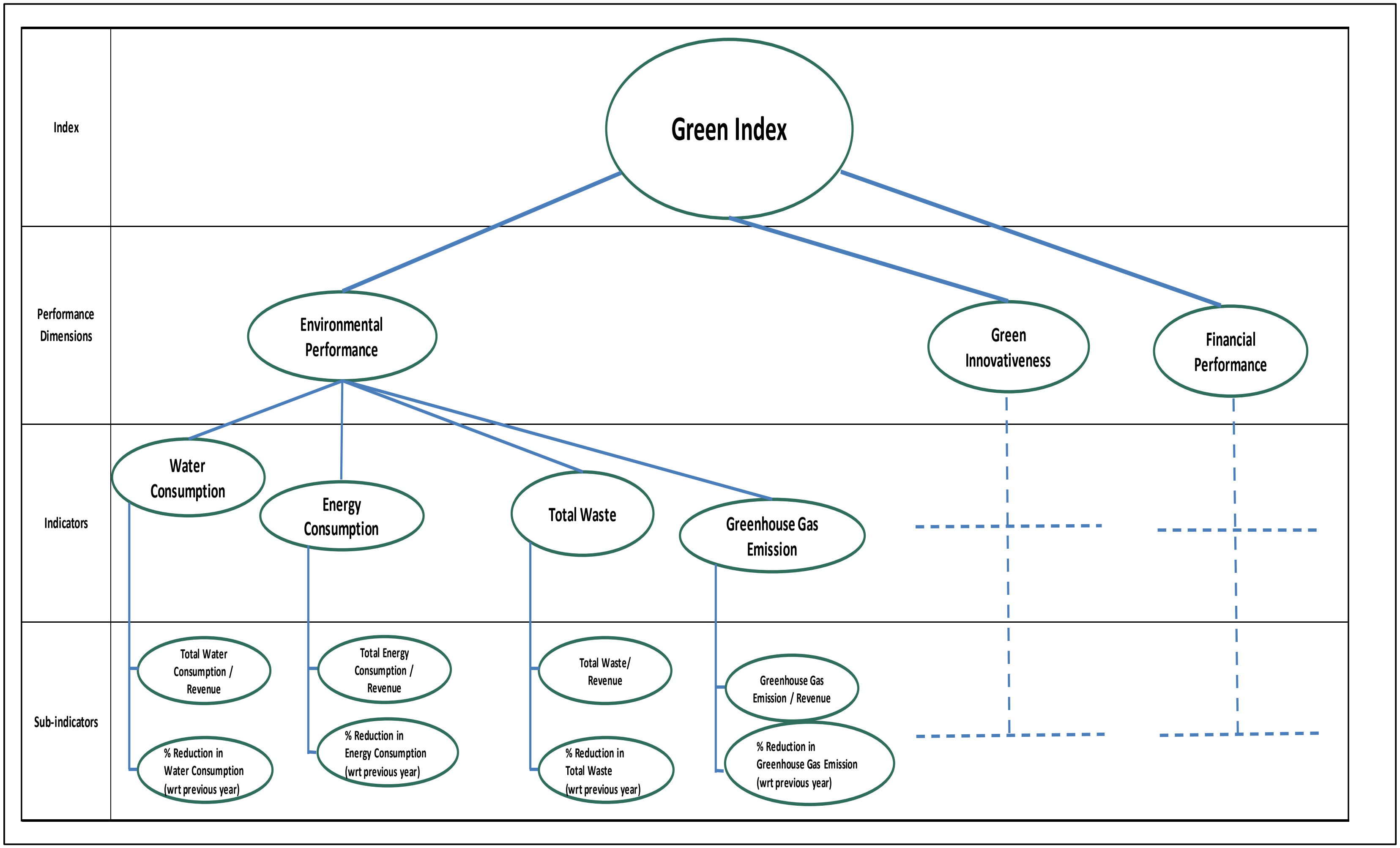


Figure 3.3. Green Innovativeness, Performance Dimension Close-Up
Graphical Representation of the HDM for Green Index

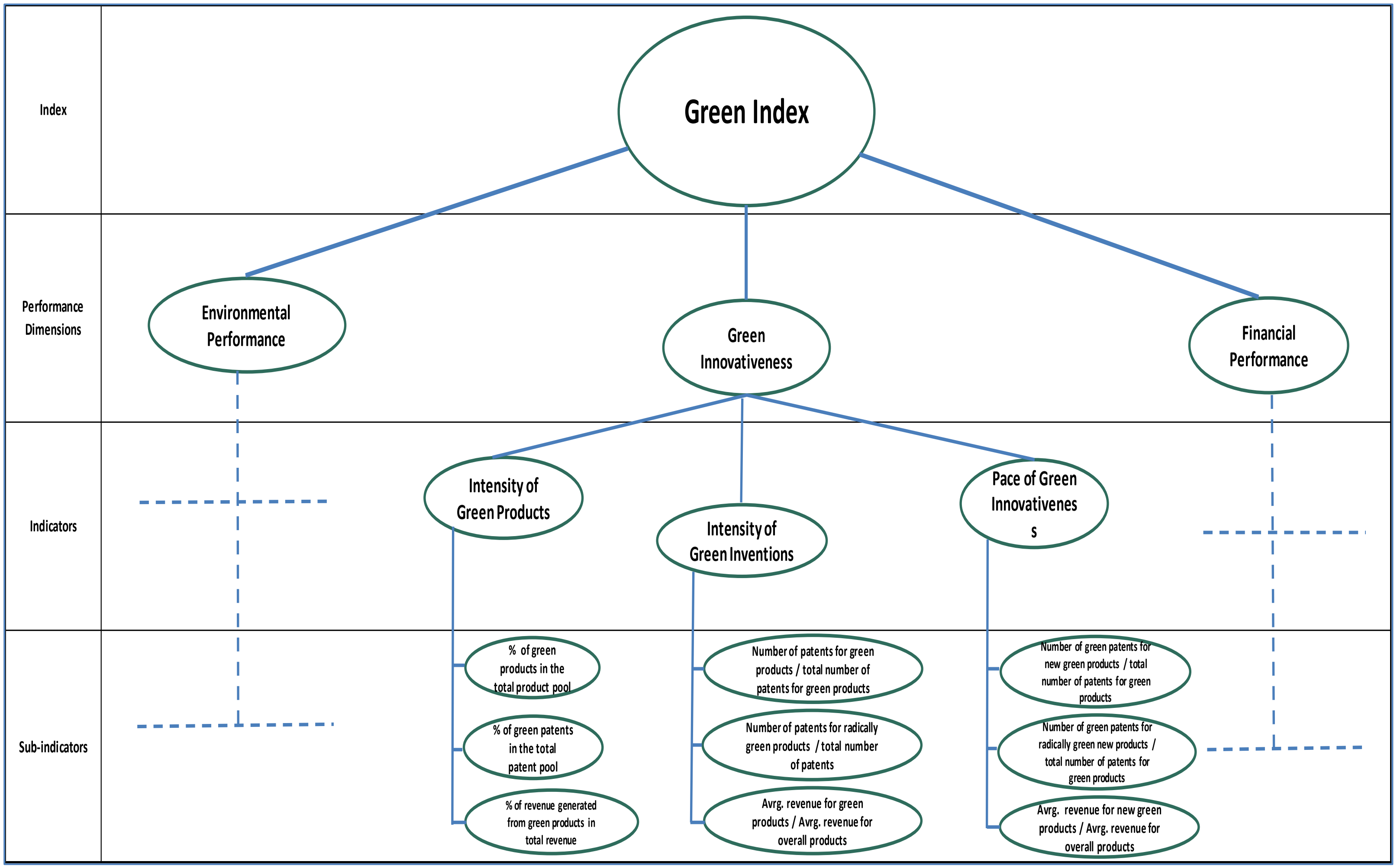
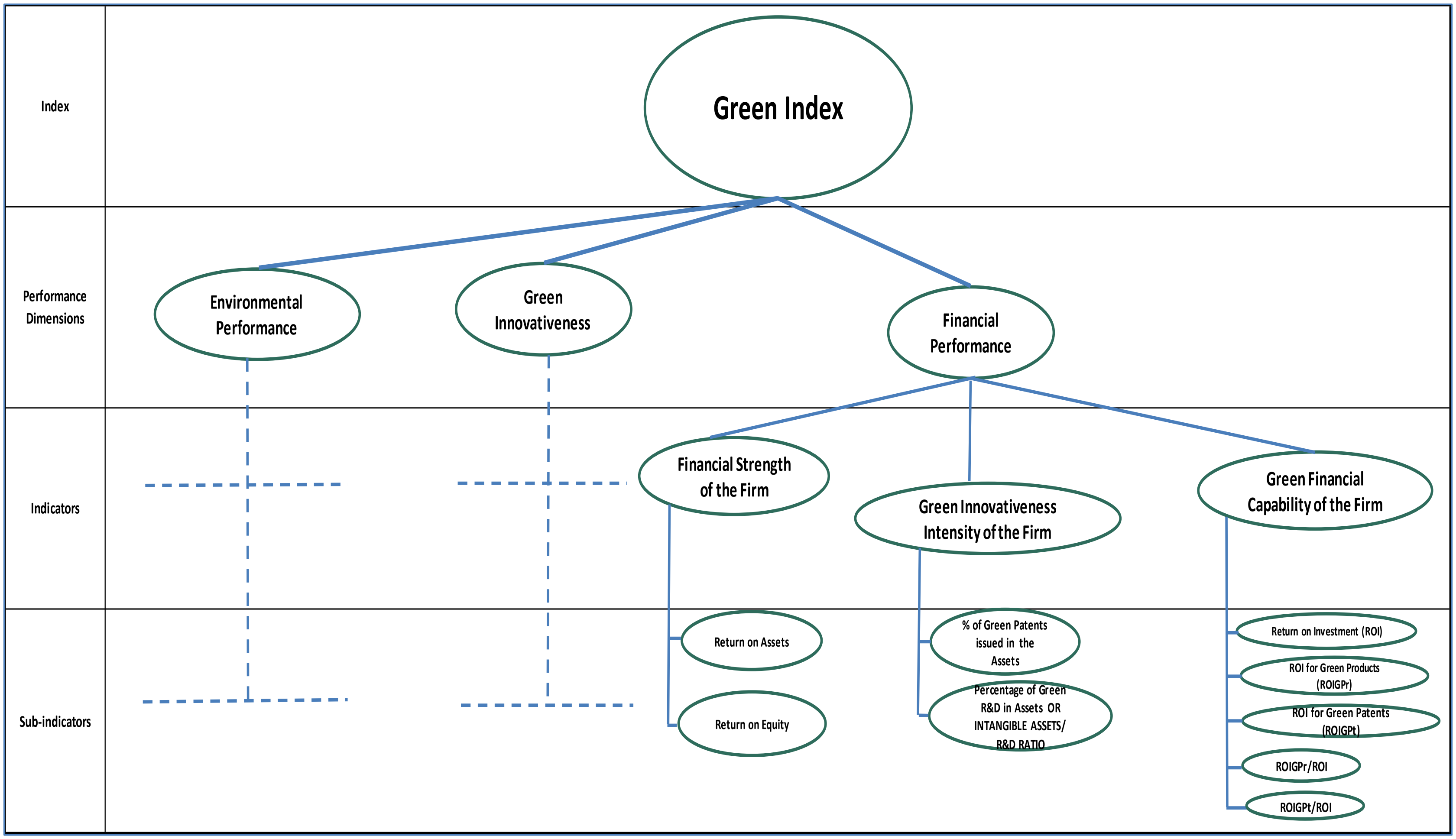


Figure 3.4. Financial Performance, Performance Dimension Close-Up Graphical Representation of the HDM for Green Index



- The Indicators and Sub-indicators under each performance dimension are listed in Tables 3.1., 3.2. and 3.3.
- The Green Index development flow as an HDM application is summarized in Figure 3.5.

Tables 3.1 thru 3.3. and Figure 3.5 are presented on the following three pages.

To address the research questions in identifying the major indicators and integrating them for the development of a new Green Index requires expertise in these areas. The building up of the Green Index will build upon the opinions of the experts in the three major areas.

The proposed research process and the application of the methodologies used for the development of the model are explained in the following sections: 3.2.1. and 3.3..

Table 3.1. Output Indicators and Sub-indicators with respect to Performance Dimensions - Environmental Performance

Performance Dimension	Indicators	Sub-indicators
Environmental Performance	Water Consumption	Total Water Consumption / Revenue
		% Reduction in Water Consumption / Revenue (wrt. previous year)
	Energy Consumption	Total Energy Consumption / Revenue
		% Reduction in Energy Consumption / Revenue (wrt. previous year)
	Total Waste	Total Waste / Revenue
		% Reduction in Total Waste / Revenue (wrt. previous year)
	Green House Gas Emissions	Greenhouse Gas Emission / Revenue
		% Reduction in Greenhouse Gas Emission / Revenue (wrt. previous year)

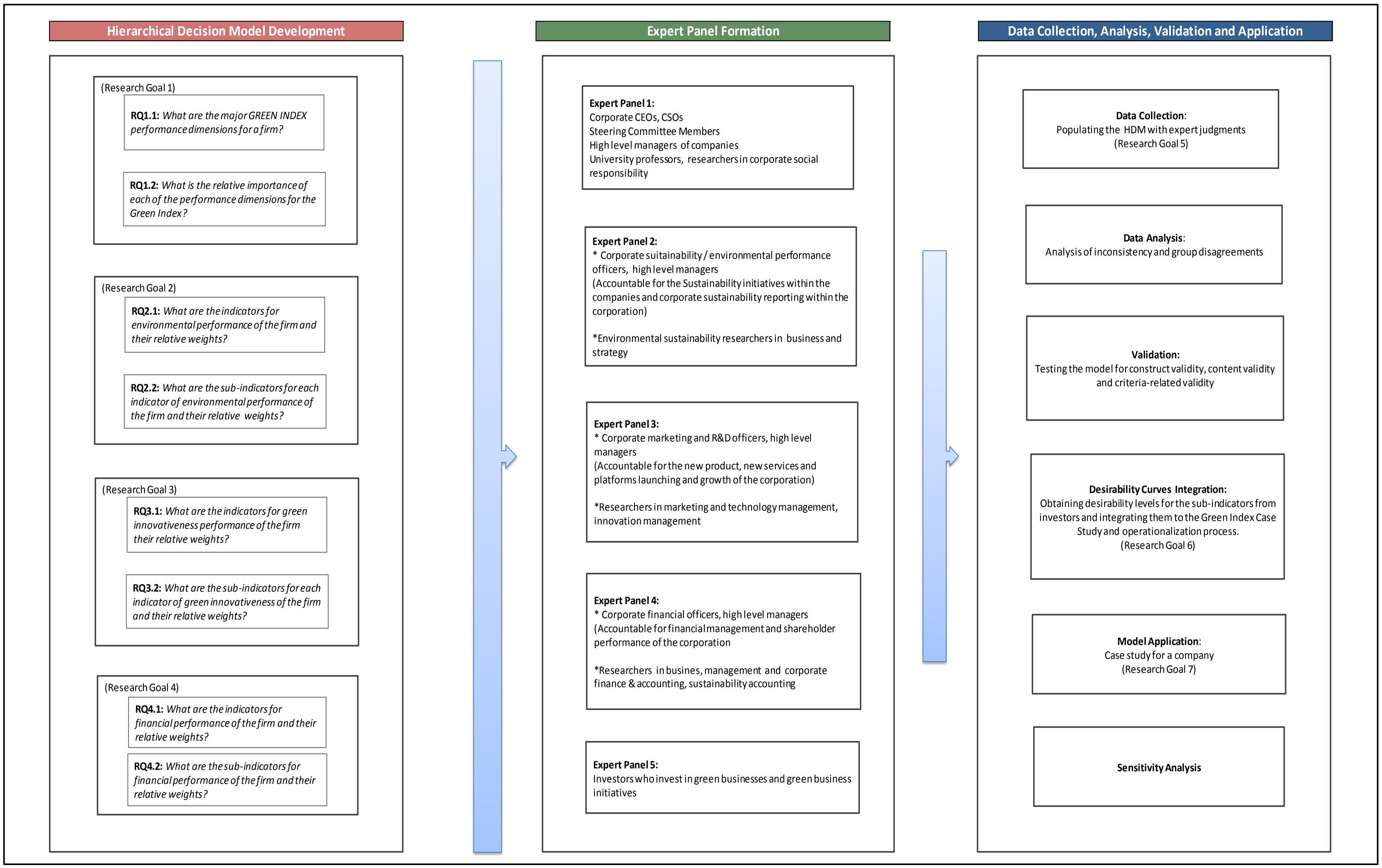
Table 3.2. Output Indicators and Sub-indicators with respect to Performance Dimensions
Green Innovativeness Performance

Performance Dimension	Indicators	Sub-indicators
Green Innovativeness	Intensity of Green Products	Percentage of green products in the total product pool
		Percentage of radically green products in the total product pool
		Revenue generated from green products as percentage of the total revenue of the company
		Revenue generated from radically green products as percentage of the total revenue of the company
	Intensity of Green Inventions	Number of green patents / Total number of patents
		Number of radically green patents / Total number of patents
		Revenue generated from licensing green patents as percentage of the total revenue of the company
		Revenue generated from licensing radically green patents as percentage of the total revenue of the company
	Pace of Green Innovativeness	Number of green patents for new products / Total number of patents for green products
		Number of radically green patents for new products / Total number of patents for green products
		Avrg. revenue for new green products / Avrg. revenue for all products
		Avrg. revenue for radically green new products / Avrg. revenue for all products

Table 3.3. Output Indicators and Sub-indicators with respect to Performance Dimensions
Financial Performance

Performance Dimension	Indicators	Sub-Indicators
Financial Performance	Financial Strength of the firm	Return on Assets
		Return on Equity
	Green Innovativeness Intensity of the firm	Percentage of Green Patents in the Assets
		Percentage of Green R&D in the Assets
	Green Financial Capability of the firm	Return on Investment (ROI)
		ROI for Green Products (ROIGPr)
		ROI for Green Patents (ROIGPt)
		ROIGPr/ROI
		ROIGPt/ROI

Figure 3.5. Green Index Development Flow via HDM Application



3.2.1. Research Process

For development of the Green Index, the research study was run in seven phases:

Phase 1: Development of the Hierarchical Decision Model (HDM)

Phase 2: Expert Panel Formation

Phase 3: Data Collection

Phase 4: Data Analysis

Phase 5: Sensitivity Analysis

Phase 6: Validation

Phase 7: Results

The methodologies corresponding to these phases of the research process are explained in detail in section 3.3.

3.3. Research Methodology

3.3.1. Phase 1: Development of the Hierarchical Decision Model

In Phase 1, a Hierarchical Decision Model (HDM) was developed for defining the Green Index at Level 1. The 3 performance dimensions:

1. Environmental Performance
2. Green Innovativeness Performance
3. Financial Performance

constituted the Second Level of the HDM. These performance dimensions were determined based on the literature search of both the scholarly and business publications.

The Second Level of the modeling process responds to the research question:

RQ1.1: What is the relative importance of each of the performance dimensions for the Green Index?

The relative weights of these Performance Dimensions determine each of their contribution percentage to the Green Index.

These weights were determined based on the expert opinions' assessment. Their relative weights were defined based on experts' judgment quantifications and the results responded to the research question RQ1.1.

The following levels (Level 3 and 4) of the HDM for Green Index were formed of the Indicators and Sub-indicators for these Indicators subsequently. Before moving on to the introduction of the following levels in the HDM, some further information is provided here for the properties and selection filter for the indicators and the sub-indicators that are corresponding to them.

The 3 Performance Dimensions with their corresponding Indicators and Sub-indicators are determined based on the synthesis of the literature search conducted. Their common properties are:

i. The literature search highlighted their direct use for sustainability and triple bottom line performance of the firm, and/or
ii. The literature search highlighted their indirect use for sustainability and triple bottom line performance of the firm, and/or
iii. The literature search highlighted a recognizable gap in their direct/indirect use for sustainability and green performance of the firm. In closely related, relatively indirect research studies, there is lack of definitive new indicators and these new proposed indicators have high potential to fill in that gap. Based on the comprehensive literature search, these indicators' integration and alignment showed high potential to meet the future needs of proactive and progressive research in addressing the green performance of the firm with respect to its environmental impact and environmentally friendly added value to the markets.
iv. The indicators with their corresponding sub-indicators are numerically quantified and are measurable outputs of the firm.
v. The indicators with their corresponding, sub-indicators are available either at publicly available data bases, or company internal reporting systems, or company reports to the regulatory governmental organizations (for Environmental Performance sub-indicators), or company financial reports (for Financial Performance sub-indicators).

The Third Level of the HDM is the Indicators Level, which defined the Performance Dimensions of the Green Index. At this level, the proposed indicators for each Performance Dimension (Environmental Performance, Green Innovativeness and Financial Performance), were validated by the experts by addressing the Research Questions:

Are the proposed indicators for:

(1) Environmental Performance of the firm valid?

(2) Green Innovativeness Performance of the firm valid?

(3) Financial Performance of the firm valid?

Following the validation of the indicators, experts gave their opinion on the relative weights for each one of the indicators. The relative weights of these major indicators determined their contribution to each of the performance dimensions at the Third Level. The relative weights of these major indicators, were addressed by experts responding to the Research Questions:

What is the relative importance of each one of the indicators of:

(1) Environmental Performance for a firm?

(2) Green Innovativeness Performance for a firm?

(3) Financial Performance for a firm?

In a similar process, the Fourth Level of the HDM constituted of the sub-indicators, which build up the indicators. The Fourth Level was built based on the corresponding answers of the experts to the Research Questions. Initially, the sub-indicators were validated by the experts by addressing the Research Questions:

Are the sub-indicators proposed for each indicator of:

(1) Environmental Performance of the firm valid?

(2) Green Innovativeness Performance of the firm valid?

(3) Financial Performance of the firm valid?

Following the validation of the sub-indicators, experts gave their opinion on the relative weights for each one of the indicators. The relative weights of these sub-indicators determined their contribution to each one of the indicators at the Fourth Level. These weights were determined based on the expert opinions' assessment. The relative weights of these sub-indicators were addressed by experts responding to the Research Questions:

What is the relative importance of each one of the sub-indicators for each indicator of:

(1) Environmental Performance of the firm?

(2) Green Innovativeness Performance of the firm?

(3) Financial Performance of the firm?

The Hierarchical Decision Model (HDM) was built by the quantification values for relative contributions of the performance measures, indicators and sub-indicators, as determined by the experts.

Following the building up of the HDM for Green Index, Desirability Curves for each one of the sub-indicators was obtained, based on another group of experts' quantifications. The Desirability Curves were built on the normalization of the subjective quantification of the experts' value judgments for certain levels of the performance metrics of the sub-indicators. With the normalization process, these value quantifications became comparable and they contributed to the building of the HDM for the Green Index quantification. Detailed application of the Desirability Curves is discussed further in the modeling section.

3.3.2. Phase 2: Expert Panel Formation

The expert panels were formed to validate the performance measures and indicators group in the HDM, to obtain their quantifications for the relationships and for the quantification of the Desirability Curves. The members of expert panels were selected to represent a balanced distribution and weight of perspectives and ideas. All the expert panel members who contributed to the research have in-depth knowledge about the research areas of environmental performance, green innovativeness performance of businesses, financial performance and have various backgrounds from academia and from the industry. Expert panels with alternative backgrounds provided that the outcomes of the study would not be affected, or were least affected by the biases due to members' backgrounds.

There were minimum 10 to 12 experts on average on each expert panel. In the literature and in the research studies the practice is to have 6 to 12 experts on an expert panel (Slottje et al. 2008). Study shows that additional experts beyond 12 do not contribute to a significant change in the results. In this dissertation expert judgments were quantified by using pair-wise comparison method, via combination of pair-wise comparisons of performance dimensions, indicators, and sub-indicators. A new software that was developed by the ETM department was used for the panel assessment of these pair-wise comparison judgment quantifications.

Expert selection was made by deploying three methods: (1) Citation Analysis, (2) Snowball Sampling and (3) Social Network Analysis. Each of these methods are very briefly summarized as follows:

Citation Analysis:

Citation analysis is the most widely used method of bibliometrics. It is the examination of the frequency, patterns, and graphs of citations in publications as books and papers. It uses citations in scholarly works to establish and trace the links to other works and researchers. Several Citation Databases, (i.e. Web of Science, Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI)) are used to determine the experts based on the citation of the research paper they have published to date.

Snowball Sampling:

Snowball or chain referral sampling is a method that has been widely used in qualitative sociological research. The method yields a study sample through referrals made among people who share or know of others who possess some characteristics that are of research interest. The method is well suited for a number of research purposes and is particularly applicable when the focus of study is on a sensitive issue, possibly concerning a relatively private matter, and thus requires the knowledge of insiders to locate people for study. In a different context, Coleman (1958) has even argued that it is a method uniquely designed for sociological research because it allows for the sampling of natural interactional units (Biernacki and Waldorf, 1981). In snowball sampling the researcher begins with a few known experts, asks for more names from them, and repeats until he or she has more names than are actually needed. This approach is known as snowball sampling or chain referral sampling. Researchers use this method to obtain knowledge or data from extended associations that have been developed over time and where there is no easy direct access.

Social Network Analysis:

It is a networks approach to the methods of analyzing social networks or structures. It is the mapping and measuring of relationships and flows among people, groups, organizations, computers or other information/knowledge processing entities. The nodes in the network are the people and/or groups while the links show relationships or flows between the nodes. This method provides both a visual and a mathematical analysis of the relationships that are being analyzed. The networks for this proposed research consist of experts, and builds around the experts which are connected via interdependencies.

Formation of the expert panels and the research questions, which were addressed by each panel, are as follows:

1. Expert Panel 1 (EP1) was comprised of (1) researchers, faculty members in the fields of corporate social responsibility, corporate management, (2) high level managers in the same or similar areas in high-tech industries in companies. A balanced representation of the three groups in the Expert Panel was maintained. This Expert Panel had 6 researchers, and 6 managers. The Panel addressed the research question:

RQ1.1: What is the relative importance of each of the Performance Dimensions of the Green Index?

2. Expert Panel 2 was comprised of experts who specialize in environmental performance of the firm and are either: (1) researchers and faculty members at universities, or (2) high level managers of corporate social responsibility in the environmental performance measurement and assessment area. A balanced representation of the members of these two groups of experts for this panel was maintained. This Expert Panel had 6 researchers, and 7 managers. The Panel addressed the research question:

RQ2.1: What are the relative weights of the indicators for Environmental Performance of the firm ?

RQ2.2: What are the relative weights of the sub-indicators for each indicator of Environmental Performance of the firm?

3. Expert Panel 3 was comprised of experts who specialize in green innovativeness of the firm and are either: (1) researchers and faculty members at universities in the areas of technology management, new product development, green innovations & products, marketing, competitive strategy, or (2) high level managers of research and development, or marketing or technology management in high-tech companies. A balanced representation of the members of these two groups of experts for this panel was maintained. This Expert Panel had 5 researchers, and 6 managers. The Panel addressed the research question:

RQ3.1: What are the relative weights of the indicators for Green Innovativeness Performance of the firm?

RQ3.2: What are the relative weights of the sub-indicators for each indicator of Green Innovativeness Performance of the firm?

4. Expert Panel 4 was comprised of experts who specialize in financial management of the firm, if possible those who are experts in the sustainability, internalization of the environmental impacts: environmental costs of the firm. These experts were selected from: (1) researchers and faculty members at universities in the areas of corporate social responsibility, financial management, sustainability accounting (2) executive managers of financial management and corporate sustainability accounting if possible. This panel had higher representation from industry and had 6 researchers, and 10 managers. The Panel addressed the research question:

RQ4.1: What are the relative weights of the indicators for Financial Performance of the firm and their relative weights?

RQ4.2: What are the relative weights of the sub-indicators for each indicator of Financial Performance of the firm?

5. **Expert Panel 5** (EP5) was formed of investors who are actively investing in green new small high-tech companies, and in some cases investing in high-tech companies of green-technologies.

EP5 members quantified the lower and upper limits for the desirability levels for the performance metrics of sub-indicators, explained in detail in 3.5.1. This Expert Panel collectively defined the formation of the desirability curves for each performance metric of the sub-indicators. This Expert Panel 9 investors.

3.3.3 Phase 3: Data Collection

At this phase quantified judgments from the experts were collected and analysis of the contributions of performance dimensions, indicators and sub-indicators for quantifying the breakdown of the Green Index measures were conducted. The data collection is discussed in 3.3.3.1.

3.3.3.1 Collection of Comparative Judgment and Quantification Data from The Experts

The Delphi Method was deployed to collect expert judgment quantifications for the performance dimensions, indicators and sub-indicators. It is the core method of the research study. And the supporting and related analysis for research design was deployed as well and they are briefly mentioned below, and in the related subsections.

With Delphi Method, a group consensus is tried to be obtained with expert judgments. Experts quantify and report their judgment for the criteria/indicators and the results are assessed for the expert panel over all at the end of the process. And this process is repeated iteratively, for the revised quantification values of and from the experts based on the previous assessment results. The iteration continues until the required consensus level is reached, by adjustments made in the case of disagreements should they arise among experts, and should the level of such disagreements is outside the predetermined level defined for agreement among experts.

For this research, four types of data were collected:

(1) Verification of the model at each level

The instrument for verification obtained experts' confirmation for each element of each level of the hierarchy. For the Green Index, 3 performance dimensions, 10 Indicators and 29 Sub-indicators were deployed. The experts validated and finalized the proposed HDM Model with their judgments, by validating the proposed indicators and sub-indicators.

(2) Quantification of expert judgments for relative importance of each element at each level of the model

Judgment quantifications from experts were obtained by pairwise comparisons to explain the relative importance of elements at a particular level. For pairwise comparisons the sum method was used as illustrated in the initial model and test case. For obtaining this data the experts were asked to complete a series of pairwise comparative judgments by allocating a total of 100 points between two elements at a time. This method is called as the "Constant-Sum Method".

The series of judgments were transformed to normalized measures of relative values in ratio scale of the elements. Pairwise comparison Method software was deployed for these transformations. The relative values of the items, the group means, the level of inconsistency of each expert were also determined (Kocaoglu, D.F., 1983). The analysis of inconsistency for experts is explained in detail in 3.3.4.

(3) Desirability curves for the performance levels of the sub-indicators

Desirability curves were developed by asking the experts to assign a value of 100 for the most desired performance level and 0 for the least desired performance level for each of the sub-indicators, and filling in the intermediate values. For the 29 sub-indicators are derived for indicators by connecting the weight of the relationship of the performance dimension to its desirability. Experts also expressed whether the relationship is linear or nonlinear as well. A specific and separate judgment quantification instrument was developed for the desirability curves as well and it is explained in detail in the sections below.

(4) Scenario Analysis applied to the Green Index model

This is the scenario development and analysis of the validated Green Index model for different values of performance level of sub-indicators for various company profiles. The results and analysis of these applications are presented in the results section of the dissertation.

3.3.4 Data Analysis

3.3.4.1.HDM Development

The development of the Green Index was done through a series of calculations. Experts' judgment quantifications were obtained from each expert panel and they were used as inputs in the calculation. The calculation formula and its deliverable in Figure 3.6. are presented on the following page.

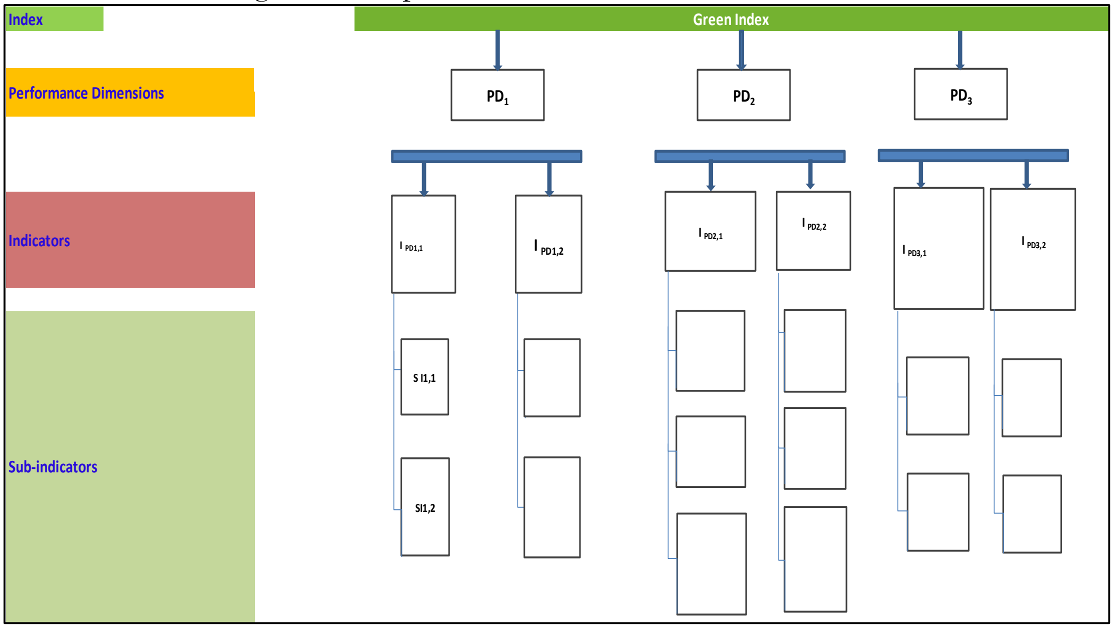
$$SI_{n,jn}^{GI} = \sum_{i=1}^{I} \sum_{n=1}^{N} \sum_{Jn=1}^{Jn} (PD_i^{GI})\ (I_n^{PDi})\ (SI_{n,\,jn}^{In})$$

For $n = 1,2,\ldots, N$ and $j_n = 1,2,\ldots, J_n$

Where

$SI_{n,jn}^{GI}$	Relative importance of the j_n^{th} Sub-Indicator under the n^{th} Indicator with respect to the Green Index for the Firm (GI)
PD_i^{GI}	Relative importance of the i^{th} Performance Dimension with respect to the Green Index (GI), $i = 1,2,3,\ldots, I$
I_n^{PDi}	Relative importance of the n^{th} Indicator with respect to the i^{th} Performance Dimension (PD), $n = 1,2,3,\ldots, N$
$SI_{n,jn}^{In}$	Relative importance of the j^{th} Sub-Indicator under the n^{th} Indicator, with respect to the n^{th} indicator, $j_n = 1,2,3, \ldots J_n$, and $n = 1,2,3, \ldots,N$

Figure 3.6. Representation of HDM for Green Index



The cumulative sum for $SI_{n,jn}^{GI}$, the Green Index value for each company could be calculated, thus the HDM model delivered its result for the determination of the Green Index value for a company.

3.3.4.1 Desirability Curves and Values

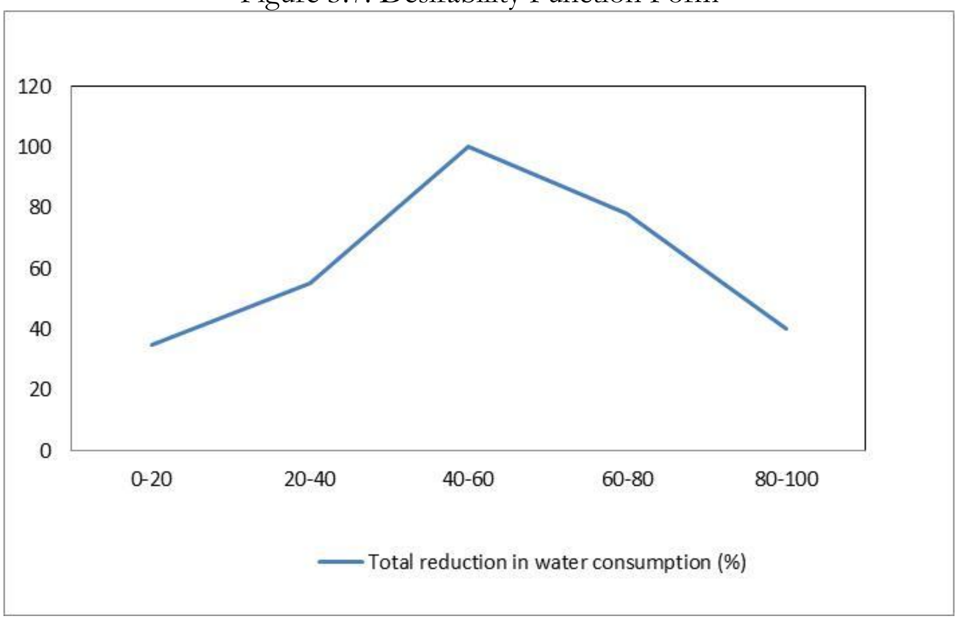
A new methodological approach was deployed for the development of Desirability Curves in this research.

The desirability curves for different levels of performance of the sub-indicators, were developed based on experts' quantifications in the range of 0 to 100; 0 being the least desirable level, 100 being the most desirable level. The measured properties of each criterion were transformed into a dimensionless desirability (d) scale, which made it possible to combine results obtained for sub-indicators having different metric measures and different scales.

Desirability curves were obtained from the experts on Expert Panel 5 for each sub-indicator by determining the relationship of its performance level to its desirability. Experts also defined the form of the relationship i.e. linear or non-linear.

An example is explained and walked through below, with Figure 3.7.:

Figure 3.7. Desirability Function Form



The X-Axis represents the total reduction in water consumption. In this example, the most desirable level is 40-60% reduction. It has the desirability value of 100. The desirability values of other reduction levels are shown in Table 3.4. below. Upper and lower limits of acceptable metric values representing the worst and the best are defined from 0 to 100 in intervals of 20 for desirability.

Table 3.4. Desirability values in Figure 3.7.

Total reduction in water consumption (%)	Desirability Value
0-20	35
20-40	55
40-60	100
60-80	78
80-100	40

In this dissertation each expert was asked to indicate the desirability level for each performance measure of the sub-indicators. Arithmetic mean of the experts' inputs were used as the group decision for desirability values.

The desirability values were incorporated into the Green Index by multiplying each sub-indicator value with the desirability value of the corresponding performance level as shown below:

$$GI = \sum_{n,Jn=1,1}^{N,JN} (SI_{n,jn}^{GI}) \cdot (D_{n,\,jn})$$

Where

$SI_{n,jn}^{GI}$ Relative importance of the j_n^{th} Sub-Indicator under the n^{th} Indicator with respect to the Green Index for the Firm (GI)

$D_{n,\,jn}$ Desirability value of the performance level of the company requested by the j_{nth} sub-indicator under the n^{th} indicator

$j_n = 1,2,3, \ldots J_n$, $i = 1,2,3, \ldots\ldots\ldots\ldots\ldots\ldots I$

$n = 1,2,3, \ldots,N$ $n, j_n = (1,1)\ldots\ldots\ldots\ldots\ldots (N,J_N)$

3.3.4.3. Assessment of the Decisions of the Experts

While the data from the experts were being collected two tests for the assessment of the experts individually and as a group were also performed. The data collection process, pairwise comparisons scheme with the two related tests are explained below:

(i) Analysis of individual inconsistency which represents the quality of the weights

(ii) Analysis of group disagreement: Measures of (1) Intra-class correlation coefficient and (2) F-test to address the degree to which the experts agree with each other.

(i) Analysis of Inconsistency represents the quality of the weights. The acceptable value for inconsistency is between 0.0 and 0.10 and it is calculated as follows (Kocaoglu, D.F., 1983):

For n elements; the constant sum calculations result in a vector of relative values $r_1, r_2, r_3, \ldots, r_n$ for each of the n! orientations of the elements. If 5 elements are evaluated, n is 5 and n! is 120 orientations such as ABCDE, ABCED, ABECD, ABEDC, ABDEC, …, EDCBA. In case there is no inconsistency in the expert judgments in providing pairwise comparisons for the elements, the relative values are to be the same for each orientation. However, in application, inconsistency does take place to a certain extent, and it results in differences in the relative values in different orientations.

In consistency measure in the constant-sum method is a measure of the variance among the relative values of the elements calculated in the n! orientations.

If

r_{ij} = relative value of the i^{th} element in the j^{th} orientation of an expert

r_{ij}= mean relative value of the i^{th} element in the j^{th} orientation of an expert

Inconsistency in the relative value of the i^{th} element is

$$\frac{1}{n}\sum_{i=1}^{n}\sqrt{\frac{1}{n!}\sum_{j=1}^{n!}(\bar{r}_i - r_{ij})^2}$$

For this research, inconsistency among experts was calculated along with the application of the pairwise comparison model's application.

(ii) Analysis of group disagreement:

For the analysis of group disagreement, two coefficients are taken into consideration: **Intraclass Correlation** and the statistical **F-Test.** Each of them is briefly explained below.

Intraclass Correlation: This coefficient is represented by the degree to which k experts are in agreement with one another on the relative importance values of n elements. The intraclass correlation coefficient is computed by following the equations i through x, as listed below:

$$r_{ic} = \frac{MS_{BS} - MS_{res}}{MS_{BS} + (k-1)MS_{res} + \left(\frac{k}{n}\right)\left(MS_{BJ} - MS_{res}\right)}$$

Where

MS_{BS}	Mean square between criteria
MS_{BJ}	Mean square between experts
MS_{res}	Mean square residual
SS_{BS}	Sum of square between criteria
SS_{BJ}	Sum of square between experts
SS_{res}	Sum of square residual
df_{BJ}	Degree □ f freedom between experts
df_{BS}	Degree of freedom between criteria
df_{res}	Degree of freedom residual
X_j	Judgment of jth expert
S_i	Relative value of ith criterion
k	Number of experts
n	Number of criteria

And the equations for each are as follows:

$$MS_{BJ} = \frac{SS_{BJ}}{df_{BJ}}$$	(1)
$$MS_{BS} = \frac{SS_{BS}}{df_{BS}}$$	(2)
$$df_{BJ} = k - 1$$	(3)
$$df_{BS} = n - 1$$	(4)
$$SS_{BJ} = \sum_{j=1}^{k} \left[\frac{\left(\sum X_j\right)^2}{n} \right] - \frac{(\sum X_T)^2}{nk}$$	(5)
$$SS_{BS} = \sum_{i=1}^{n} \left[\frac{\left(\sum S_i\right)^2}{k} \right] - \frac{(\sum X_T)^2}{nk}$$	(6)
$$MS_{res} = \frac{SS_{res}}{df_{res}}$$	(7)

$SS_{res} = SS_T - SS_{BJ} - SS_{BS}$	(8)
$SS_T = \sum X_T^2 - \frac{(\sum X_T)^2}{nk}$	(9)
$df_{res} = (n-1)(k-1)$	(10)

The intraclass correlation coefficient r_{ic}, can possibly fall within the range of

$$\frac{1}{(k-1)} < r_{ic} < +1$$

Its value is equal to +1 when the relative priorities of the criteria from all the experts are exactly the same. The value of r_{ic} is 0 when there is substantial difference among the elements', indicators' values from all the experts. Any value of the intraclass correlation coefficient that falls in between 0 and 1 indicates the degree to which all experts agree upon the criteria' values; the higher the value is the higher the level of agreement. When the r_{ic} has a negative value, the negative correlation is generally considered as 0.

For this research, the level of group agreement on the relative importance of the sub-indicators, indicators, performance dimensions to the Green Index was determined by making use of the coefficient of intra-class correlation.

F-Test:

F-test, for between-group variability where

The null hypothesis is:

H_0: *There is disagreement (there is no correlation of the judgments by experts on the subjects)*

H_0: r_{ic}

H_a : *There is statistically significant evidence that there is some level of agreement [Alternative Hypothesis]*

$H_a : r_{ic} > 0$

F-value is calculated as

F = Between–group variability / Within group variability

Where the "between-group variability" is

$$\sum_i n_i(\bar{Y}_{i\cdot} - \bar{Y})^2/(K-1)$$

Where $\bar{Y}_{i\cdot}$ denotes the sample mean in the i^{th} group, n_i is the number of observations in the i^{th} group, $\bar{Y}$ denotes the overall mean of the data, and K denotes the number of groups.

The "within-group variability" is

$$\sum_{ij}(Y_{ij} - \bar{Y}_{i\cdot})^2/(N-K),$$

Where Y_{ij} is the j^{th} observation in the i^{th} out of K groups, and N is the overall sample size. This F-statistic follows the F-distribution with $K-1$, $N-K$ degrees of freedom under the null hypothesis.

The F-value is compared to the critical F-value and the calculated F-value must exceed to reject the test. In general, case a significance level of 5% ($\alpha = 0.05$) is considered to be a high level of confidence for testing group difference.

[An $\alpha = 0.05$ indicates that there is only one chance in twenty that this event happened by coincidence and a 0.05 level of statistical significance is being implied. The lower the significance level, the stronger the evidence required. It is conventional to use a 5% level of significance for many applications.]

For this research the group disagreement among experts was tested by deploying the F-test, for between-group variability where

3.3.6 Phase 5: Validation

For this phase, following data collection, research results were validated. There are three types of validation that were applied: the first two were at the beginning stages, the last one was after the results were obtained. These three types of validation tests are briefly introduced and summarized below:

(1) Content Validity: This is the testing of the readiness of the instrument for data collection. Before the model is sent to the whole group of experts, a small group of experts is asked to test the content of the model. This validation group can be a small part of the official expert group members and can as well be a select group of experts from outside, who are called just to test the content.

(2) Construct Validity: The experts are asked to verify and confirm the appropriateness and functionality of the model structure. It implies that the measures and the operationalized attributes are mutually exclusive, If the experts do not confirm as appropriate, the related modifications to the structure of the model are to be made, as advised by the experts.

(3) Criterion-Related Validity: The experts are asked to validate the final results of the study, they will examine if the results are acceptable. This is also known as predictive validity or instrumental validity. The generalizability of the model and its applicability as a new index for measuring the integrated sustainability performance of a company is tested to be verified by the experts.

In addition to these three major validations, Reliability and Practicability tests is conducted. Practicability is conducted during pilot testing as to if the pilot testing runs and inherent practicability can be observed. Reliability test is conducted following the results becoming available, and it addresses the consistency and reliability of the indicators, via statistical consistency analyses.

3.3.7 Phase 6: Results

The results from the expert panels will deliver the relative weights for performance dimensions, indicators and sub-indicators. The desirability function values for each one of the indicators and sub-indicators is combined with the weights and the summation along the chain upward, will deliver a "Green Value" for each performance dimension and its indicators for each company that the model will later on be applied to.

With the desirability functions application to the HDM model, how far each company is away from, or close to the best level for each indicator's most desired level, is detectable. The outcome is identification of how good is company's "Green Value" for a specific indicator, and the amount of room there is for enhancement.

In the case of inconsistencies of individual experts, and disagreements that are beyond the tolerance limits among experts, the experts is contacted and requested to review their individual quantifications and rerun of expert group assessments is conducted until agreement is reached, in order.

3.4 Scenario Analysis

The HDM for the Green Index was demonstrated in a scenario analysis. A total of seven scenarios were developed to see the application of the Green Index. The scenarios developed were:

Scenario 1: Ideal Green Company Case (Scenario 1): A company at the best levels of performance for all of the 3 Performance Dimensions

Scenario 2: A company Best at Environmental Performance and Worst at Green Innovativeness and Financial Performance

Scenario 3: A company Best at Green Innovativeness Performance and Worst at Environmental and Financial Performance

Scenario 4: A company Best at Financial Performance and Worst at Environmental and Green Innovativeness Performance

Scenario 5: A company at balanced levels of performance for all three performance dimensions, with major success at Environmental Performance

Scenario 6: A company at balanced levels of performance for all three performance dimensions, with major success at Green Innovativeness

Scenario 7: A company at balanced levels of performance for all three performance dimensions, with major success at Financial Performance

These seven scenarios and their results are discussed in detail in the results section.

CHAPTER 4

Research Results

4.1. Introduction

In this chapter the results and findings of the Green Index model are presented in the order of the two stages of the Green Index development process:

Stage 1: Development of the Green Index Hierarchical Decision Model by Expert Panels 1 thru 4.

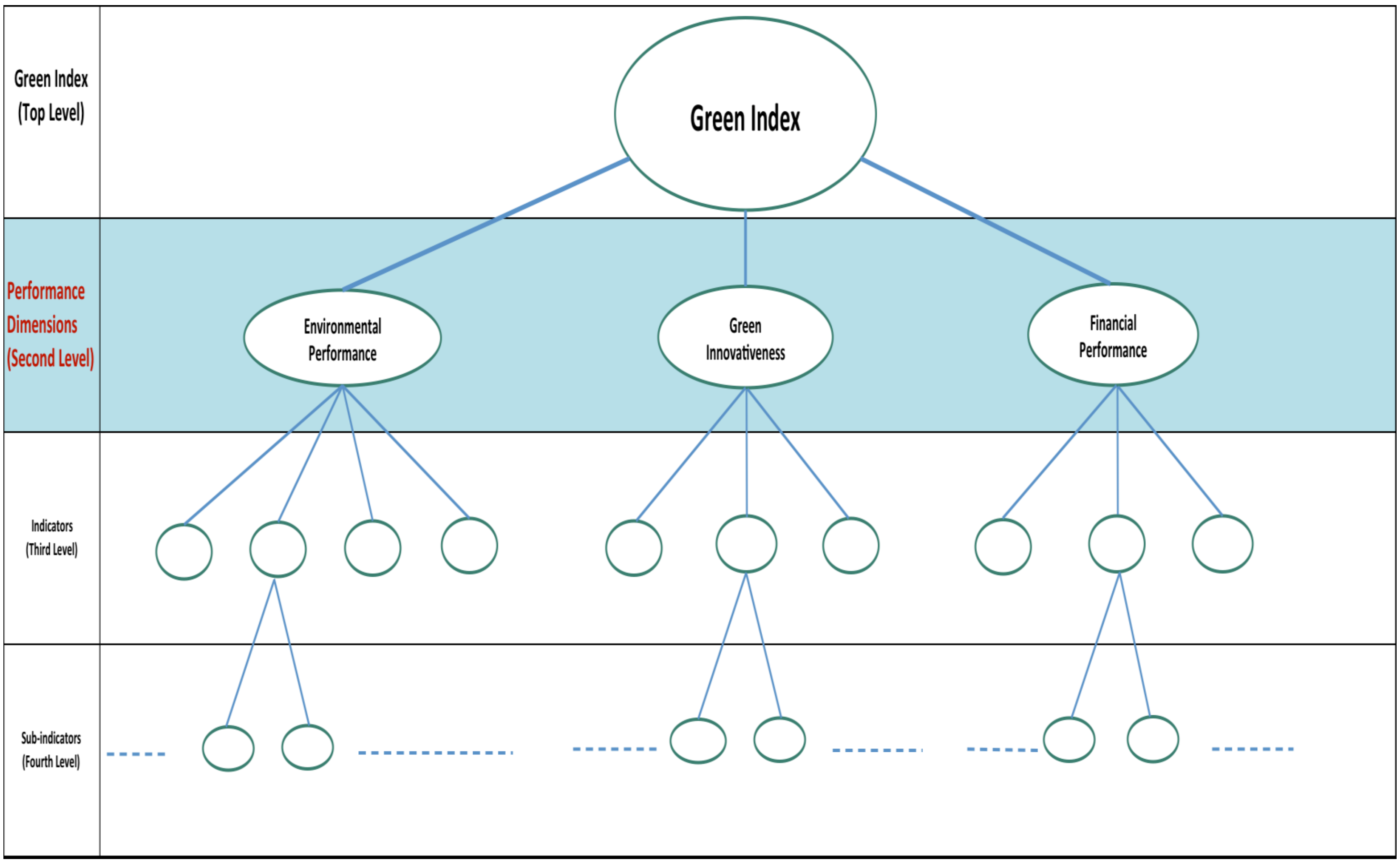
Stage 2: Development of the Desirability Curves for the sub-indicators of the Green Index HDM

and the phases of each stage.

4.1.1. Stage 1

The Green Index HDM was developed by a group of 22 experts from academia, industry, who formed the Expert Panels 1, 2, 3 and 4. Each expert panel had the mission to collectively decide on the weights of performance dimensions, indicators and sub-indicators of the Green Index. These Expert Panels, decided on the weights of the 3 levels of the Green Index HDM under the Green Index top level. The representation of Green Index HDM and the levels of the model are presented in Figure 4.1. on the following page.

Figure 4.1. Green Index HDM Model Levels



4.1.1.1. Results from Expert Panel 1

Expert Panel 1 developed the second level of the HDM for Green Index and decided on the weights of the Performance Dimensions of the Green Index. Experts gave their judgment quantification on the pairwise comparisons of the three performance dimensions of the Green Index:

(1) Environmental Performance

(2) Green Innovativeness

(3) Financial Performance

This panel comprised of a total of 12 experts as researchers, corporate executive managers, and corporate social responsibility executives.

With the judgment quantifications of Expert Panel 1, the HDM model results for the 2nd level of Performance Dimensions are as follows in Table 4.1.

Table 4.1. 2nd Level of the Green Index

Green Index	Environmental Performance	Green Innovativeness	Financial Performance
Mean	0.37	0.25	0.38

According the Experts on Panel 1, Financial Performance has the highest weight of 38%, while Environmental Performance has a weight of 37% and Green Innovativeness has a weight of 25%.

Expert Panel 1's decisions were analyzed, and the inconsistency level of each expert for the performance dimensions is very low, less than the allowed inconsistency level of 0.1. The value of the disagreement among experts is acceptable with the disagreement value of 0.09, which is fairly low. In conclusion, the aggregate results from the experts on Panel 1 are acceptable based on inconsistency, and the F-test value of 4.18 at 0.05 level, as presented in Table 4.2 and 4.3. below.

Table 4.2. Individual inconsistencies & group disagreement for Expert Panel 1

Green Index	Environmental Performance	Green Innovativeness	Financial Performance	Inconsistency
Expert 1	0.33	0.33	0.33	0
Expert 2	0.29	0.11	0.6	0.03
Expert 3	0.31	0.21	0.48	0
Expert 4	0.45	0.3	0.25	0
Expert 5	0.46	0.26	0.28	0.07
Expert 6	0.36	0.12	0.52	0
Expert 7	0.33	0.33	0.33	0
Expert 8	0.27	0.4	0.33	0
Expert 9	0.38	0.25	0.38	0
Expert 10	0.36	0.18	0.47	0
Expert 11	0.43	0.33	0.25	0
Expert 12	0.46	0.26	0.28	0.07
Mean	0.37	0.25	0.38	

Table 4.3. Analysis of the group decision of Expert Panel 1
toward Green Index

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.11	2	0.054	4.18
Between Conditions:	0	11	0	
Residual:	0.28	22	0.013	
Total:	0.39	35		
Critical F-value with degrees of freedom 2 & 22 at 0.05 level:				3.44

4.1.1.2. Results from Expert Panel 2

Expert Panel 2, developed the third and fourth level of the HDM for Green Index, for the Environmental Performance Dimension. Experts initially were asked to validate the proposed indicators and sub-indicators for the Environmental Performance Dimension of the Green Index, and followingly were asked to give their judgment quantification on the indicators and sub-indicators.

4.1.1.2.1. Results for Indicators of Environmental Performance

Following the validation of indicators and sub-indicators of Environmental Performance Dimension, each one of the 13 experts was asked to compare two indicators at a time, regarding their relative importance toward the Environmental Performance Dimension. In the last step of data collection from Expert Panel 2, each expert was asked to compare two sub-indicators at a time, regarding their relative importance toward the indicators: Water Consumption, Energy Consumption, Total Waste and Green House Gas Emission.

Expert Panel 2 comprised of a total of 13 experts as researchers, corporate executive managers, NGO representatives of environmental governance organizations, managers from the high tech industry. According to the experts on Panel 2, the weights for the indicators of Environmental Performance Dimension are as: Water Consumption: 0.24, Energy Consumption: 0.31, Total Waste: 0.24, Green House Gas Emission: 0.21.

With the judgment quantifications of Expert Panel 2, the HDM model results for the 3rd level of Indicators for Environmental Performance are as follows as in Table 4.4.

Table 4.4. Group mean, individual inconsistencies & group disagreement for Expert Panel 2 for Indicators of Environmental Performance

Environmental Performance	Water Consumption	Energy Consumption	Total Waste	Green House Gas Emission	Inconsistency
Expert 1	0.19	0.23	0.50	0.08	0.02
Expert 2	0.29	0.27	0.20	0.24	0.00
Expert 3	0.23	0.42	0.20	0.15	0.02
Expert 4	0.14	0.29	0.33	0.24	0.01
Expert 5	0.37	0.24	0.20	0.20	0.02
Expert 6	0.36	0.28	0.11	0.26	0.01
Expert 7	0.20	0.48	0.16	0.16	0.01
Expert 8	0.25	0.25	0.25	0.25	0.00
Expert 9	0.18	0.30	0.20	0.33	0.00
Expert 10	0.30	0.34	0.20	0.16	0.01
Expert 11	0.20	0.20	0.37	0.24	0.01
Expert 12	0.20	0.48	0.16	0.16	0.01
Expert 13	0.25	0.25	0.25	0.25	0.00
Mean	0.24	0.31	0.24	0.21	

Expert Panel 2's decisions were analyzed, and the inconsistency level of each expert for the indicators of Environmental Performance is, less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on Panel 2 are acceptable based on the inconsistency, and the F-test value of 2.45 at 0.10 level, as presented in Tables 4.4. and 4.5.

Table 4.5. Analysis of the group decision of Expert Panel 2 for Indicators toward Environmental Performance

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.07	3	0.023	2.45
Between Conditions:	0	12	0	
Residual:	0.34	36	0.01	
Total:	0.41	51		
Critical F-value with degrees of freedom 3 & 36 at 0.1 level:				2.24

4.1.1.2.2. Results for Sub-indicators of Environmental Performance

According to Expert Panel 2, the weights of Sub-indicators for each one of the indicators of the Environmental Performance are as:

1. Water Consumption:

1.1. Water Consumption / Revenue (Million Gallons / Billion USD): 0.44

1.2. Percent Change in Water Consumption / Revenue with respect to previous year: 0.56

2. Energy Consumption:

2.1. Energy Consumption / Revenue (Billion KWh / Billion USD): 0.43

2.2. Percent Change in Water Consumption / Revenue with respect to previous year: 0.57

3. Total Waste:

3.1. Total Waste / Revenue (Million Tons / Billion USD): 0.46

3.2. Percent Change in Water Consumption / Revenue with respect to previous year: 0.54

4. Green House Gas Emission:

4.1. Green House Gas Emission / Revenue

(Million Metric Tons of CO_2 equivalent / Billion USD): 0.42

4.2. Percent Change in Water Consumption / Revenue with respect to previous year: 0.58

Members of Expert Panel 2 was divided into 4 smaller expert panels of 10 experts to collectively decide on the relative weights of the sub-indicators for each indicator of the Environmental Performance Dimension.

With the judgment quantifications of these smaller consumption specific panels, the HDM model results for the 4th level of sub-indicators for Environmental Performance are as follows in Tables 4.6. thru 4.13.

According to the experts on the panel for Water Consumption, the weight for Water Consumption per Revenue is 0.44 and the weight of Percentage Change in Water Consumption with respect to the previous year is 0.56.

Table 4.6. Group mean, individual inconsistencies & group disagreement for the Expert Panel on the sub-indicators of Water Consumption

Water Consumption	Water Consumption / Revenue	% Change in Water Consumption / Revenue	Inconsistency
Expert 1	0.50	0.50	0
Expert 2	0.35	0.65	0
Expert 3	0.35	0.65	0
Expert 4	0.25	0.75	0
Expert 5	0.50	0.50	0
Expert 6	0.50	0.50	0
Expert 7	0.50	0.50	0
Expert 8	0.50	0.50	0
Expert 9	0.40	0.60	0
Expert 10	0.50	0.50	0
Mean	0.44	0.56	

This Expert Panel's decisions were analyzed. The inconsistency level of each expert for the sub-indicators of Water Consumption is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on this panel are acceptable based on the inconsistency, and the F-test value of 5.05 at 0.10 level, as presented in Table 4.7.

Table 4.7. Analysis of the group decision of the Expert Panel on the sub-indicators of Water Consumption

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.08	1	0.085	5.05
Between Conditions:	0	9	0	
Residual:	0.15	9	0.017	
Total:	0.24	19		
Critical F-value with degrees of freedom 1 & 9 at 0.1 level:				3.36

According to the experts on the panel for Energy Consumption, the weight for Energy Consumption per Revenue is 0.43 and the weight of Percentage Change in Water Consumption with respect to the previous year is 0.57, as presented in Table 4.8.

Table 4.8. Group mean, individual inconsistencies & group disagreement for the Expert Panel on the sub indicators of Energy Consumption

Energy Consumption	Energy Consumption / Revenue	% Change in Energy Consumption / Revenue	Inconsistency
Expert 1	0.50	0.50	0
Expert 2	0.30	0.70	0
Expert 3	0.35	0.65	0
Expert 4	0.40	0.60	0
Expert 5	0.40	0.60	0
Expert 6	0.50	0.50	0
Expert 7	0.50	0.50	0
Expert 8	0.40	0.60	0
Expert 9	0.40	0.60	0
Expert 10	0.50	0.50	0
Mean	0.43	0.57	

This Expert Panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Energy Consumption is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on this panel are acceptable based on the inconsistency, and the F-test value of 10.95 at 0.01 level, as presented in Tables 4.8 and 4.9.

Table 4.9. Analysis of the group decision of the Expert Panel on the sub-indicators of Energy Consumption

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.11	1	0.113	10.95
Between Conditions:	0	9	0	
Residual:	0.09	9	0.01	
Total:	0.21	19		
Critical F-value with degrees of freedom 1 & 9 at 0.01 level:				10.56

According to the experts on the panel for Total Waste, the weight for Total Waste per Revenue is 0.46 and the weight of Percentage Change in Total Waste with respect to the previous year is 0.54, as presented in Table 4.10.

Table 4.10. Group mean, individual inconsistencies & group disagreement for the Expert Panel on the sub-indicators of Total Waste

Total Waste	Total Waste / Revenue	% Change in Total Waste / Revenue	Inconsistency
Expert 1	0.50	0.50	0
Expert 2	0.55	0.45	0
Expert 3	0.35	0.65	0
Expert 4	0.50	0.50	0
Expert 5	0.40	0.60	0
Expert 6	0.50	0.50	0
Expert 7	0.50	0.50	0
Expert 8	0.40	0.60	0
Expert 9	0.40	0.60	0
Expert 10	0.50	0.50	0
Mean	0.46	0.54	

This Expert Panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Total Waste is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on this panel are acceptable based on the inconsistency, and the F-test value of 3.69 at 0.10 level, as presented in Tables 4.10 and 4.11.

Table 4.11. Analysis of the group decision of the expert panel on the sub-indicators of Total Waste

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.03	1	0.032	3.69
Between Conditions:	0	9	0	
Residual:	0.08	9	0.009	
Total:	0.11	19		
Critical F-value with degrees of freedom 1 & 9 at 0.1 level:				3.36

According to the experts on the panel for Green House Gas Emission, the weight for Green House Gas Emission per Revenue is 0.42 and the weight of Percentage Change in Total Waste with respect to the previous year is 0.58, as presented in Table 4.12.

Table 4.12. Group mean, individual inconsistencies & group disagreement for the Expert Panel on the sub-indicators of Green House Gas Emission

Green House Gas Emission (GHGE)	GHGE / Revenue	% Change in GHGE / Revenue	Inconsistency
Expert 1	0.50	0.50	0
Expert 2	0.30	0.70	0
Expert 3	0.35	0.65	0
Expert 4	0.45	0.55	0
Expert 5	0.30	0.70	0
Expert 6	0.50	0.50	0
Expert 7	0.50	0.50	0
Expert 8	0.40	0.60	0
Expert 9	0.40	0.60	0
Expert 10	0.50	0.50	0
Mean	0.42	0.58	

This Expert Panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Green House Gas Emission is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on this panel are acceptable based on the inconsistency, and the F-test value of 9.44 at 0.01 level, as presented in Tables 4.12 and 4.13.

Table 4.13. Analysis of the group decision of the Expert Panel on the sub-indicators of Green House Gas Emission

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.13	1	0.128	9.44
Between Conditions:	0	9	0	
Residual:	0.12	9	0.014	
Total:	0.25	19		
Critical F-value with degrees of freedom 1 & 9 at 0.01 level:				10.56

4.1.1.3. Results from Expert Panel 3

Expert Panel 3, developed the third and fourth level of the HDM for Green Index, for the Green Innovativeness Performance Dimension. There were 13 experts on Expert Panel 3 and they were initially were asked to validate the proposed indicators and sub-indicators for the Green Innovativeness Performance Dimension of the Green Index, and followingly were asked to give their judgment quantification on the indicators and sub-indicators.

4.1.1.3.1. Results for Indicators of Green Innovativeness

Following the validation of indicators and sub-indicators of Green Innovativeness Performance Dimension, each expert was asked to compare two indicators at a time, regarding their relative importance toward the Green Innovativeness Performance Dimension. In the last step of data collection from Expert Panel 3, each expert was asked to compare two sub-indicators at a time, regarding their relative importance toward the indicators: Intensity of Green Products, Intensity of Green Inventions and Pace of Green Innovativeness.

Expert Panel 3 comprised of a total of 13 experts as researchers, corporate executive managers, R&D managers from the high tech industry. According to the experts on Panel 3, the weights for the indicators of Green Innovativeness Performance Dimension are as: Intensity of Green Products: 0.26, Intensity of Green Inventions: 0.33, Pace of Green Innovativeness: 0.41. With the judgment quantifications of Expert Panel 3, the HDM model results for the 3rd level of Indicators for Green Innovativeness are as follows as in Table 4.14.

Table 4.14. Group mean, individual inconsistencies & group disagreement for Expert Panel 3 for Indicators of Green Innovativeness

Green Innovativeness	Intensity of Green Products	Intensity of Green Inventions	Pace of Green Innovativeness	Inconsistency
Expert 1	0.18	0.49	0.32	0.04
Expert 2	0.33	0.33	0.33	0
Expert 3	0.21	0.31	0.48	0
Expert 4	0.48	0.24	0.28	0.01
Expert 5	0.17	0.43	0.4	0.06
Expert 6	0.22	0.27	0.51	0
Expert 7	0.2	0.26	0.54	0
Expert 8	0.33	0.33	0.33	0
Expert 9	0.21	0.31	0.48	0
Expert 10	0.25	0.38	0.38	0
Expert 11	0.33	0.33	0.33	0
Mean	0.26	0.33	0.41	

Expert Panel 3's decisions were analyzed, and the inconsistency level of each expert for the indicators of Green Innovativeness is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on Panel 3 are acceptable based on the inconsistency, and the F-test value of 4.44 at 0.10 level, as presented in Tables 4.14. and 4.15.

Table 4.15. Analysis of the group decision of Expert Panel 3 for Indicators toward Green Innovativeness

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.1	2	0.049	4.44
Between Conditions:	0	10	0	
Residual:	0.22	20	0.011	
Total:	0.32	32		
Critical F-value with degrees of freedom 2 & 20 at 0.1 level:				2.59

4.1.1.3.2. Results for Sub-indicators of Green Innovativeness

According to Expert Panel 3, the weights of the 12 Sub-indicators grouped by indicators of the Green Innovativeness are as follows:

1. Intensity of Green Products:

1.1. Percentage of Green Products in the Total Product Pool: 0.19

1.2. Percentage of Radically Green Products in the Total Product Pool: 0.25

1.3. Revenue from Green Products as percentage of the Total Revenue of the Company: 0.25

1.4. Revenue from Radically Green Products as percentage of the Total Revenue of the Company: 0.31

2. Intensity of Green Inventions:

2.1. Ratio of the Number of Green Patents to the Total Patents of the Company: 0.26

2.2. Ratio of the Number of Radically Green Patents to the Total Patents of the Company: 0.31

2.3. Revenue generated from Licensing Green Patents as percentage of the Total Revenue of the Company: 0.20

2.4. Revenue generated from Licensing Radically Green Patents as percentage of the Total Revenue of the Company: 0.23

3. Pace of Green Innovativeness:

3.1. Ratio of the Number of Green Patents for New products to the Total Number of Patents for Green Products (over the last 3 years): 0.21

3.2. Ratio of the Number of Radically Green Patents for New products to the Total Number of Patents for Green Products (over the last 3 years): 0.24

3.3. Ratio of the Average Revenue for New Green Products to the Average Revenue for All the Products (over the last 3 years): 0.25

3.4. Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for All the Products (over the last 3 years): 0.30

Members of greater Expert Panel 3 was divided into smaller expert panels of 10 to 13 experts to collectively decide on the relative weights of the indicators and sub-indicators for each indicator of the Green Innovativeness Performance Dimension.

With the judgment quantifications of these specific panels, the results for the 4th level of the HDM for the sub-indicators for Green Innovativeness Performance are as follows in Tables 4.16. thru 4.21.

According to the experts on the panel for Intensity of Green Products, the weight for Percentage of Green Products in the Total Product Pool is 0.19, Percentage of Radically Green Products in the Total Product Pool is 0.25, Revenue from Green Products as percentage of the Total Revenue of the Company is 0.25, Revenue from Radically Green Products as percentage of the Total Revenue of the Company is 0.31, as presented in Table 4.16. below.

Table 4.16. Group mean, individual inconsistencies & group disagreement for the panel on the sub-indicators of Intensity of Green Products of Green Innovativeness

Intensity of Green Products	% of Green Products	% of Radically Green Products	Revenue from Green Products as % of Revenue of the Company	Revenue from Radically Green Products as % of Revenue of the Company	Inconsistency
Expert 1	0.25	0.25	0.25	0.25	0.00
Expert 2	0.16	0.31	0.23	0.3	0.01
Expert 3	0.29	0.38	0.16	0.17	0.00
Expert 4	0.09	0.14	0.27	0.5	0.02
Expert 5	0.23	0.2	0.27	0.3	0.01
Expert 6	0.13	0.18	0.33	0.35	0.00
Expert 7	0.2	0.22	0.25	0.33	0.01
Expert 8	0.25	0.25	0.25	0.25	0.00
Expert 9	0.08	0.27	0.27	0.38	0.03
Expert 10	0.25	0.25	0.25	0.25	0.00
Mean	0.19	0.25	0.25	0.31	

The panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Intensity of Green Products is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on Panel 3 are acceptable based on the inconsistency, and the F-test value of 3.33 at 0.05 level, as presented in Tables 4.16. and 4.17.

Table 4.17. Analysis of the group decision of the panel on the sub-indicators of Intensity of Green Products of Green Innovativeness

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.07	3	0.022	3.33
Between Conditions:	0	9	0	
Residual:	0.18	27	0.007	
Total:	0.25	39		
Critical F-value with degrees of freedom 3 & 27 at 0.05 level:				2.96

According to the experts on the panel for Intensity of Green Inventions, the weight for Percentage of Green Patents is the Total Patent Pool is 0.19, Percentage of Radically Green Patents in the Total Patent Pool is 0.25, Revenue from Licensing Green Patents as percentage of the Total Revenue of the Company is 0.25, Revenue from Licensing Radically Green Products as percentage of the Total Revenue of the Company is 0.31. The results are presented on the following page, in Table 4.18.

Table 4.18. Group mean, individual inconsistencies & group disagreement for the panel on the sub-indicators of Intensity of Green Inventions of Green Innovativeness

Intensity of Green Inventions	Ratio of the Number of Green Patents to the Total Patents of the Company	Ratio of the Number of Radically Green Patents to the Total Patents of the Company	Revenue generated from Licensing Green Patents as percentage of the Total Revenue of the Company	Revenue generated from Licensing Radically Green Patents as percentage of the Total Revenue of the Company	Inconsistency
Expert 1	0.25	0.25	0.25	0.25	0.00
Expert 2	0.24	0.43	0.17	0.16	0.00
Expert 3	0.31	0.45	0.12	0.13	0.00
Expert 4	0.23	0.36	0.19	0.22	0.01
Expert 5	0.37	0.24	0.2	0.2	0.02
Expert 6	0.25	0.25	0.25	0.25	0.00
Expert 7	0.14	0.23	0.22	0.41	0.01
Expert 8	0.25	0.25	0.25	0.25	0.00
Expert 9	0.27	0.43	0.11	0.18	0.00
Expert 10	0.25	0.25	0.25	0.25	0.00
Mean	0.26	0.31	0.2	0.23	

This panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Intensity of Green Inventions is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the panel are acceptable based on the inconsistency, and the F-test value of 3.38 at 0.05 level, as presented in Tables 4.18. and 4.19.

Table 4.19. Analysis of the group decision of the panel on the sub-indicators of Intensity of Green Inventions of Green Innovativeness

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.07	3	0.023	3.38
Between Conditions:	0	9	0	
Residual:	0.19	27	0.007	
Total:	0.25	39		
Critical F-value with degrees of freedom 3 & 27 at 0.05 level:				2.96

According to the experts on the panel for Pace of Green Innovativeness, the weight for Ratio of the Number of Green Patents for New products to the Total Number of Patents for Green Products (over the last 3 years) is 0.21, Ratio of the Number of Radically Green Patents for New products to the Total Number of Patents for Green Products (over the last 3 years) is 0.24, Ratio of the Average Revenue for New Green Products to the Average Revenue for All the Products (over the last 3 years) is 0.25, Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for All the Products (over the last 3 years) is 0.30. The results are presented on the following page, in Table 4.20.

Table 4.20. Group mean, individual inconsistencies & group disagreement for the panel on the sub-indicators of Pace of Green Innovativeness of Green Innovativeness

Pace of Green Innovativeness	Ratio of the Number of Green Patents for New Products to the Total Number of Patents for Green Products	Ratio of the Number of Radically Green Patents for New Products to the Total Number of Patents for Green Products	Ratio of the Average Revenue for New Green Products to the Average Revenue for All the Products	Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for All the Products	Inconsistency
Expert 1	0.25	0.25	0.25	0.25	0.00
Expert 2	0.20	0.25	0.25	0.30	0.01
Expert 3	0.15	0.19	0.26	0.40	0.00
Expert 4	0.21	0.22	0.24	0.33	0.05
Expert 5	0.25	0.25	0.25	0.25	0.00
Expert 6	0.14	0.21	0.27	0.38	0.01
Expert 7	0.22	0.16	0.33	0.30	0.01
Expert 8	0.25	0.49	0.17	0.10	0.01
Expert 9	0.16	0.16	0.27	0.41	0.02
Expert 10	0.25	0.25	0.25	0.25	0.00
Expert 11	0.18	0.22	0.27	0.33	0.01
Expert 12	0.25	0.25	0.25	0.25	0.00
Expert 13	0.25	0.25	0.25	0.25	0.00
Mean	0.21	0.24	0.25	0.30	

The panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Intensity of Green Products is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on Panel 3 are acceptable based on the inconsistency, and the F-test value of 3.33 at 0.05 level, as presented in Tables 4.16. and 4.17.

Table 4.21. Group mean, individual inconsistencies & group disagreement for the panel on the sub-indicators of Pace of Green Innovativeness of Green Innovativeness

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.04	3	0.01	2.61
Between Conditions:	0.00	12	0.00	
Residual:	0.20	36	0.01	
Total:	0.24	51		
Critical F-value with degrees of freedom 3 & 36 at 0.1 level:				2.24

4.1.1.4. Results from Expert Panel 4

Expert Panel 4, developed the third and fourth level of the HDM for Green Index, for the Financial Performance Dimension. There were 18 experts on the expert pool for Expert Panel 4. These experts, with their various backgrounds as researchers, executive managers of high-tech companies, corporate governance executives, were grouped into smaller expert panels in relevance to the indicators and sub-indicators of being assessed. The experts were were initially were asked to validate the proposed indicators and sub-indicators for the Financial Performance Dimension of the Green Index, and followingly were asked to give their judgment quantifications on the indicators and sub-indicators.

4.1.1.4.1. Results for Indicators of Financial Performance

Following the validation of indicators and sub-indicators of Financial Performance Dimension, each expert was asked to compare two indicators at a time, regarding their relative importance toward the Financial Performance Dimension. In the last step of data collection from the expert panel, each expert was asked to compare two sub-indicators at a time, regarding each of their relative importance toward the indicators: Financial Strength of the company, Green Innovativeness Intensity of the Firm, and Green Financial Capability of the Firm.

Expert Panel 4 comprised of a total of 18 experts as researchers, corporate executive managers, product managers, marketing managers from the high-tech industry and finance sector. According to the experts on the panel, the weights for the indicators of Financial Performance Dimension are as: Financial Strength 0.39, Green Innovativeness Intensity of the Firm: 0.38, Green Financial Capability: 0.33. With the judgment quantifications of the panel, the results for the 3rd level of the HDM for Financial Performance are as follows as in Table 4.22.

The panel's decisions were analyzed, and the inconsistency level of each expert for the indicators of Financial Performance is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on the panel are acceptable based on the inconsistency, and the F-test value of 3.99 at 0.05 level, as presented in Tables 4.22. and 4.23.

Table 4.22. Group mean, individual inconsistencies & group disagreement for the panel on the indicators of Financial Performance

Financial Performance	Financial Strength	Green Innovativeness Intensity of the Firm	Green Financial Capability	Inconsistency
Expert 1	0.33	0.33	0.33	0
Expert 2	0.65	0.11	0.24	0.03
Expert 3	0.33	0.38	0.29	0.02
Expert 4	0.48	0.21	0.31	0
Expert 5	0.29	0.29	0.43	0
Expert 6	0.33	0.29	0.38	0.02
Expert 7	0.39	0.21	0.39	0
Expert 8	0.33	0.33	0.33	0
Expert 9	0.53	0.17	0.3	0.02
Expert 10	0.33	0.33	0.33	0
Expert 11	0.35	0.45	0.21	0
Expert 12	0.21	0.34	0.45	0
Expert 13	0.5	0.19	0.31	0
Expert 14	0.33	0.33	0.33	0.05
Expert 15	0.53	0.17	0.3	0.02
Expert 16	0.33	0.33	0.33	0
Mean	0.39	0.28	0.33	

Table 4.23. Group mean, individual inconsistencies & group disagreement for panel on the indicators of Financial Performance

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.10	2	0.05	3.99
Between Conditions:	0.00	15	0.00	
Residual:	0.38	30	0.01	
Total:	0.48	47		
Critical F-value with degrees of freedom 2 & 30 at 0.05 level:				3.32

4.1.1.4.2. Results for Sub-indicators of Financial Performance

According to the experts on Panel 4, the weights of the 9 Sub-indicators grouped by indicators of the Financial Performance are as follows:

1. Financial Strength:

1.1. Return on Assets: 0.45

1.2. Return on Equity: 0.55

2. Green Innovativeness Intensity of the Firm

2.1. Percentage of Green Patents in the Assets: 0.45

2.2. Percentage of Green R & D in the Assets: 0.55

3. Green Financial Capability of the Firm:

3.1. Return on Investment (ROI): 0.26

3.2. Return on Investment for Green Products (ROIG.Pr.): 023

3.3. Return on Investment for Green Patents (ROIG.Pt.): 0.16

3.4. Ratio of Return on Investment for Green Products to the Return on Investment (ROIG.Pr. / ROI): 0.19

3.5. Ratio of Return on Investment for Green Patents to the Return on Investment (ROIG.Pt. / ROI): 0.16

Members of the greater Expert Panel 4 were divided into smaller expert panels of 14 to 18 to collectively decide on the relative weights of the indicators and sub-indicators for each indicator of the Financial Performance Dimension.

With the judgment quantifications of these specific panels, the results for the 4th level of the HDM for the sub-indicators Financial Performance are as follows in Tables 4.24. thru 4.29.

According to the experts on the panel for Financial Strength, the weight for Return on Assets is 0.45, Return on Equity is 0.55, as presented in Table 4.24. below.

Table 4.24. Group mean, individual inconsistencies & group disagreement for the panel on the sub-indicators of Financial Strength

Financial Strength	ROA	ROE	Inconsistency
Expert 1	0.50	0.50	0
Expert 2	0.35	0.65	0
Expert 3	0.50	0.50	0
Expert 4	0.50	0.50	0
Expert 5	0.50	0.50	0
Expert 6	0.30	0.70	0
Expert 7	0.45	0.55	0
Expert 8	0.30	0.70	0
Expert 9	0.30	0.70	0
Expert 10	0.40	0.60	0
Expert 11	0.50	0.50	0
Expert 12	0.50	0.50	0
Expert 13	0.60	0.40	0
Expert 14	0.55	0.45	0
Expert 15	0.40	0.60	0
Expert 16	0.50	0.50	0
Mean	0.45	0.55	

The panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Financial Strength is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on the panel are acceptable based on the inconsistency, and the F-test value of 5.12 at 0.05 level, as presented in Tables 4.24. and 4.25.

Table 4.25. Analysis of the group decision of the panel on the sub-indicators of Financial Strength

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.09	1	0.09	5.12
Between Conditions:	0	15	0	
Residual:	0.26	15	0.018	
Total:	0.36	31		
Critical F-value with degrees of freedom 1 & 15 at 0.05 level:				4.54

According to the experts on the panel for Green Innovativeness Intensity of the Firm, Percentage of Green Patents in the Assets is 0.45, Percentage of Green R & D in the Assets is 0.55, as presented in Table 4.26. below.

Table 4.26. Group mean, individual inconsistencies & group disagreement for the panel on the sub-indicators of Green Innovativeness Intensity of the Firm

Green Innovativeness Intensity of the Firm	**Percentage of Green Patents in the Assets**	**Percentage of Green R&D in the Assets**	**Inconsistency**
Expert 1	0.5	0.5	0.00
Expert 2	0.5	0.5	0.00
Expert 3	0.6	0.4	0.00
Expert 4	0.4	0.6	0.00
Expert 5	0.35	0.65	0.00
Expert 6	0.25	0.75	0.00
Expert 7	0.5	0.5	0.00
Expert 8	0.4	0.6	0.00
Expert 9	0.4	0.6	0.00
Expert 10	0.45	0.55	0.00
Expert 11	0.5	0.5	0.00
Expert 12	0.55	0.45	0.00
Expert 13	0.4	0.6	0.00
Expert 14	0.5	0.5	0.00
Mean	0.45	0.55	

The panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Financial Strength is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on the panel are acceptable based on the inconsistency, and the F-test value of 4.33 at 0.10 level, as presented in Tables 4.26. and 4.27.

Table 4.27. Analysis of the group decision of the panel on the sub-indicators of Green Innovativeness Intensity of the Firm

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.07	1	0.07	4.33
Between Conditions:	0	13	0	
Residual:	0.21	13	0.016	
Total:	0.28	27		
Critical F-value with degrees of freedom 1 & 13 at 0.1 level:				3.14

According to the experts on the panel for Green Financial Capability of the Firm, Return on Investment (ROI) is 0.26, Return on Investment for Green Products (ROIG.Pr.) is 023, Return on Investment for Green Patents (ROIG.Pt.) is 0.16, Ratio of Return on Investment for Green Products to the Return on Investment (ROIG.Pr. / ROI) is 0.19, Ratio of Return on Investment for Green Patents to the Return on Investment (ROIG.Pt. / ROI) is 0.16, as presented in Table 4.28. below.

Table 4.28. Group mean, individual inconsistencies & group disagreement for the panel on the sub-indicators of Green Financial Capability of the Firm

Green Financial Capability of the Firm	ROI	ROI for Green Products (ROIG.Pr.)	ROI for Green Patents (ROIG.Ptn.)	ROIG.Pr. / ROI	ROIG.Ptn. / ROI	Inconsistency
Expert 1	0.20	0.20	0.20	0.20	0.20	0.00
Expert 2	0.45	0.27	0.16	0.07	0.05	0.04
Expert 3	0.05	0.33	0.17	0.26	0.19	0.01
Expert 4	0.20	0.26	0.17	0.21	0.16	0.00
Expert 5	0.41	0.27	0.10	0.16	0.05	0.00
Expert 6	0.22	0.22	0.18	0.22	0.17	0.01
Expert 7	0.27	0.36	0.16	0.11	0.09	0.02
Expert 8	0.18	0.23	0.22	0.18	0.18	0.01
Expert 9	0.58	0.17	0.08	0.11	0.05	0.01
Expert 10	0.29	0.18	0.15	0.18	0.20	0.04
Expert 11	0.26	0.29	0.13	0.16	0.16	0.02
Expert 12	0.20	0.20	0.20	0.20	0.20	0.00
Expert 13	0.17	0.20	0.20	0.22	0.22	0.00
Expert 14	0.08	0.15	0.12	0.35	0.30	0.01
Expert 15	0.34	0.20	0.12	0.19	0.15	0.02
Expert 16	0.14	0.20	0.24	0.21	0.21	0.00
Expert 17	0.26	0.29	0.13	0.16	0.16	0.02
Expert 18	0.20	0.20	0.20	0.20	0.20	0.00
Mean	0.25	0.23	0.16	0.19	0.16	

The panel's decisions were analyzed, and the inconsistency level of each expert for the sub-indicators of Green Financial Capability is less than the allowed inconsistency level of 0.1. In conclusion, the aggregate results from the experts on the panel are acceptable based on the inconsistency, and the F-test value of 3.92 at 0.01 level, as presented in Tables 4.28. and 4.29.

Table 4.29. Analysis of the group decision of the panel on the sub-indicators of Green Financial Capability of the Firm

Source of Variation	Sum of Square	Degrees of freedom	Mean Square	F-test value
Between Subjects:	0.12	4.00	0.03	3.92
Between Conditions:	0.00	17.00	0.00	
Residual:	0.51	68.00	0.01	
Total:	0.63	89.00		
Critical F-value with degrees of freedom 4 & 68 at 0.01 level:				3.61

4.1.2. Stage 2

Collection of data from Expert Panel 5 for the creation of the Desirability Curves for each sub-indicator of the Green Index model.

4.1.2.1. Results from Expert Panel 5

Expert Panel 5, developed the Desirability Curves of the performance metrics for each one of the sub-indicators. Expert Panel 5 comprised of 8 investors, angel investors, and venture capitalists who invest in high-tech companies. About 50 % the experts on this panel, also has investments in green technologies, and green entrepreneurial companies. The group means of the experts desirability quantifications for the various levels of the performance metric of each sub-indicator were used to obtain the Desirability Curves for each. These 29 Desirability Curves obtained for each sub-indicator are presented below in order, with the corresponding mean quantifications by the experts on the panel.

Sub-Indicator 1: Total Water Consumption / Revenue

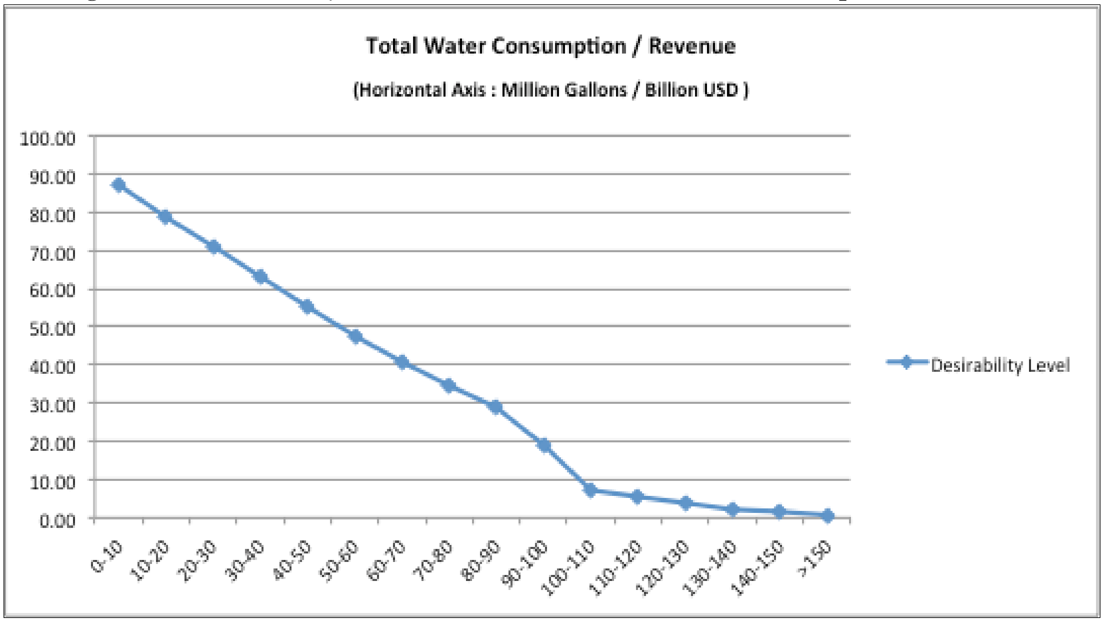
Desirability Curves for the Performance Metric for Sub-indicator 1 (PM-1)

Experts on the panel quantified the desirability values for various performance levels of Total Water Consumption / Revenue (Million Gallons / Billion USD) as follows. The desirability curve represents a negatively linear form with increased values of Total Water Consumption per Revenue, the highest desirability level achievable is 86.99 for 0-10 Million Gallons / Billion USD performance metric interval. The results are presented in Table 4.30 and Figure 4.2.

Table 4.30. Desirability levels for PM – 1 Total Water Consumption / Revenue

PM-1	**Total Water Consumption / Revenue**
Million Gallons / Billion USD	**Desirability Level**
0-10	86.88
10-20	78.88
20-30	70.88
30-40	62.88
40-50	55.50
50-60	47.63
60-70	41.00
70-80	34.75
80-90	29.13
90-100	18.88
100-110	7.00
110-120	5.75
120-130	4.13
130-140	2.00
140-150	1.38
>150	0.75

Figure 4.2. Desirability Curve for PM – 1 Total Water Consumption / Revenue



Sub-Indicator 2: Percentage Change in (Total Water Consumption / Revenue) with respect to previous year

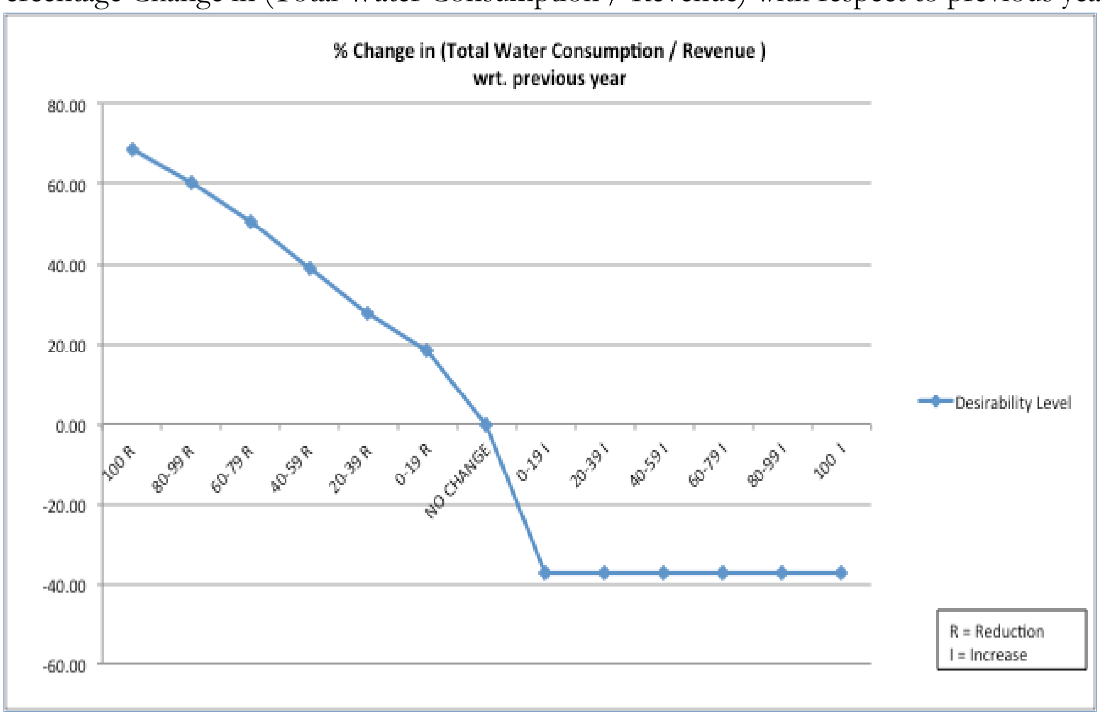
Desirability Curves for the Performance Metric for Sub-indicator 2 (PM-2)

Experts on the panel quantified the desirability values for various performance levels of Percentage Change in (Total Water Consumption / Revenue) with respect to previous year as follows. The desirability curve represents a negatively linear form with increased values of percentage change and negative desirability levels are quantified for increase in percentage change. The highest desirability level achievable is 68.75 for 100% reduction in (Total Water Consumption / Revenue) with respect to previous year, and the lowest desirability level is -37.50 for 0-100 % increase. The results are presented in Table 4.31 and Figure 4.3.

Table 4.31. Desirability levels for PM – 2
Percentage Change in (Total Water Consumption / Revenue) with respect to previous year

PM-2	% Change wrt. previous year
%	**Desirability Level**
100 R	68.75
80-99 R	60.25
60-79 R	50.38
40-59 R	38.75
20-39 R	27.63
0-19 R	18.13
NO CHANGE	0.00
0-19 I	-37.50
20-39 I	-37.50
40-59 I	-37.50
60-79 I	-37.50
80-99 I	-37.50
100 I	-37.50

Figure 4.3. Desirability Curves for PM – 2
Percentage Change in (Total Water Consumption / Revenue) with respect to previous year



Sub-Indicator 3: Total Energy Consumption / Revenue

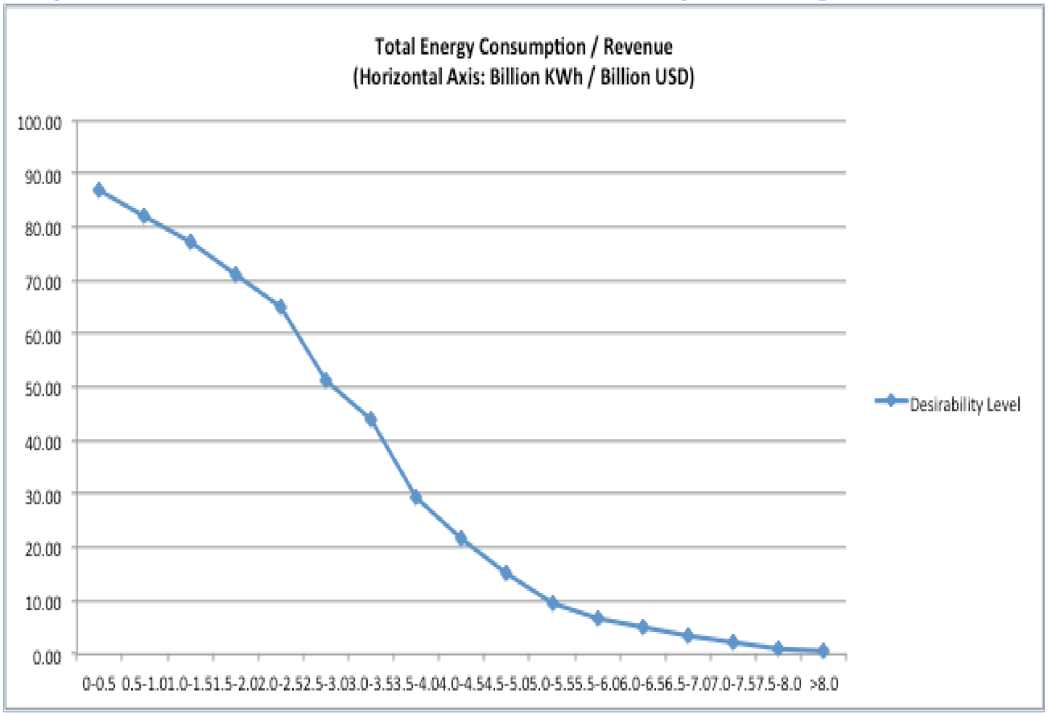
Desirability Curves for the Performance Metric for Sub-indicator 3 (PM-3)

Experts on the panel quantified the desirability values for various performance levels of Total Energy Consumption / Revenue (Billion KWh / Billion USD) as follows. The desirability curve represents a negatively linear form, almost logarithmic with increased values of Total Energy Consumption per Revenue. The highest desirability level achievable is 87.13 for 0-0.5 Billion KWh / Billion USD performance metric interval. The results are presented in Table 4.32 and Figure 4.4.

Table 4.32. Desirability levels for PM – 3 Total Energy Consumption / Revenue

PM-3	**Total Energy Consumption / Revenue**
Billion KWh / Billion USD	**Desirability Level**
0-0.5	87.13
0.5-1.0	82.25
1.0-1.5	77.25
1.5-2.0	71.25
2.0-2.5	65.25
2.5-3.0	51.25
3.0-3.5	44.00
3.5-4.0	29.25
4.0-4.5	21.50
4.5-5.0	15.00
5.0-5.5	9.63
5.5-6.0	6.75
6.0-6.5	5.13
6.5-7.0	3.50
7.0-7.5	2.13
7.5-8.0	1.00
>8.0	0.50

Figure 4.4. Desirability Curve for PM – 3 Total Energy Consumption / Revenue



Sub-Indicator 4: Percentage Change in (Total Energy Consumption / Revenue) with respect to previous year

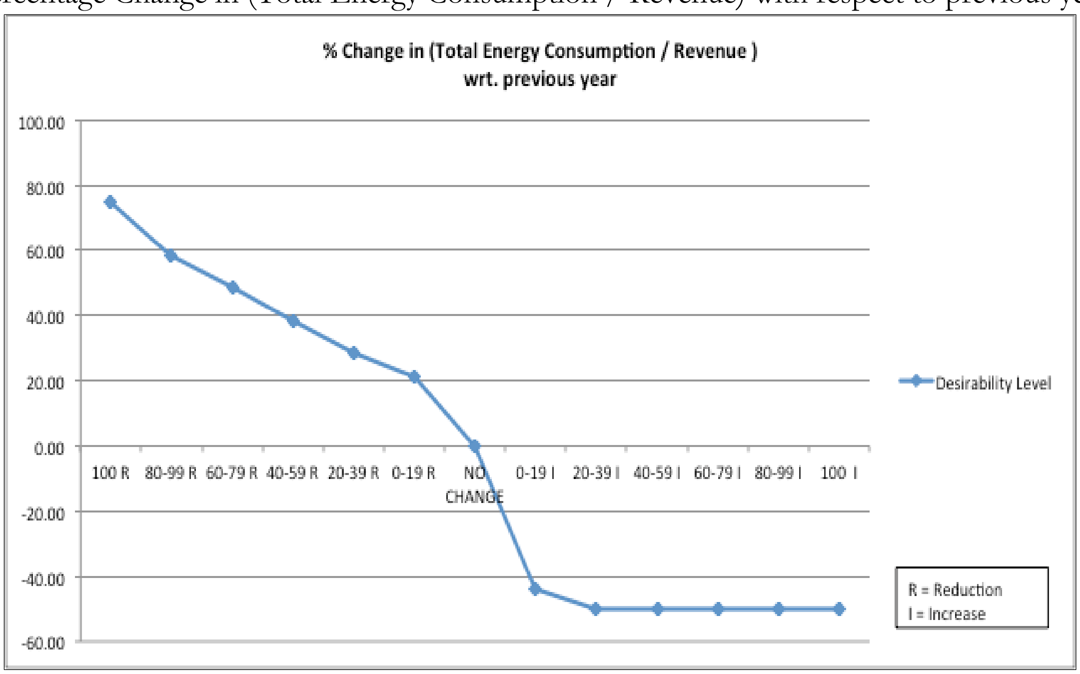
Desirability Curves for the Performance Metric for Sub-indicator 4 (PM-4)

Experts on the panel quantified the desirability values for various performance levels of Percentage Change in (Total Energy Consumption / Revenue) with respect to previous year as follows. The desirability curve represents a negatively linear form with increased values of percentage change and negative desirability levels are quantified for increase in percentage change. The highest desirability level achievable is 74.88 for 100% reduction in (Total Energy Consumption / Revenue) with respect to previous year, and the lowest desirability level is -50.00 for 0-100 % increase. The results are presented in Table 4.33 and Figure 4.5.

Table 4.33. Desirability levels for PM – 4
Percentage Change in (Total Energy Consumption / Revenue) with respect to previous year

PM-4	% Change wrt. previous year
%	Desirability Level
100 R	74.88
80-99 R	58.75
60-79 R	48.50
40-59 R	38.25
20-39 R	28.75
0-19 R	21.38
NO CHANGE	0.00
0-19 I	-43.75
20-39 I	-50.00
40-59 I	-50.00
60-79 I	-50.00
80-99 I	-50.00
100 I	-50.00

Figure 4.5. Desirability Curves for PM – 4
Percentage Change in (Total Energy Consumption / Revenue) with respect to previous year



Sub-Indicator 5: Total Waste / Revenue

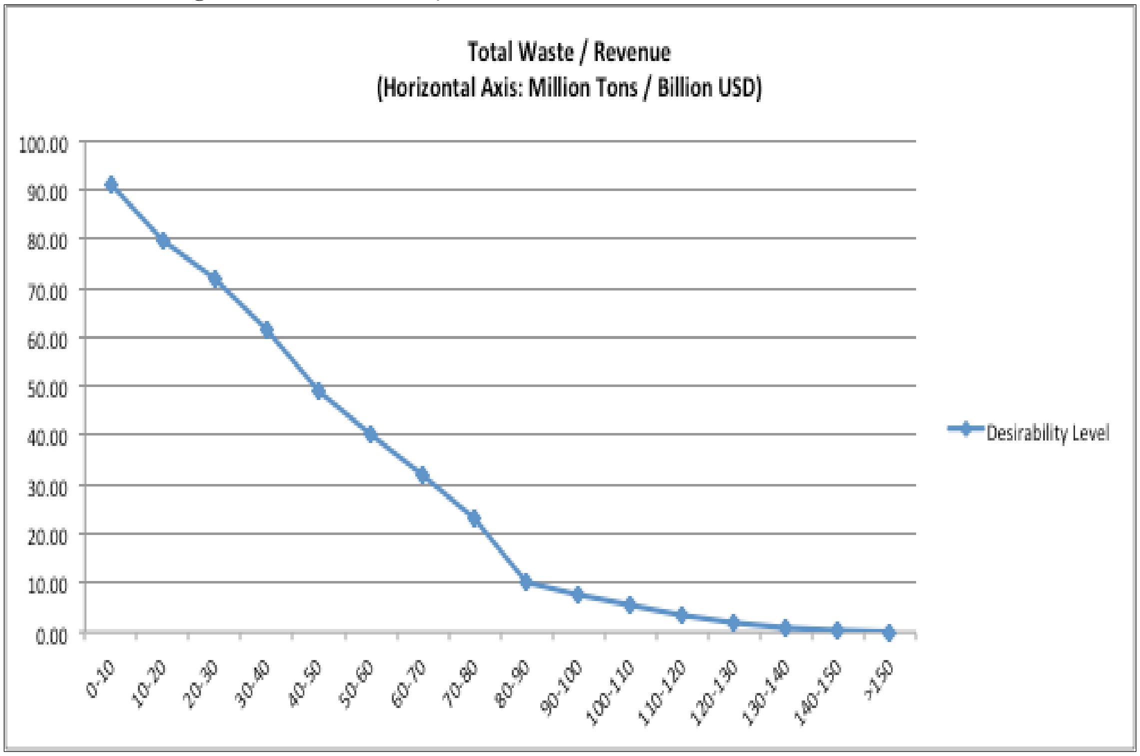
Desirability Curves for the Performance Metric for Sub-indicator 5 (PM-5)

Experts on the panel quantified the desirability values for various performance levels of Total Waste / Revenue (Million Tons / Billion USD) as follows. The desirability curve represents a negatively linear form with increased values of Total Waste per Revenue. The highest desirability level achievable is 91.13 for 0-10 Million Tons / Billion USD performance metric interval. The results are presented in Table 4.34 and Figure 4.6.

Table 4.34. Desirability levels for PM – 5 Total Waste / Revenue

PM-5	**Total Waste / Revenue**
Million Tons / Billion USD	**Desirability Level**
0-10	91.13
10-20	79.50
20-30	71.88
30-40	61.63
40-50	49.00
50-60	40.50
60-70	31.75
70-80	23.00
80-90	10.38
90-100	7.50
100-110	5.50
110-120	3.38
120-130	2.00
130-140	0.88
140-150	0.50
>150	0.00

Figure 4.6. Desirability Curve for PM – 5 Total Waste / Revenue



Sub-Indicator 6: Percentage Change in (Total Waste / Revenue) with respect to previous year

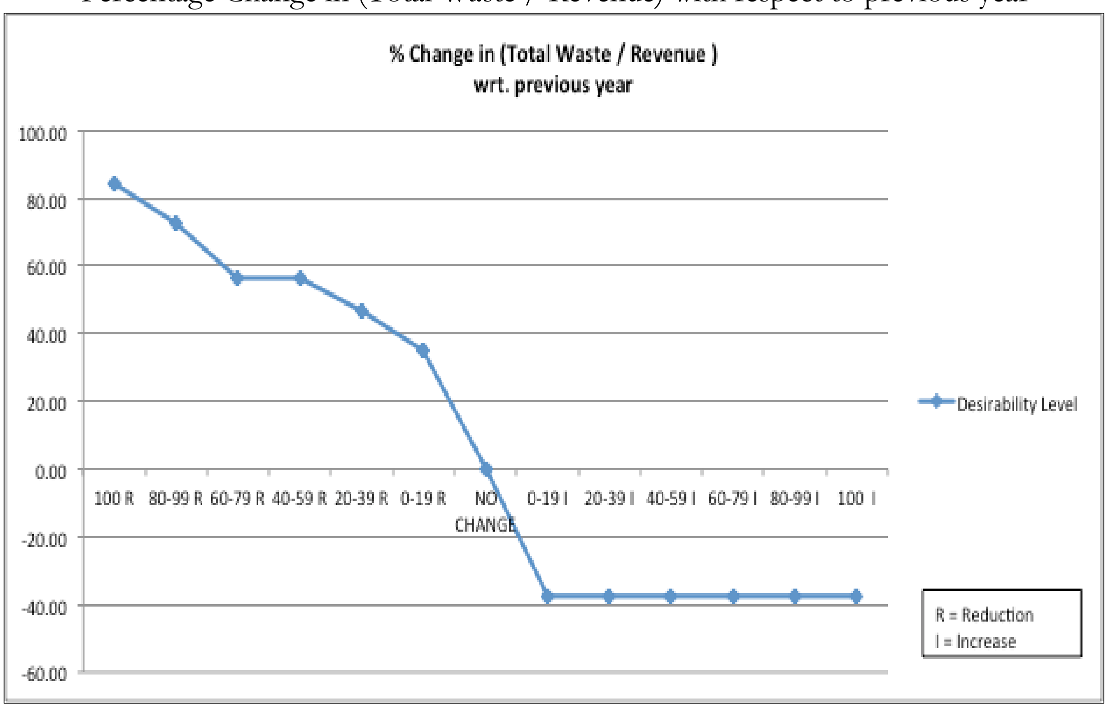
Desirability Curves for the Performance Metric for Sub-indicator 6 (PM-6)

Experts on the panel quantified the desirability values for various performance levels of Percentage Change in (Total Waste / Revenue) with respect to previous year as follows. The desirability curve represents a negatively curvi-linear form with increased values of percentage change and negative desirability levels are quantified for increase in percentage change. The highest desirability level achievable is 84.63 for 100% reduction in (Total Waste / Revenue) with respect to previous year, and the lowest desirability level is -37.50 for 0-100 % increase. The results are presented in Table 4.35 and Figure 4.7.

Table 4.35. Desirability levels for PM – 6
Percentage Change in (Total Waste / Revenue) with respect to previous year

PM-6	% Change wrt. previous year
%	**Desirability Level**
100 R	84.63
80-99 R	72.75
60-79 R	56.25
40-59 R	56.25
20-39 R	46.88
0-19 R	34.75
NO CHANGE	0.00
0-19 I	-37.50
20-39 I	-37.50
40-59 I	-37.50
60-79 I	-37.50
80-99 I	-37.50
100 I	-37.50

Figure 4.7. Desirability Curves for PM – 6
Percentage Change in (Total Waste / Revenue) with respect to previous year



Sub-Indicator 7: Green House Gas Emission / Revenue

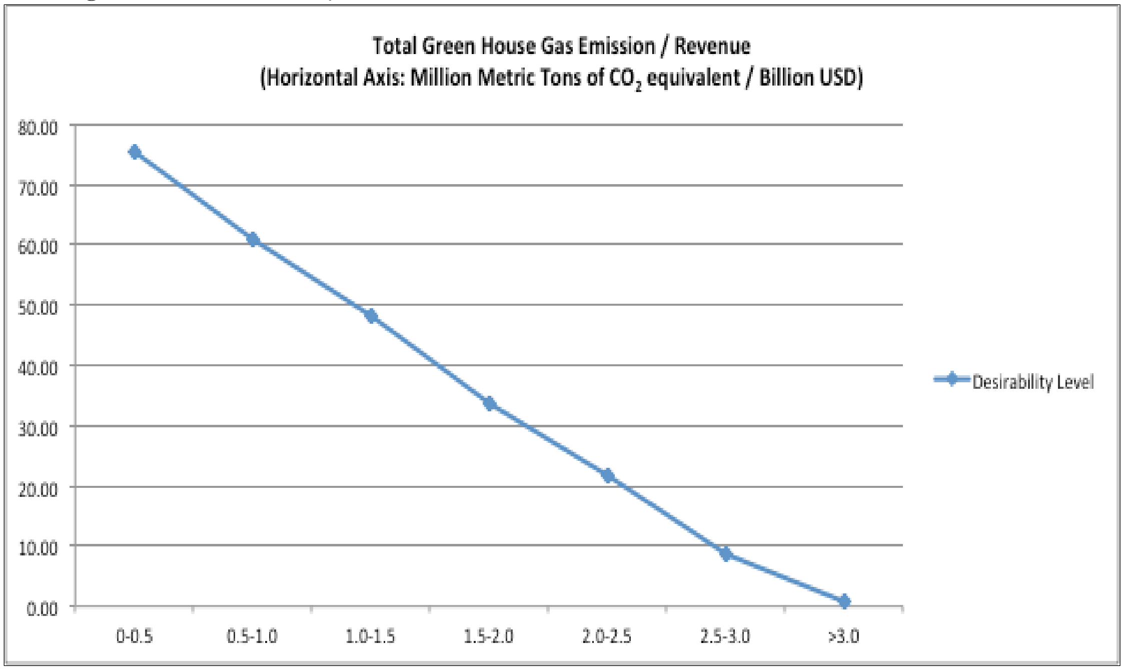
Desirability Curves for the Performance Metric for Sub-indicator 7 (PM-7)

Experts on the panel quantified the desirability values for various performance levels of Green House Gas Emission / Revenue (Million Metric Tons of CO_2 equivalent / Billion USD) as follows. The desirability curve represents a negatively linear form with increased values of Million Metric Tons of CO_2 equivalent. The highest desirability level achievable is 75.38 for 0 - 0.5 Million Metric Tons of CO_2 equivalent / Billion USD performance metric interval. The results are presented in Table 4.36 and Figure 4.8.

Table 4.36. Desirability levels for PM – 7 Green House Gas Emission / Revenue

PM-7	Green House Gas Emission / Revenue
Million Metric Tons of CO_2 equivalent / Billion USD	**Desirability Level**
0-0.5	75.38
0.5-1.0	60.88
1.0-1.5	48.25
1.5-2.0	33.50
2.0-2.5	21.88
2.5-3.0	8.75
>3.0	0.63

Figure 4.8. Desirability Curve for PM – 7 Green House Gas Emission / Revenue



Sub-Indicator 8: Percentage Change in (Green House Gas Emission / Revenue) with respect to previous year

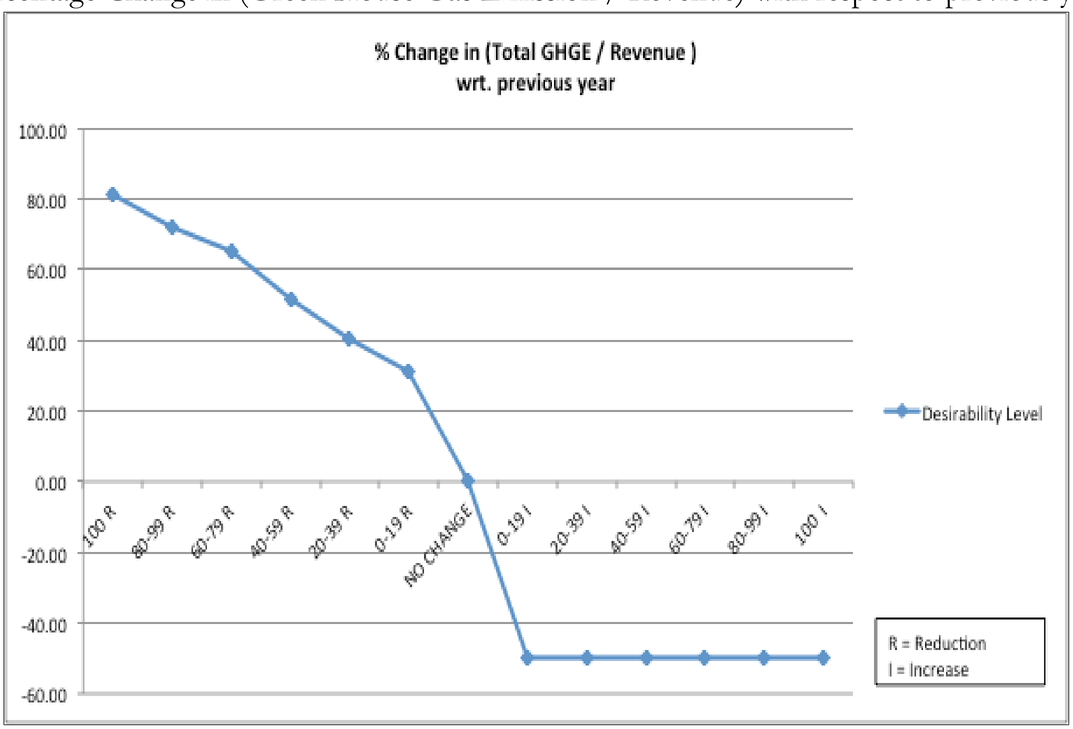
Desirability Curves for the Performance Metric for Sub-indicator 8 (PM-8)

Experts on the panel quantified the desirability values for various performance levels of Percentage Change in (Green House Gas Emission / Revenue) with respect to previous year as follows. The desirability curve represents a negatively curvi-linear form with increased values of percentage change and negative desirability levels are quantified for increase in percentage change. The highest desirability level achievable is 81.13 for 100% reduction in (Green House Gas Emission / Revenue) with respect to previous year, and the lowest desirability level is -50.00 for 0-100 % increase. The results are presented in Table 4.37 and Figure 4.9.

Table 4.37. Desirability levels for PM – 8
Percentage Change in (Green House Gas Emission / Revenue) with respect to previous year

PM-8	% Change wrt. previous year
%	**Desirability Level**
100 R	81.13
80-99 R	72.25
60-79 R	65.25
40-59 R	51.38
20-39 R	40.63
0-19 R	31.50
NO CHANGE	0.00
0-19 I	-50.00
20-39 I	-50.00
40-59 I	-50.00
60-79 I	-50.00
80-99 I	-50.00
100 I	-50.00

Figure 4.9. Desirability Curves for PM – 8
Percentage Change in (Green House Gas Emission / Revenue) with respect to previous year



Sub-Indicator 9: Percentage of Green Products in the Total Product Pool

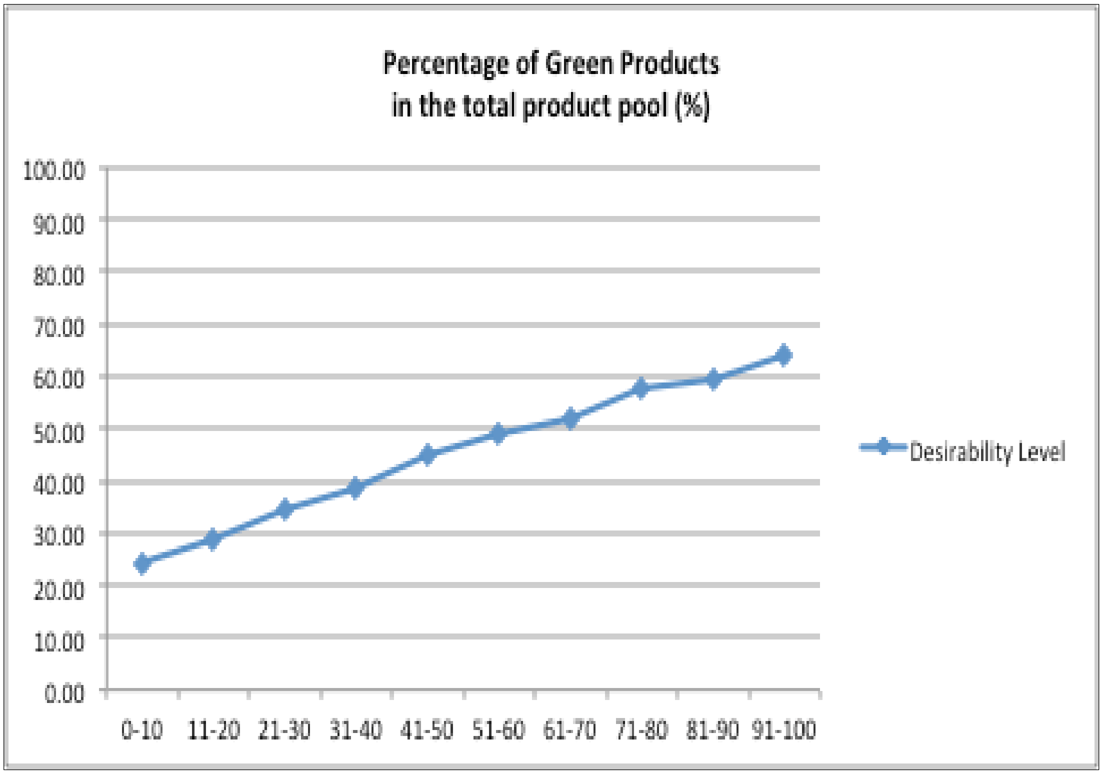
Desirability Curves for the Performance Metric for Sub-indicator 9 (PM-9)

Experts on the panel quantified the desirability values for various performance levels of Percentage of Green Products in the Total Product Pool (%) as follows. The desirability curve represents a positively linear form with increased values of percentage of Green Products in the total product pool. The highest desirability level achievable is 64.00 for (91 – 100) % and 24.38 as the lowest desirability level for (0 – 10) %performance metric interval respectively. The results are presented in Table 4.38 and Figure 4.10.

Table 4.38. Desirability levels for PM – 9 Percentage of Green Products in the Total Product Pool

PM-9	**Percentage of Green Products in the Total Product Pool**
%	**Desirability Level**
0-10	24.38
11-20	28.63
21-30	34.38
31-40	38.50
41-50	44.75
51-60	48.75
61-70	52.13
71-80	57.50
81-90	59.63
91-100	64.00

Figure 4.10. Desirability Curve for PM – 9 Percentage of Green Products in the Total Product Pool



Sub-Indicator 10: Percentage of Radically Green Products in the Total Product Pool

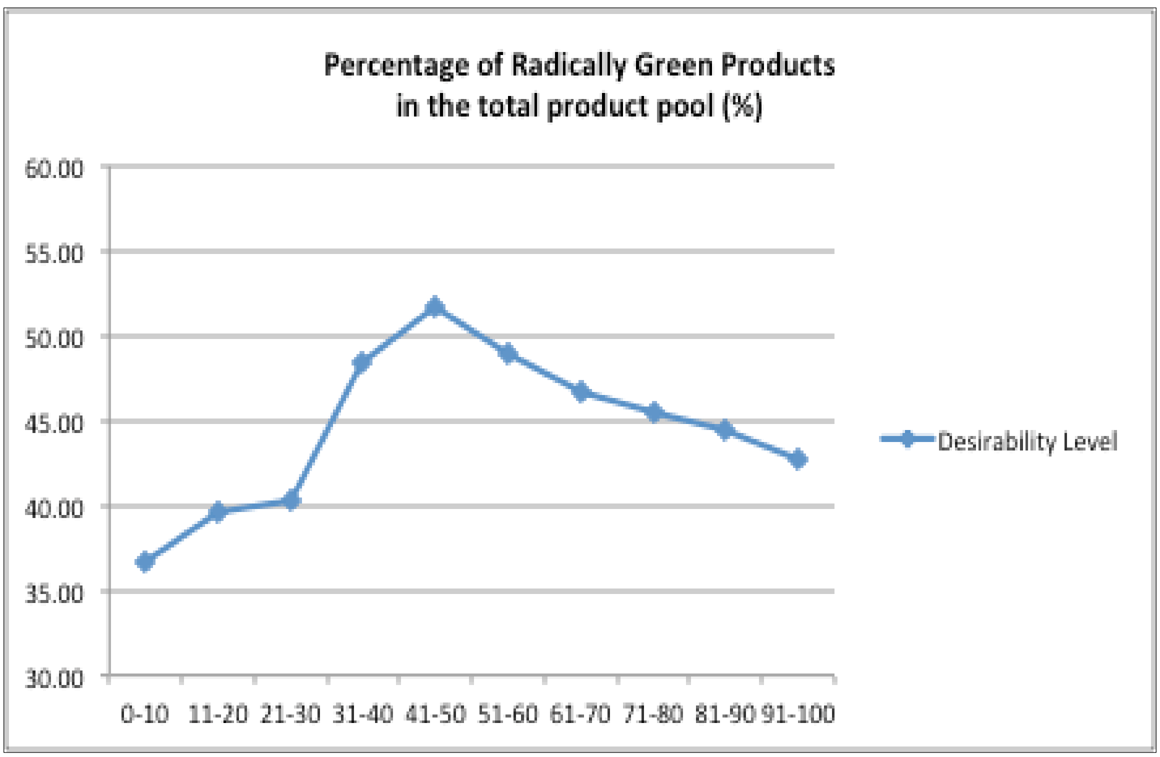
Desirability Curves for the Performance Metric for Sub-indicator 10 (PM-10)

Experts on the panel quantified the desirability values for various performance levels of Percentage of Radically Green Products in the Total Product Pool (%) as follows. The desirability curve represents a concave form with a peak value for 41-50 % interval, increasing until that level, and reducing for higher values of radically green product percentage in the product portfolio. The highest desirability level achievable is 51.63 for 41 - 50 %, lowest desirability level of 36.63 for (0-10) % performance metric intervals respectively. The desirability level for having Radically Green Products at (91-100) % share is 42.75. The results are presented in Table 4.39 and Figure 4.11.

Table 4.39. Desirability levels for PM – 10 Percentage of Radically Green Products in the Total Product Pool

PM-10	Percentage of Radically Green Products in the Total Product Pool
%	Desirability Level
0-10	36.63
11-20	39.63
21-30	40.38
31-40	48.38
41-50	51.63
51-60	48.88
61-70	46.63
71-80	45.50
81-90	44.38
91-100	42.75

Figure 4.11. Desirability Curve for PM – 10 Percentage of Radically Green Products in the Total Product Pool



Sub-Indicator 11: Revenue generated from Green Products as percentage of the total revenue of the company

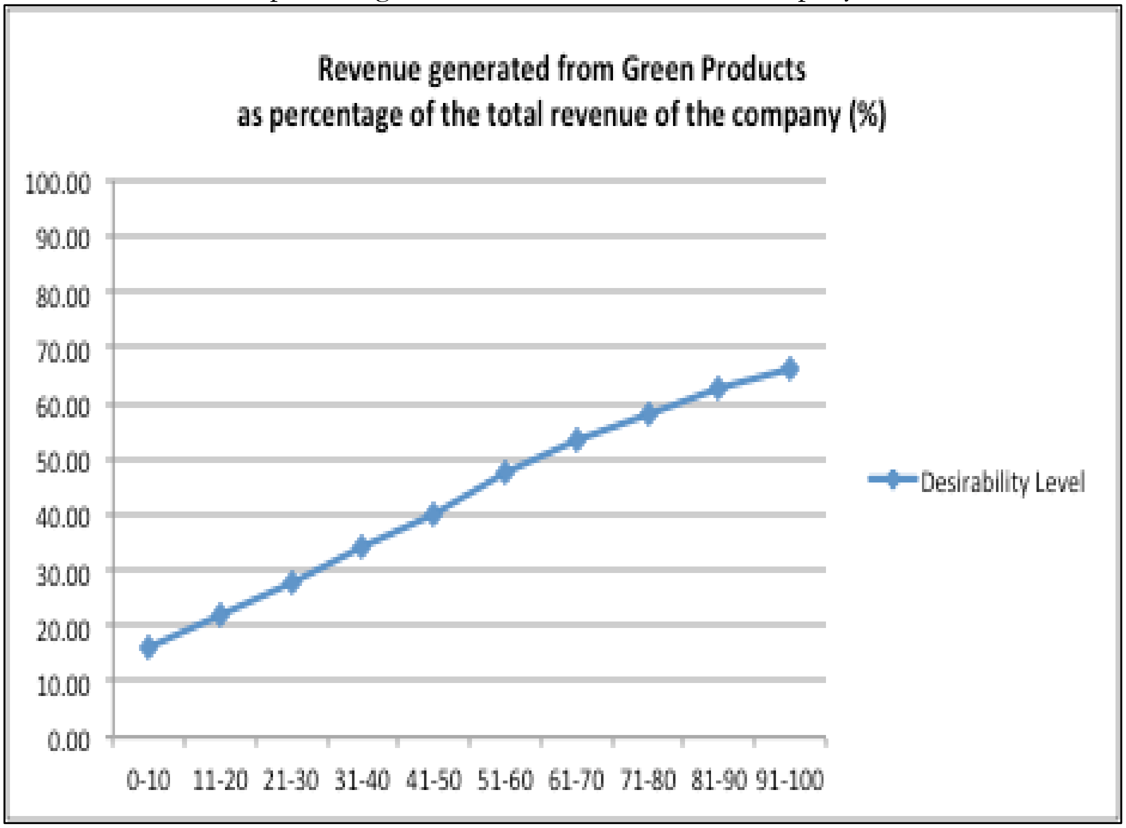
Desirability Curves for the Performance Metric for Sub-indicator 11 (PM-11)

Experts on the panel quantified the desirability values for various performance levels of Revenue generated from Green Products as percentage of the total revenue of the company (%) as follows. The desirability curve represents a positively linear form with increased values of Revenue generated from Green Products as percentage of the total revenue of the company. The highest desirability value achievable is 65.88 for (91 – 100) % while the lowest desirability level of 16.13 corresponds to (0-10) % performance metric interval. The results are presented in Table 4.40 and Figure 4.12.

Table 4.40. Desirability levels for PM – 11 Revenue generated from Green Products as percentage of the total revenue of the company

PM-11	**Revenue generated from Green Products as percentage of the total revenue of the company**
%	**Desirability Level**
0-10	16.13
11-20	21.63
21-30	27.50
31-40	34.00
41-50	39.75
51-60	47.38
61-70	53.25
71-80	57.75
81-90	62.38
91-100	65.88

Figure 4.12. Desirability Curve for PM – 11 Revenue generated from Green Products as percentage of the total revenue of the company



Sub-Indicator 12: Revenue generated from Radically Green Products as percentage of the total revenue of the company

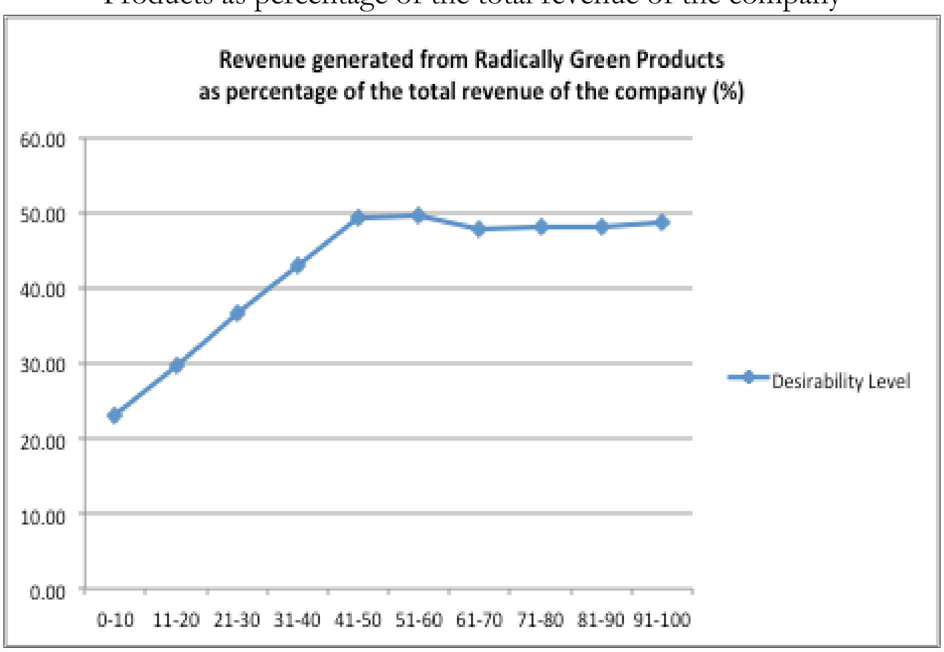
Desirability Curves for the Performance Metric for Sub-indicator 12 (PM-12)

Experts on the panel quantified the desirability values for various performance levels of Revenue generated from Radically Green Products as percentage of the total revenue of the company (%) as follows. The desirability curve represents concave form with increased values of Revenue generated from Radically Green Products as percentage of the total revenue of the company. The highest desirability level achievable is 49.75 for 51-60 % performance metric interval. The desirability curve represents a concave form with a peak value of 49.75 for 51-60 % performance metric interval increasing until that level, and getting almost stable for higher percentage values of Revenue generated from Radically Green Products as percentage of the total revenue of the company. The highest desirability level achievable is 49.75 for 51 - 60 %, lowest desirability level of 23.13 for (0-10) % performance metric intervals respectively. The desirability level for having Revenue generated from Radically Green Products at the level of (91-100) percentage of the total revenue of the company 48.88. The results are presented in Table 4.41 and Figure 4.13.

Table 4.41. Desirability levels for PM – 12 Revenue generated from Radically Green Products as percentage of the total revenue of the company

PM-12	Revenue generated from Radically Green Products as percentage of the total revenue of the company
%	**Desirability Level**
0-10	23.13
11-20	29.63
21-30	36.50
31-40	43.00
41-50	49.25
51-60	49.75
61-70	47.75
71-80	48.13
81-90	48.25
91-100	48.88

Figure 4.13. Desirability Curve for PM – 12 Revenue generated from Radically Green Products as percentage of the total revenue of the company



Sub-Indicator 13: Ratio of the number of Green Patents to the total number of patents (%)

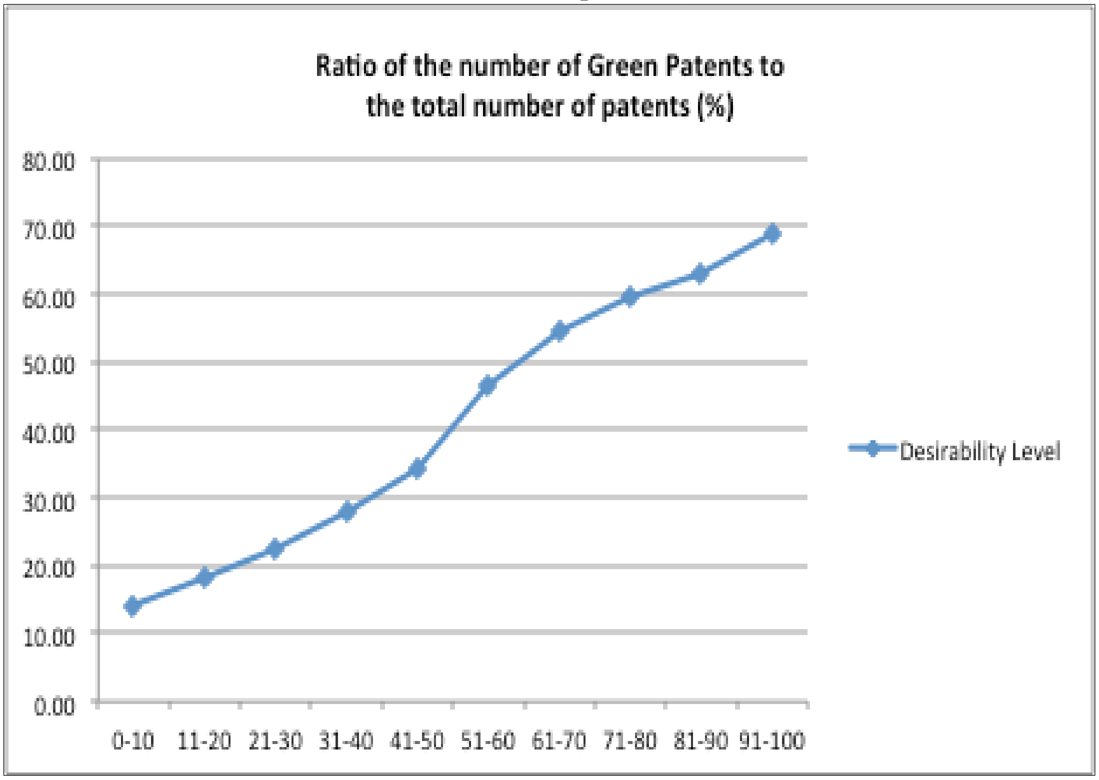
Desirability Curves for the Performance Metric for Sub-indicator 13 (PM-13)

Experts on the panel quantified the desirability values for various performance levels of Ratio of the number of Green Patents to the total number of patents (%) as follows. The desirability curve represents almost a positively linear form with increased values of Ratio of the number of Green Patents to the total number of patents. The highest desirability level achievable is 69.00 for 91-100 % performance metric interval. And the lowest desirability level of 14.13 corresponds to the (0-10) % performance metric interval. The results are presented in Table 4.42 and Figure 4.14.

Table 4.42. Desirability levels for PM – 13 Ratio of the number of Green Patents to the total number of patents (%)

PM-13	Ratio of the number of Green Patents to the total number of patents (%)
%	**Desirability Level**
0-10	14.13
11-20	18.25
21-30	22.38
31-40	28.00
41-50	34.13
51-60	46.38
61-70	54.75
71-80	59.63
81-90	63.13
91-100	69.00

Figure 4.14. Desirability Curve for PM – 13 Ratio of the number of Green Patents to the total number of patents (%)



Sub-Indicator 14: Ratio of the number of Radically Green Patents to the total number of patents

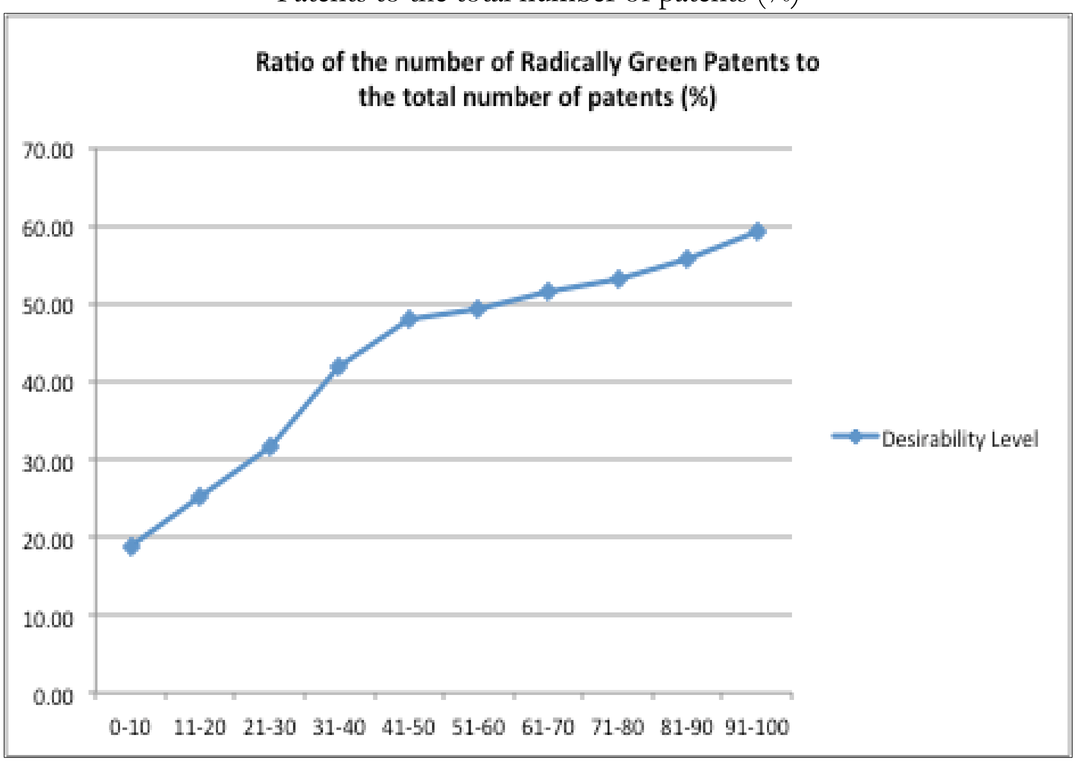
Desirability Curves for the Performance Metric for Sub-indicator 14 (PM-14)

Experts on the panel quantified the desirability values for various performance levels of Ratio of the number of Radically Green Patents to the total number of patents (%) as follows. The desirability curve represents almost a positively linear form with increased values of Ratio of the number of Radically Green Patents to the total number of patents. The highest desirability level achievable is 59.25 for 91-100 % performance metric interval. And the lowest desirability level of 18.88 corresponds to the (0-10) % performance metric interval. The results are presented in Table 4.43 and Figure 4.15.

Table 4.43. Desirability levels for PM – 14 Ratio of the number of Radically Green Patents to the total number of patents (%)

PM-14	Ratio of the number of Radically Green Patents to the total number of patents (%)
%	Desirability Level
0-10	18.88
11-20	25.25
21-30	31.63
31-40	41.88
41-50	48.00
51-60	49.38
61-70	51.63
71-80	53.13
81-90	55.88
91-100	59.25

Figure 4.15. Desirability Curve for PM – 14 Ratio of the number of Radically Green Patents to the total number of patents (%)



Sub-Indicator 15: Revenue generated from Licensing Green Patents as percentage of the total revenue of the company

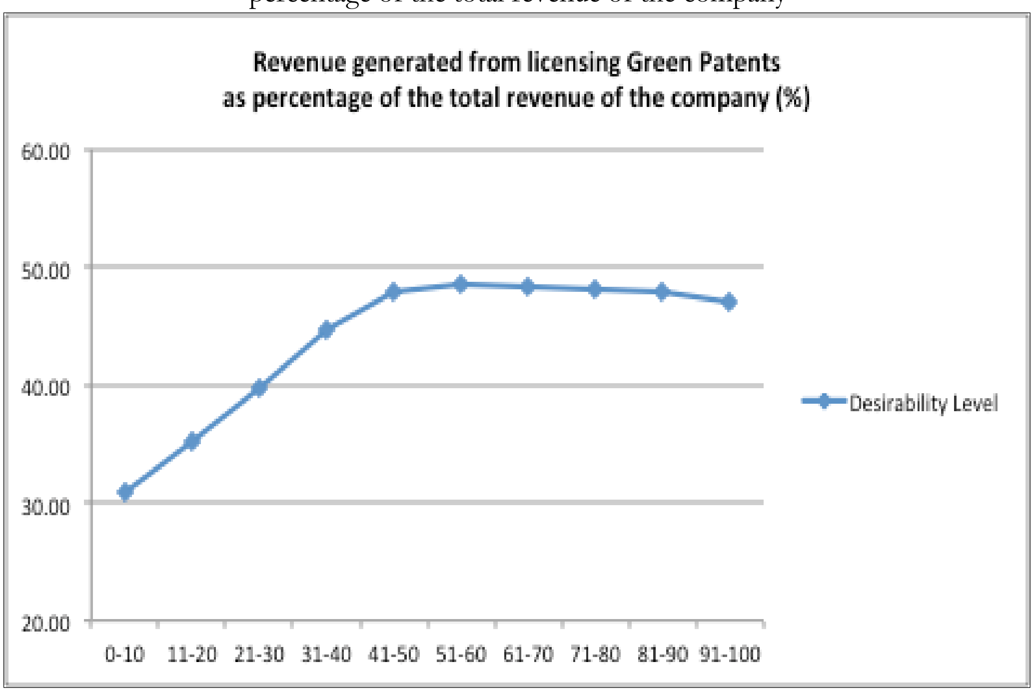
Desirability Curves for the Performance Metric for Sub-indicator 15 (PM-15)

Experts on the panel quantified the desirability values for various performance levels of Revenue generated from Licensing Green Patents as percentage of the total revenue of the company (%) as follows. The desirability curve represents concave form with increased values of Revenue generated from Licensing Green Patents as percentage of the total revenue of the company. The highest desirability level achievable is 48.50 for 51-60 % performance metric interval. The desirability curve represents a concave form with a peak value of 49.75 for 51-60 % performance metric interval increasing until that level, and slightly dropping down for higher percentage values of Revenue generated from Licensing Green Patents as percentage of the total revenue of the company. The lowest desirability level is 30.88 for (0-10) % performance metric interval. The desirability level for having Revenue generated from Licensing Green Patents as percentage of the total revenue of the company at the level of (91-100) percentage of the total revenue of the company is 47.13. The results are presented in Table 4.44 and Figure 4.16.

Table 4.44. Desirability levels for PM – 15 Revenue generated from Licensing Green Patents as percentage of the total revenue of the company

PM-15	Revenue generated from Licensing Green Patents as percentage of the total revenue of the company
%	**Desirability Level**
0-10	30.88
11-20	35.25
21-30	39.63
31-40	44.63
41-50	48.00
51-60	48.50
61-70	48.38
71-80	48.13
81-90	48.00
91-100	47.13

Figure 4.16. Desirability Curve for PM - 15 Revenue generated from Licensing Green Patents as percentage of the total revenue of the company



Sub-Indicator 16: Revenue generated from Licensing Radically Green Patents as percentage of the total revenue of the company

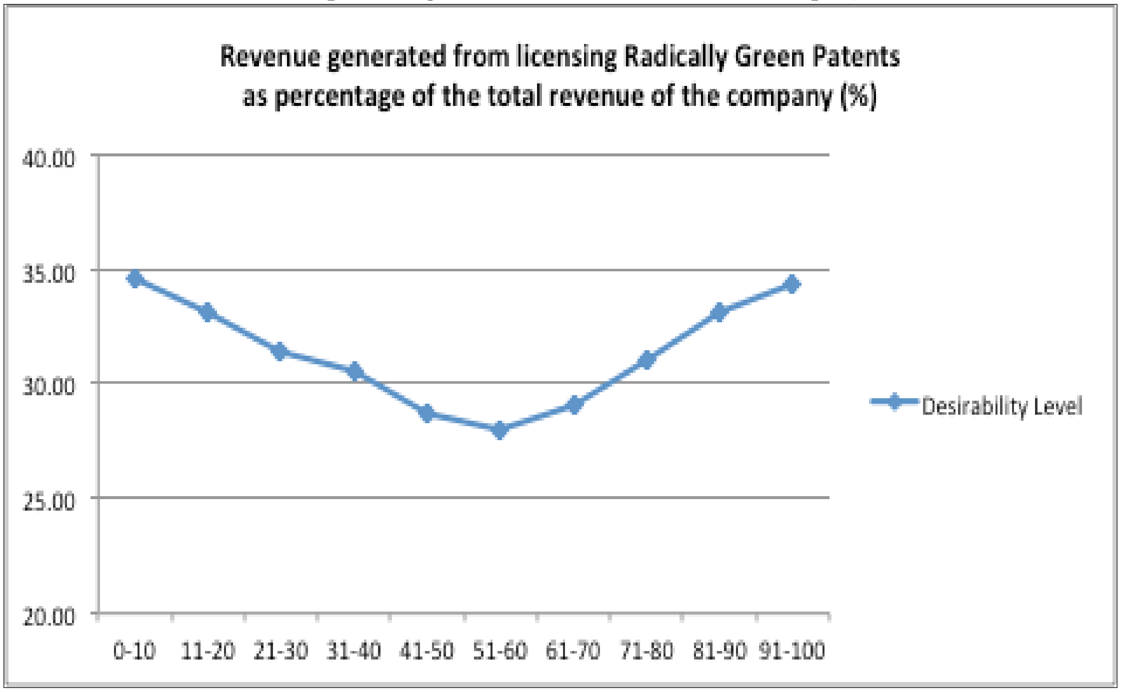
Desirability Curves for the Performance Metric for Sub-indicator 16 (PM-16)

Experts on the panel quantified the desirability values for various performance levels of Revenue generated from Licensing Radically Green Patents as percentage of the total revenue of the company (%) as follows. The desirability curve represents a slightly convex form having its lowest value at 28.00 for the (51-60) % interval. The highest desirability level achievable is 34.63 for (0-10) % performance metric interval while the desirability level that corresponds to the (91-100) % performance metric interval is 34.38. The results are presented in Table 4.45 and Figure 4.17.

Table 4.45. Desirability levels for PM – 16 Revenue generated from Licensing Radically Green Patents as percentage of the total revenue of the company (%)

PM-16	**Revenue generated from Licensing Radically Green Patents as percentage of the total revenue of the company**
%	**Desirability Level**
0-10	34.63
11-20	33.13
21-30	31.38
31-40	30.50
41-50	28.75
51-60	28.00
61-70	29.13
71-80	31.00
81-90	33.13
91-100	34.38

Figure 4.17. Desirability Curve for PM – 16 Revenue generated from Licensing Radically Green Patents as percentage of the total revenue of the company (%)



Sub-Indicator 17: Ratio of the number of Green patents for New Green Products to the total number of patents for Green Products

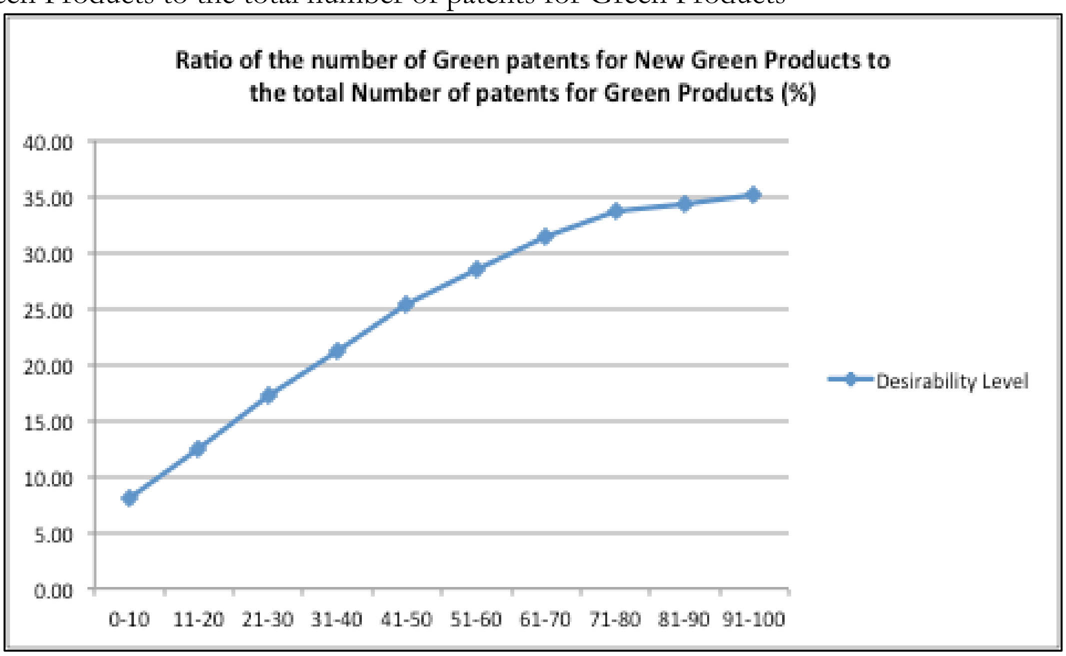
Desirability Curves for the Performance Metric for Sub-indicator 17 (PM-17)

Experts on the panel quantified the desirability values for various performance levels of Ratio of the number of Green patents for New Green Products to the total number of patents for Green Products (%) as follows. The desirability curve represents a positively curvilinear form with increased values of Ratio of the number of Green patents for New Green Products to the total number of patents for Green Products. The highest desirability level achievable is 34.14 for (91 – 100) % performance metric interval. And the lowest desirability level of 8 corresponds to (0-10) % performance metric interval The results are presented in Table 4.46 and Figure 4.18.

Table 4.46. Desirability levels for PM – 17 Ratio of the number of Green patents for New Green Products to the total number of patents for Green Products

PM-17	Ratio of the number of Green patents for New Green Products to the total number of patents for Green Products
%	Desirability Level
0-10	8.00
11-20	12.43
21-30	17.14
31-40	21.14
41-50	25.43
51-60	28.57
61-70	31.43
71-80	33.71
81-90	34.43
91-100	35.14

Figure 4.18. Desirability Curve for PM – 17 Ratio of the number of Green patents for New Green Products to the total number of patents for Green Products



Sub-Indicator 18: Ratio of the number of Radically Green patents for New Green Products to the total number of patents for Green Products

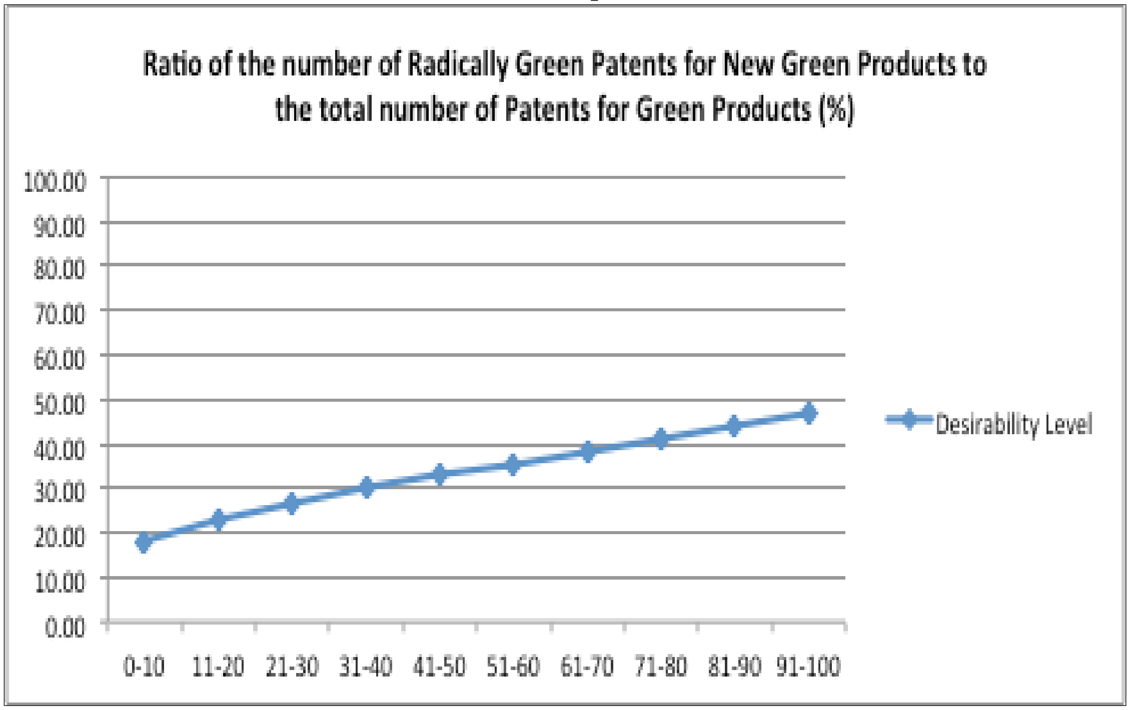
Desirability Curves for the Performance Metric for Sub-indicator 18 (PM-18)

Experts on the panel quantified the desirability values for various performance levels of Ratio of the number of Radically Green patents for New Green Products to the total number of patents for Green Products (%) as follows. The desirability curve represents a positively linear form with increased values of Ratio of the number of Radically Green patents for New Green Products to the total number of patents for Green Products. The highest desirability level achievable is 46.88 for (91-100) % and the lowest desirability value is 18.13 for the (0-10) % performance metric interval. The results are presented in Table 4.47 and Figure 4.19.

Table 4.47. Desirability levels for PM – 18 Ratio of the number of Radically Green patents for New Green Products to the total number of patents for Green Products

PM-18	Ratio of the number of Radically Green patents for New Green Products to the total number of patents for Green Products
%	**Desirability Level**
0-10	18.13
11-20	22.75
21-30	26.25
31-40	29.88
41-50	32.88
51-60	35.13
61-70	38.50
71-80	41.25
81-90	44.25
91-100	46.88

Figure 4.19. Desirability Curve for PM – 18 Ratio of the number of Radically Green patents for New Green Products to the total number of patents for Green Products



Sub-Indicator 19: Ratio of the Average Revenue for New Green Products to the Average Revenue for all products

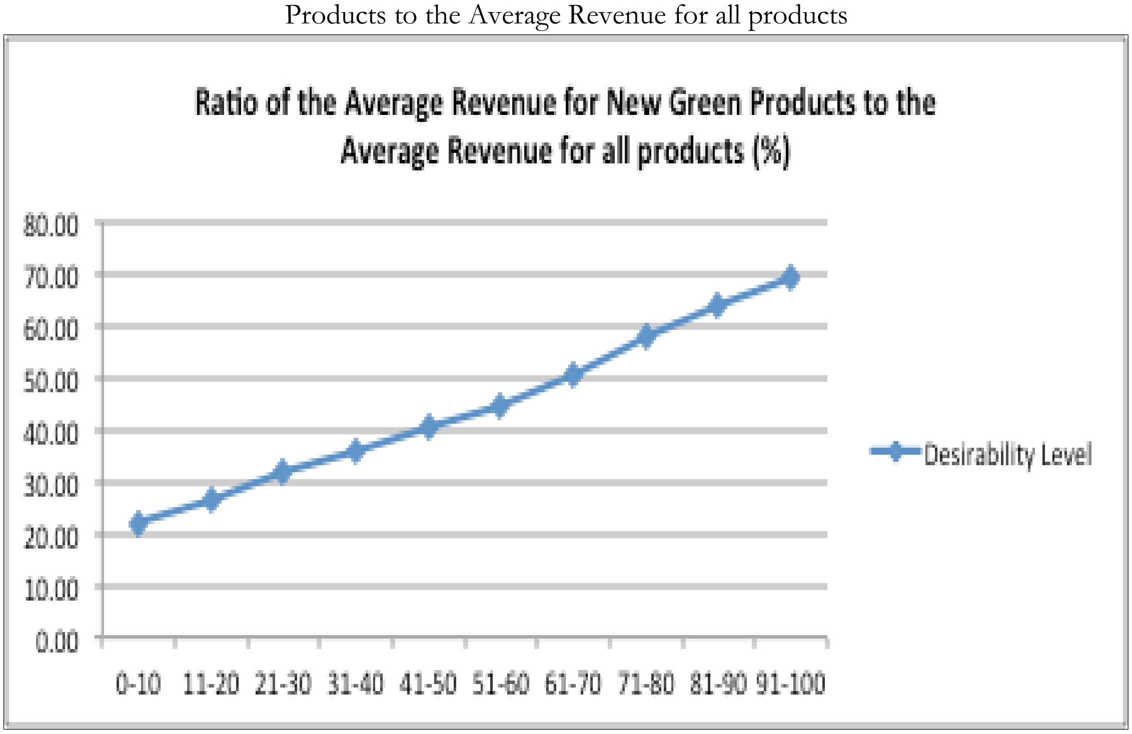
Desirability Curves for the Performance Metric for Sub-indicator 19 (PM-19)

Experts on the panel quantified the desirability values for various performance levels of Ratio of the Average Revenue for New Green Products to the Average Revenue for all products (%) as follows. The desirability curve represents a positively linear form with increased values of Ratio of the Average Revenue for New Green Products to the Average Revenue for all products. The highest desirability level achievable is 69.13 for (91-100) % and the lowest desirability value is 22.13 for the (0-10) % performance metric interval. The results are presented in Table 4.48 and Figure 4.20.

Table 4.48. Desirability levels for PM – 19 Ratio of the Average Revenue for New Green Products to the Average Revenue for all products

PM-19	Ratio of the Average Revenue for New Green Products to the Average Revenue for all products
%	**Desirability Level**
0-10	22.13
11-20	26.75
21-30	31.75
31-40	36.13
41-50	40.50
51-60	44.63
61-70	50.38
71-80	57.63
81-90	64.00
91-100	69.13

Figure 4.20. Desirability Curve for PM – 19 Ratio of the Average Revenue for New Green Products to the Average Revenue for all products



Sub-Indicator 20: Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for all products

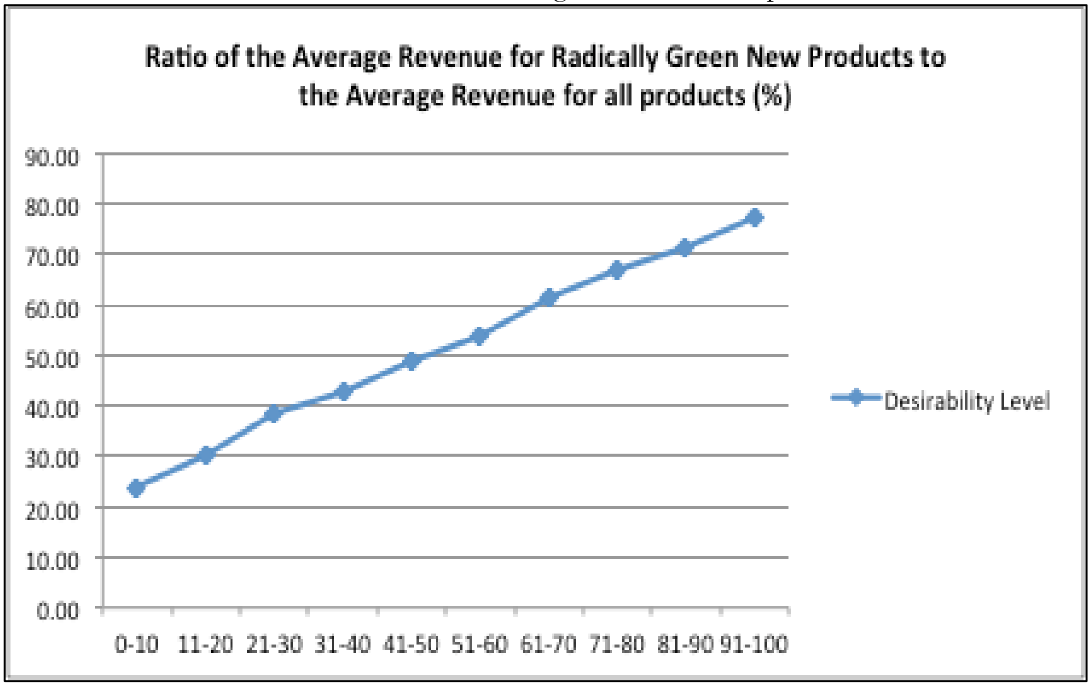
Desirability Curves for the Performance Metric for Sub-indicator 20 (PM-20)

Experts on the panel quantified the desirability values for various performance levels of Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for all products (%) as follows. The desirability curve represents a positively linear form with increased values of Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for all products. The highest desirability level achievable is 77.38 for (91-100) % and the lowest desirability value is 23.88 for the (0-10) % performance metric interval. The results are presented in Table 4.49 and Figure 4.21.

Table 4.49. Desirability levels for PM – 20 Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for all products

PM-20	Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for all products
%	**Desirability Level**
0-10	23.88
11-20	30.00
21-30	38.25
31-40	43.00
41-50	48.63
51-60	54.00
61-70	61.25
71-80	67.00
81-90	71.38
91-100	77.38

Figure 4.21. Desirability Curve for PM – 20 Ratio of the Average Revenue for New Radically Green Products to the Average Revenue for all products



Sub-Indicator 21: Return on Assets (ROA)

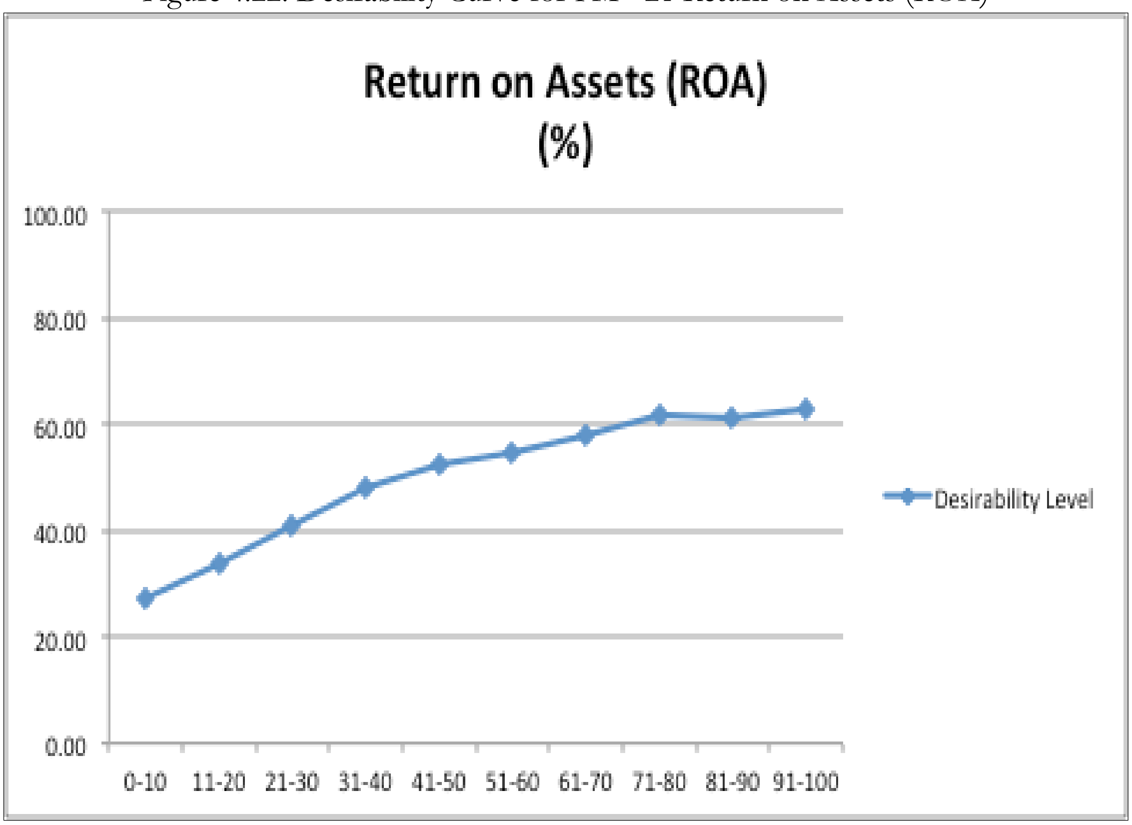
Desirability Curves for the Performance Metric for Sub-indicator 21 (PM-21)

Experts on the panel quantified the desirability values for various performance levels of Return on Assets (ROA) (%) as follows. The desirability curve represents a positively curvilinear form with increased values of Return on Assets (ROA) (%). The highest desirability level achievable is 62.75 for (91-100) % and the lowest desirability value is 27.25 for the (0-10) % performance metric interval. The results are presented in Table 4.50 and Figure 4.22.

Table 4.50. Desirability levels for PM – 21 Return on Assets (ROA)

PM-21	Return on Assets (ROA)
%	**Desirability Level**
0-10	27.25
11-20	34.00
21-30	40.88
31-40	47.88
41-50	52.25
51-60	54.75
61-70	57.88
71-80	61.63
81-90	61.38
91-100	62.75

Figure 4.22. Desirability Curve for PM - 21 Return on Assets (ROA)



Sub-Indicator 22: Return on Equity (ROE)

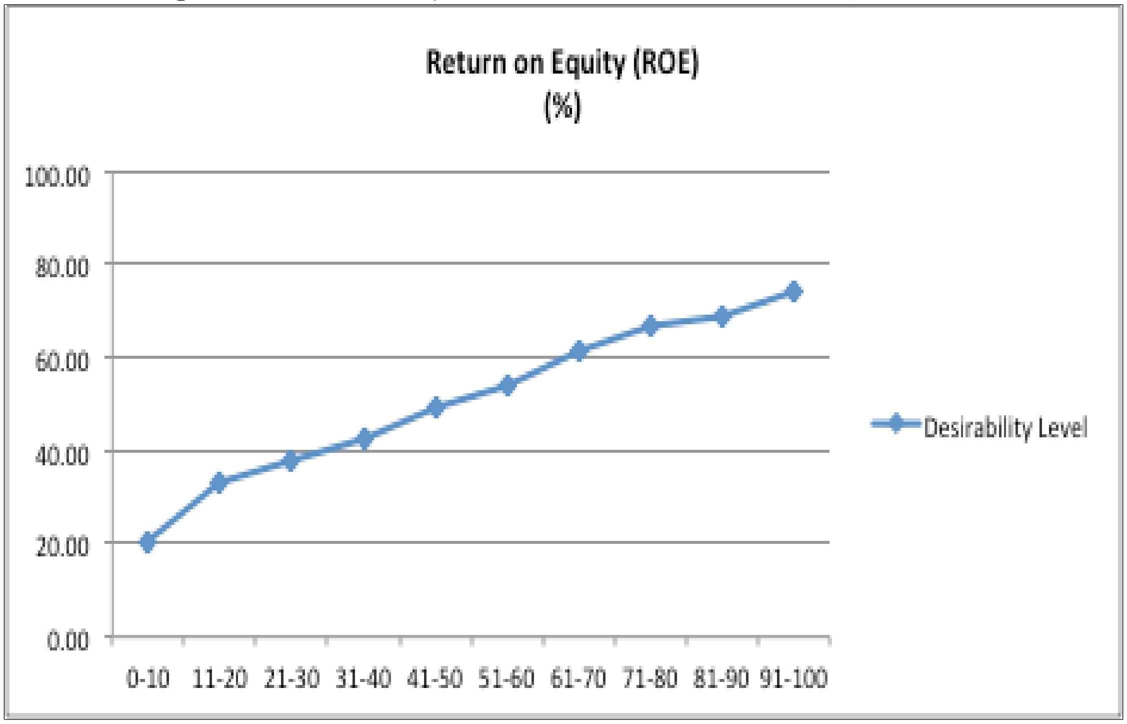
Desirability Curves for the Performance Metric for Sub-indicator 22 (PM-22)

Experts on the panel quantified the desirability values for various performance levels of Return on Equity (ROE) (%) as follows. The desirability curve represents a positively linear form with increased values of Return on Equity (ROE). The highest desirability level achievable is 74.13 for (91-100) % and the lowest desirability value is 20.50 for the (0-10) % performance metric interval. The results are presented in Table 4.51 and Figure 4.23.

Table 4.51. Desirability levels for PM – 22 Return on Equity (ROE)

PM-22	**Return on Equity (ROE)**
%	**Desirability Level**
0-10	20.50
11-20	33.38
21-30	37.63
31-40	42.75
41-50	49.50
51-60	54.00
61-70	61.50
71-80	66.50
81-90	68.75
91-100	74.13

Figure 4.23. Desirability Curve for PM – 22 Return on Equity (ROE)



Sub-Indicator 23: Percentage of Green Patents in the Assets

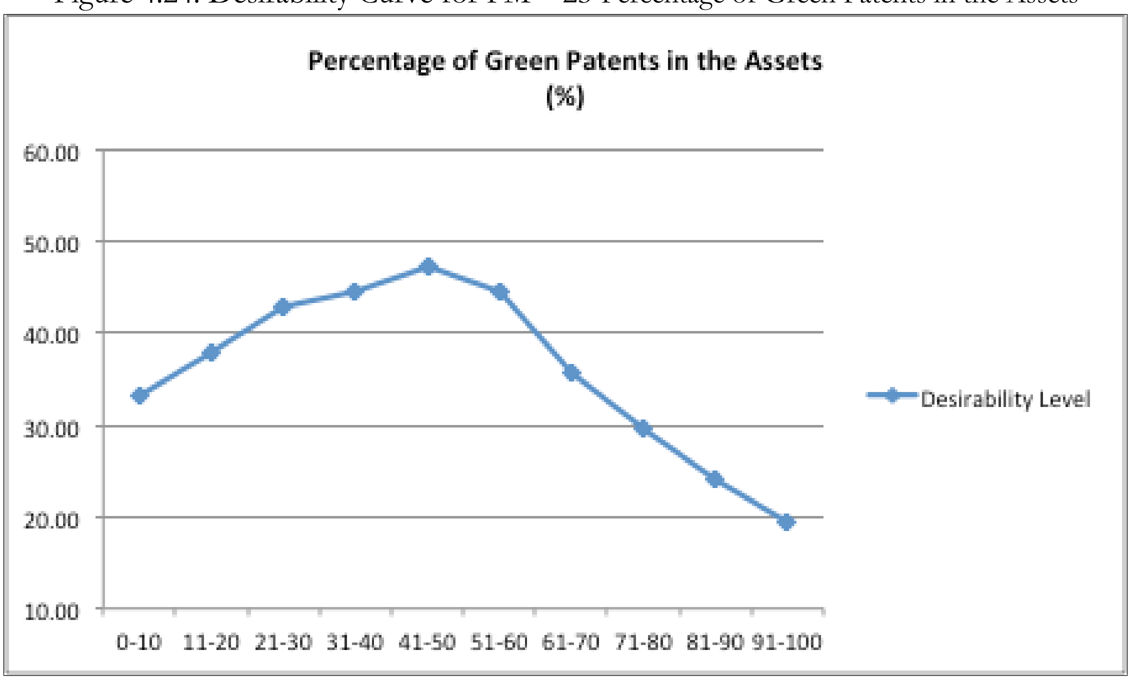
Desirability Curves for the Performance Metric for Sub-indicator 23 (PM-23)

Experts on the panel quantified the desirability values for various performance levels of Percentage of Green Patents in the Assets (%) as follows. The desirability curve represents concave form with increased values of Percentage of Green Patents in the Assets. The highest desirability level achievable is 47.13 for (41-50) % performance metric interval. The desirability curve represents a concave form with a peak value of 47.13 for (41–50) % performance metric interval increasing until that level, and slightly dropping down for higher percentage values of Percentage of Green Patents in the Assets. The lowest desirability level is 19.50 for (91-100) % performance metric interval. The desirability level for having Percentage of Green Patents in the Assets at the level of (0-10) percent level is 33.13. The results are presented in Table 4.52 and Figure 4.24.

Table 4.52. Desirability levels for PM – 23 Percentage of Green Patents in the Assets

PM-23	Percentage of Green Patents in the Assets
%	Desirability Level
0-10	33.13
11-20	37.88
21-30	42.88
31-40	44.50
41-50	47.13
51-60	44.63
61-70	35.75
71-80	29.63
81-90	24.13
91-100	19.50

Figure 4.24. Desirability Curve for PM – 23 Percentage of Green Patents in the Assets



Sub-Indicator 24: Percentage of Green R & D in the Assets

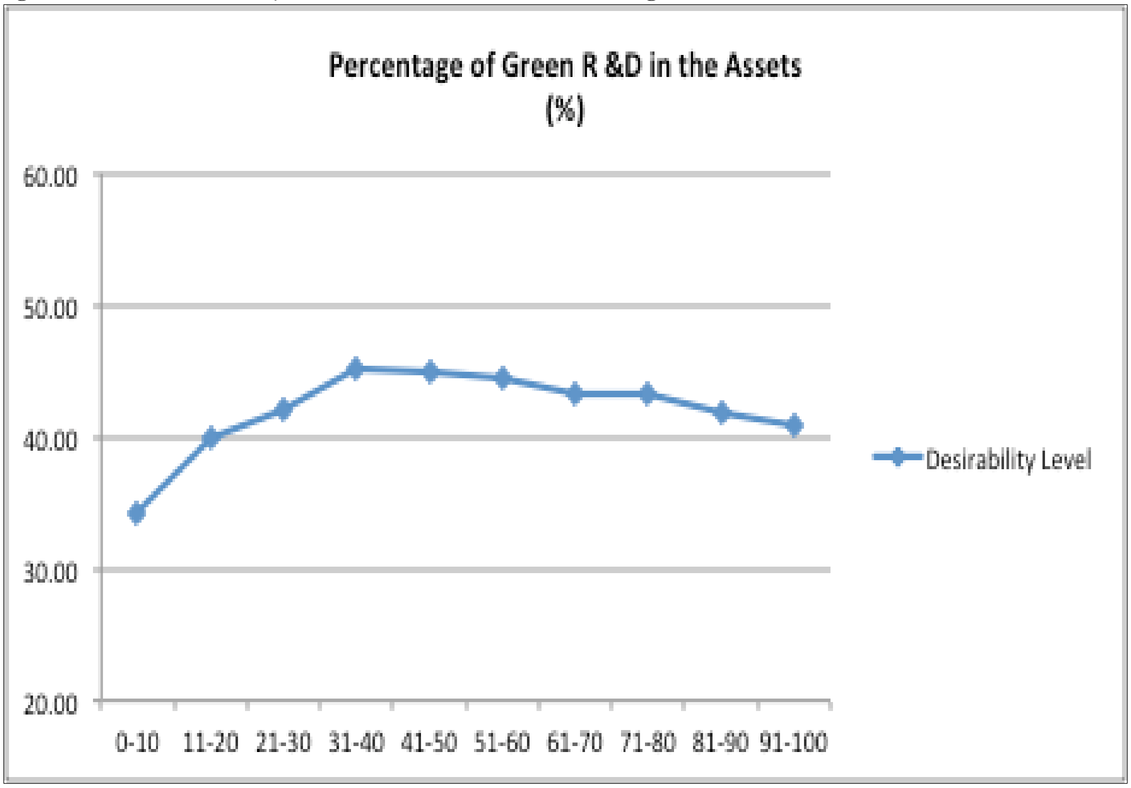
Desirability Curves for the Performance Metric for Sub-indicator 24 (PM-24)

Experts on the panel quantified the desirability values for various performance levels of Percentage of Green R & D in the Assets (%) as follows. The desirability curve represents concave form with increased values of Percentage of Green R&D in the Assets. The highest desirability level achievable is 45.25 for (31-40) % performance metric interval. The desirability curve represents a concave form with a peak value of 45.25 for (31-40) % performance metric interval increasing until that level, and slightly dropping down for higher percentage values of Percentage of Green R&D in the Assets. The lowest desirability level is 34.25 for (0-10) % performance metric interval. The desirability level for having Percentage of Green R&D in the Assets at the level of (91-100) percent level is 40.488. The results are presented in Table 4.53 and Figure 4.25.

Table 4.53. Desirability levels for PM – 24 Percentage of Green R & D in the Assets

PM-24	Percentage of Green R & D in the Assets
%	**Desirability Level**
0-10	34.25
11-20	39.88
21-30	42.13
31-40	45.25
41-50	45.00
51-60	44.38
61-70	43.38
71-80	43.38
81-90	41.75
91-100	40.88

Figure 4.25. Desirability Curve for PM – 24 Percentage of Green R & D in the Assets



Sub-Indicator 25: Return on Investment (ROI)

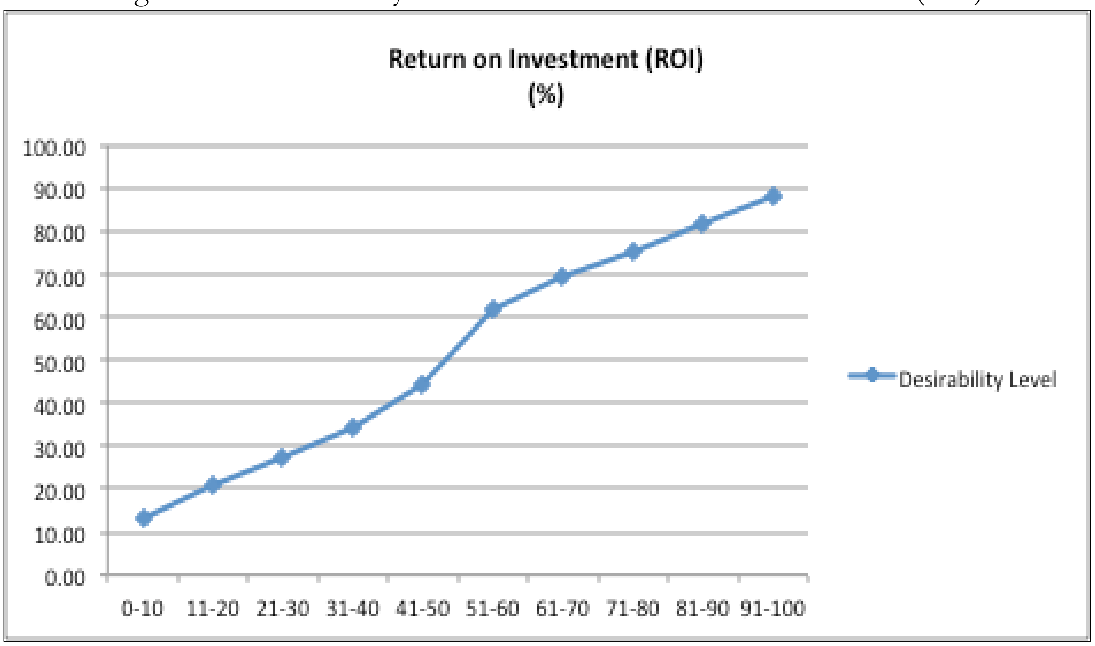
Desirability Curves for the Performance Metric for Sub-indicator 25 (PM-25)

Experts on the panel quantified the desirability values for various performance levels of Return on Investment (ROI) (%) as follows. The desirability curve represents a positively linear form with increased values of Return on Investment (ROI). The highest desirability level achievable is 88.38 for (91-100) % and the lowest desirability value is 13.13 for the (0-10) % performance metric interval. The results are presented in Table 4.54 and Figure 4.26.

Table 4.54. Desirability levels for PM – 25 Return on Investment (ROI)

PM-25	Return on Investment (ROI)
%	**Desirability Level**
0-10	13.13
11-20	21.13
21-30	27.38
31-40	34.25
41-50	44.13
51-60	61.63
61-70	69.63
71-80	75.38
81-90	82.00
91-100	88.38

Figure 4.26. Desirability Curve for PM – 25 Return on Investment (ROI)



Sub-Indicator 26: ROI for Green Products (ROIG.Pr.)

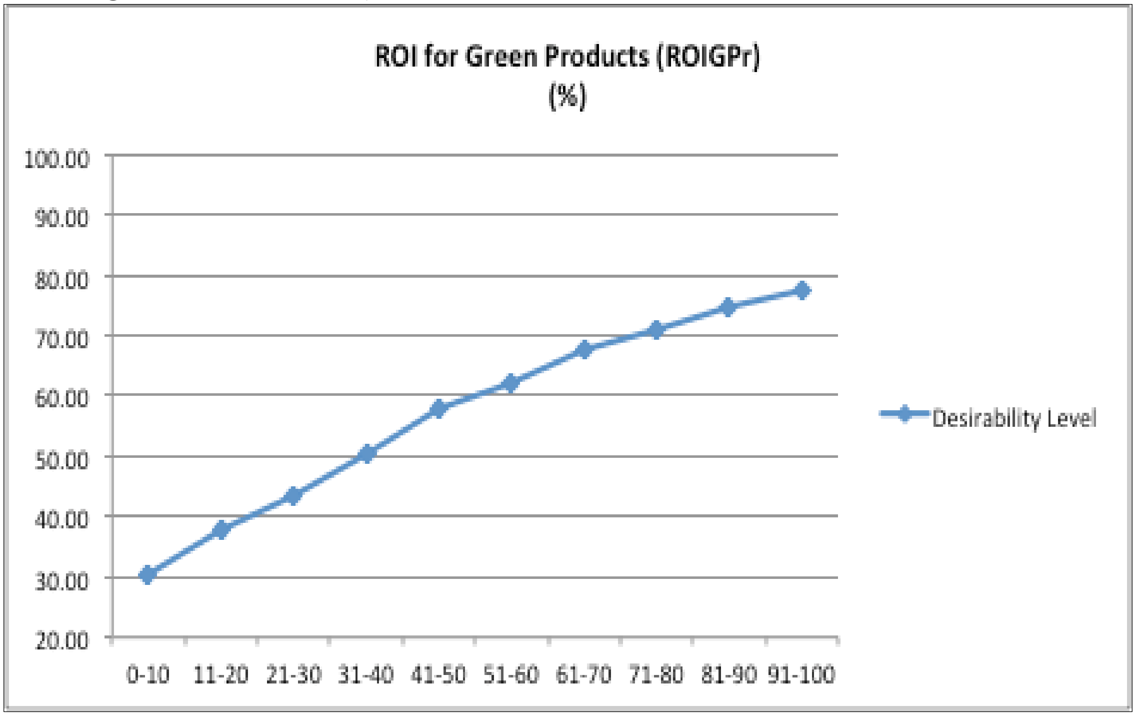
Desirability Curves for the Performance Metric for Sub-indicator 26 (PM-26)

Experts on the panel quantified the desirability values for various performance levels of : ROI for Green Products (ROIG.Pr.) (%) as follows. The desirability curve represents a positively linear form with increased values of ROI for Green Products (ROIG.Pr.) .The highest desirability level achievable is 77.50 for (91-100) % and the lowest desirability value is 30.25 for the (0-10) % performance metric interval. The results are presented in Table 4.55 and Figure 4.27.

Table 4.55. Desirability levels for PM – 26: ROI for Green Products (ROIG.Pr.)

PM-26	**ROI for Green Products (ROIG.Pr.)**
%	**Desirability Level**
0-10	30.25
11-20	37.75
21-30	43.63
31-40	50.25
41-50	57.88
51-60	62.25
61-70	67.50
71-80	70.75
81-90	74.50
91-100	77.50

Figure 4.27. Desirability Curve for PM – 26: ROI for Green Products (ROIG.Pr.)



Sub-Indicator 27: ROI for Green Patents (ROIG.Pt.)

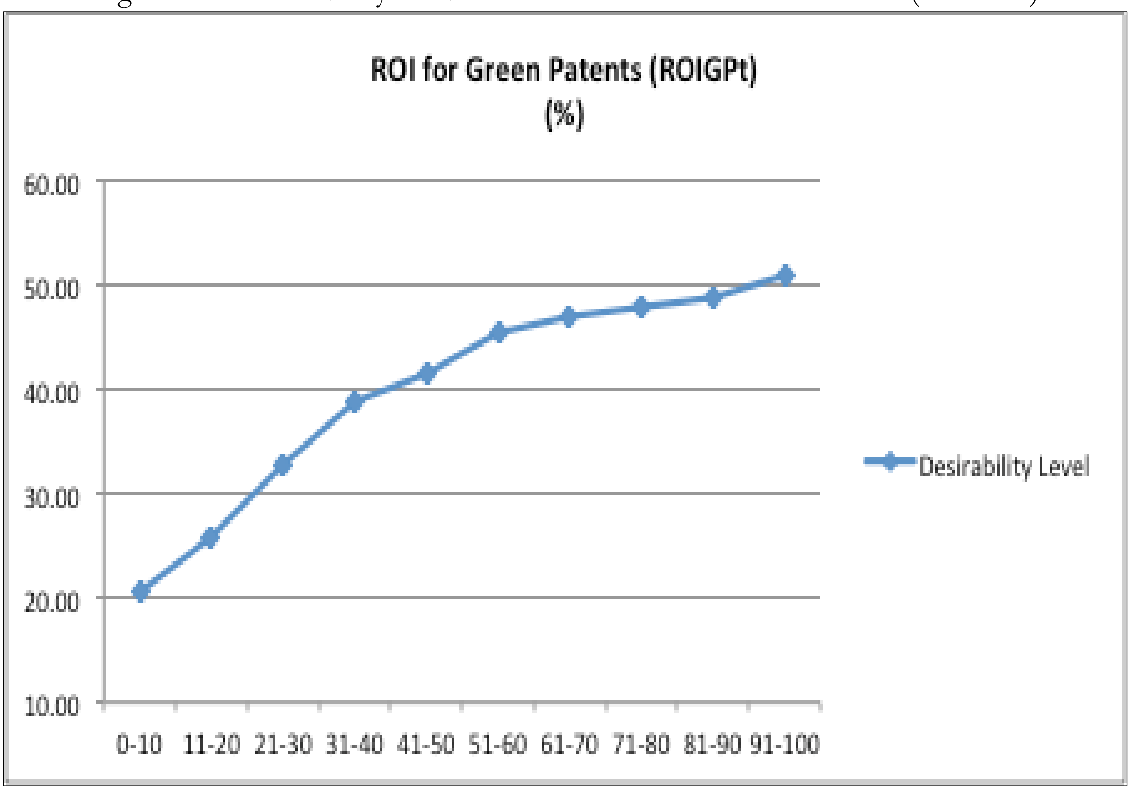
Desirability Curves for the Performance Metric for Sub-indicator 27 (PM-27)

Experts on the panel quantified the desirability values for various performance levels of ROI for Green Patents (ROIG.Pt.) (%) as follows. The desirability curve represents a positively curvilinear form with increased values of ROI for Green Patents (ROIG.Pt.) .The highest desirability level achievable is 51.00 for (91-100) % and the lowest desirability value is 20.63 for the (0-10) % performance metric interval. The results are presented in Table 4.56 and Figure 4.28.

Table 4.56. Desirability levels for PM – 27 ROI for Green Patents (ROIG.Pt.)

PM-27	ROI for Green Patents (ROIG.Pt.)
%	**Desirability Level**
0-10	20.63
11-20	25.88
21-30	32.63
31-40	38.63
41-50	41.63
51-60	45.50
61-70	47.00
71-80	47.75
81-90	48.88
91-100	51.00

Figure 4.28. Desirability Curve for PM – 27 ROI for Green Patents (ROIG.Pt.)



Sub-Indicator 28 : Ratio of ROI for Green Products to ROI (ROIG.Pr. / ROI)

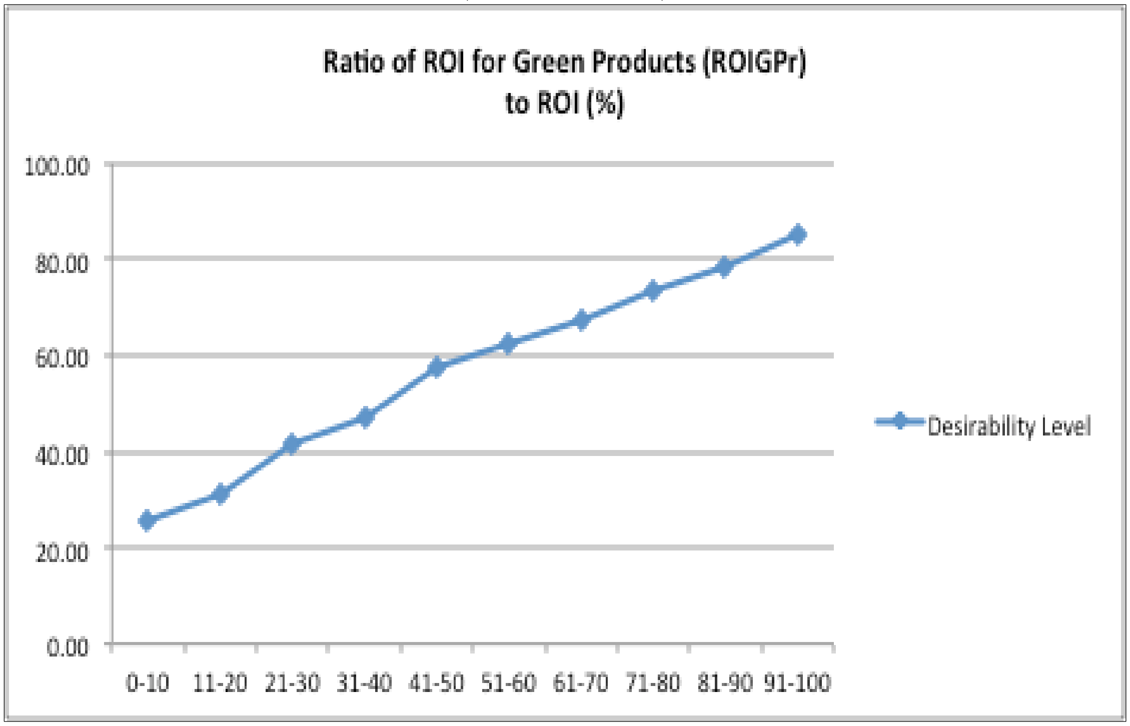
Desirability Curves for the Performance Metric for Sub-indicator 28 (PM-28)

Experts on the panel quantified the desirability values for various performance levels of Ratio of ROI for Green Products to ROI (ROIG.Pr. / ROI) (%) as follows. The desirability curve represents a positively linear form with increased values of Ratio of ROI for Green Products to ROI (ROIG.Pr. / ROI). .The highest desirability level achievable is 77.50 for (91-100) % and the lowest desirability value is 25.50 for the (0-10) % performance metric interval. The results are presented in Table 4.57 and Figure 4.29.

Table 4.57. Desirability levels for PM – 28 Ratio of ROI for Green Products to ROI (ROIG.Pr. / ROI)

PM-28	**ROIG.Pr. / ROI**
%	**Desirability Level**
0-10	25.50
11-20	30.88
21-30	41.38
31-40	47.38
41-50	57.38
51-60	62.25
61-70	67.13
71-80	73.25
81-90	78.50
91-100	84.88

Figure 4.29. Desirability Curve for PM - 28 Ration of ROI for Green Products to ROI (ROIG.Pr. / ROI)



Sub-Indicator 29: Ratio of ROI for Green Patents to ROI (ROIG.Pt. / ROI)

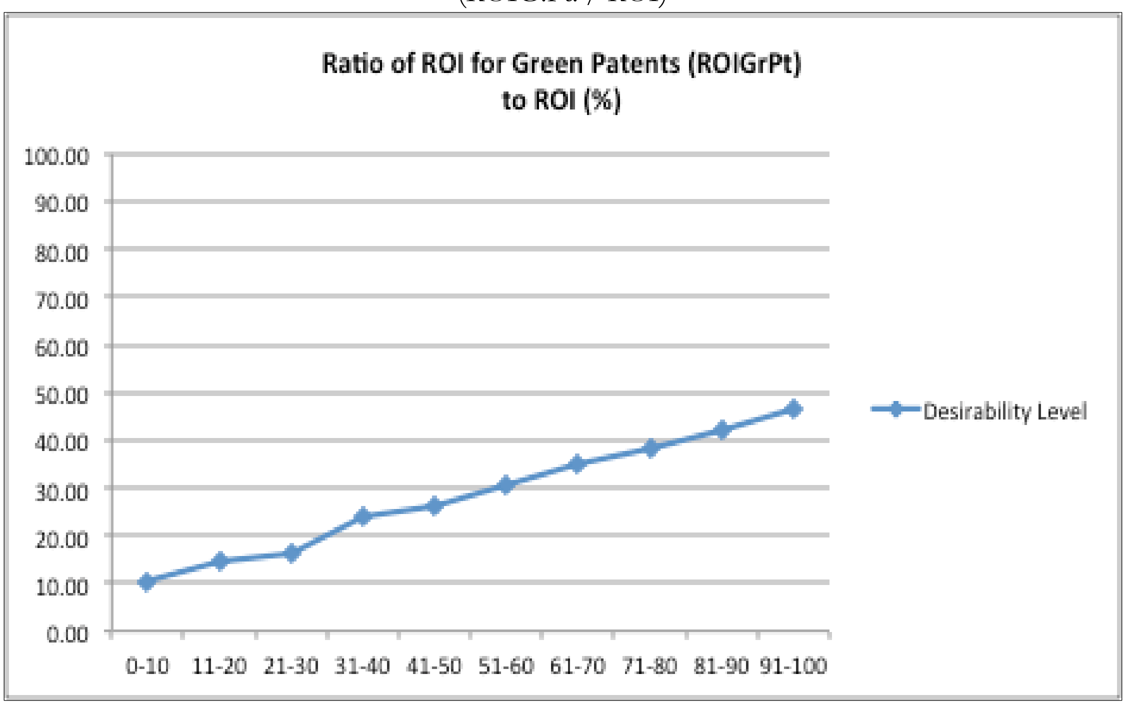
Desirability Curves for the Performance Metric for Sub-indicator 29 (PM-29)

Experts on the panel quantified the desirability values for various performance levels of Ratio of ROI for Green Patents to ROI (ROIG.Pt. / ROI) (%) as follows. The desirability curve represents a positively linear form with increased values of Ratio of ROI for Green Patents to ROI (ROIG.Pt. / ROI). .The highest desirability level achievable is 46.38 for (91-100) % and the lowest desirability value is 10.50 for the (0-10) % performance metric interval. The results are presented in Table 4.58 and Figure 4.30.

Table 4.58. Desirability levels for PM – 29 Ratio of ROI for Green Patents to ROI (ROIG.Pt. / ROI)

PM-29	**ROIG.Pt. / ROI**
%	**Desirability Level**
0-10	10.50
11-20	14.75
21-30	16.38
31-40	23.75
41-50	26.13
51-60	30.38
61-70	35.13
71-80	38.50
81-90	42.00
91-100	46.38

Figure 4.30. Desirability Curve for PM – 29 Ratio of ROI for Green Patents to ROI (ROIG.Pt. / ROI)



4.2. Assessment of the results from Desirability Curves:

According to the Expert Panel 5 of Angel Investors and VCs

(1) Sub-indicators of Green Financial Capability (ROIs) and Pace of Green Innovativeness have positive linear forms of Desirability Curves for increasing levels of performance.

(2) Sub-indicators of Green Innovativeness Intensity of the Firm (% of Green R&D and Green Patents) have concave (inverted U) forms of Desirability Curves.

(3) Desirability values for ROA and ROE increaase curvi-linearly and linearly with increased percentages, respectively.

(4) % of Green Products and % of Radically Green Products, have positive linear forms of Desirability Curves for increasing levels of performance.

(5) % of Green Patents, and % of Radically Green Patents, have positive linear forms of Desirability Curves for increasing levels of performance.

(6) Revenue generated from Green Products has a linear form of Desirability Curve, while that from Radically Green Products has an increasing curvi-linear form, for increased levels of performance.

(7) Revenue generated from Licensing Green Patents has a curvi-linear form of Desirability Curve, while that from Radically Green Patents has a convex form with increased levels of performance.

(8) Ratio of Avg. Rev. for New Green Products and that for New Radically Green Products to the Avg. Revenue for all products have positively linear Desirability Curve forms.

(9) All of the Environmental Performance sub-indicators of Total (Water/Energy/Waste/GHGE) per Revenue have negatively decreasing linear forms of Desirability Curves with increasing levels of negative environmental impact

(10) All the Environmental Performance sub-indicators of % Change in (Water/Energy/Waste/GHGE) per Revenue wrt. previous year have negatively decreasing linear forms of Desirability Curves with reducing levels of reduction.

(11) All the Environmental Performance sub-indicators of % Change in (Water/Energy/Waste/GHGE) per Revenue wrt previous year has negatively increasing logarithmic forms of Desirability Curves with increasing levels of higher environmental footprint change. Highest levels of negative desirability apply to increase in GHGE and Energy for (20 – 100) % increase range.

(12) Penalization due to increasing negative environmental impact is a first time quantification of this dissertation and it reflects while applying the Green Index model, changing the ranking of companies (shown at Scenario Analysis results).

4.3. Scenario Analysis

(1) Results of the HDM developed for Green Index

(2) Desirability curves obtained from Expert Panel 5

were integrated and 7 alternative scenarios were run for companies at alternative performance levels with respect to three performance dimensions : Environmental Performance, Green innovativeness, Financial Performance.

Scenario 1, is developed for the Ideal Green Firm, where a firm is at bets performance levels for each performance dimension.

3 scenarios were developed for the "best" performance in each dimension, where as for:

Scenario 2: A firm that is best at Environmental Performance & worst at others,

Scenario 3: A firm that is Best at Green Innovativeness & worst at others,

Scenario 4: A firm that is Best at Financial Performance & worst at others.

Similarly, 3 more scenarios were developed for "balanced "performance, where as for:

Scenario 5: A firm that is Best at Environmental Performance & competent at others,

Scenario 6: A firm that is Best at Green Innovativeness & competent at others,

Scenario 7: A firm that is Best at Financial Performance & competent at others.

The application and results of these 7 scenarios per each performance level breakdown are presented in Figures 4.31 thru 4.33 below.

Figure 4.31. 7 Scenarios by Environmental Performance Dimension

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Green Index Sub-indicators		Ideal Green Firm	Best at Env. Perf. (worst at else)	Best at Green Innv. (worst at else)	Best at Fin. Perf. (worst at else)	Friend of the Earth	Green Innovator	Wealth Creator
Environmental Performance	Water Consumption / Revenue (Million Gallons / Billion USD)	0 - 10	0 - 10	> 150	> 150	0 - 10	50 - 60	50 - 60
	% Change in Water Consumption / Revenue	-100	-100	+ (0 - 100)	+ (0 - 100)	-100	+ (0 - 19)	+ (20 - 39)
	Energy Consumption / Revenue (Billion KWh / Billion USD)	0 - 0.5	0 - 0.5	> 8	> 8	0 - 0.5	3.5 - 4.0	2.0 - 2.5
	% Change in Energy Consumption / Revenue	-100	-100	+ (0 - 100)	+ (0 - 100)	-100	+ (20 - 39)	+ (0 - 19)
	Total Waste / Revenue (Million Tons / Billion USD)	0 - 10	0 - 10	> 150	> 150	0 - 19	40 - 50	40 - 50
	% Change in Total Waste / Revenue	-100	-100	+ (0 - 100)	+ (0 - 100)	-100	0	- (0 - 19)
	Green House Gas Emission / Revenue (Million Metric Tons of CO_2 / Billion USD)	0 - 0.5	0 - 0.5	> 3	> 3	0 - 0.5	0.5 - 1.0	1.0 - 1.5
	% Reduction in Green House Gas Emission / Revenue	-100	-100	+ (0 - 100)	+ (0 - 100)	-100	+ (0 - 19)	+ (20 - 39)

Figure 4.32. 7 Scenarios by Green Innovativeness Performance Dimension

Green Index Sub-indicators		Scenario 1 Ideal Green Firm	Scenario 2 Best at Env. Perf. (worst at else)	Scenario 3 Best at Green Innv. (worst at else)	Scenario 4 Best at Fin. Perf. (worst at else)	Scenario 5 Friend of the Earth	Scenario 6 Green Innovator	Scenario 7 Wealth Creator
Green Innovativeness	% of Green products in the total product pool	91 - 100	0 - 10	91 - 100	0 - 10	21 - 30	91 - 100	41 - 50
	% of Radically green products in the total product pool	41 - 50	0 - 10	41 - 50	0 - 10	11 - 20	41 - 50	21 - 30
	Revenue generated from green products (as % of total revenue)	91 - 100	0 - 10	91 - 100	0 - 10	21 - 30	91 - 100	51 - 60
	Revenue generated from radically green products (as % of total revenue)	51 - 60	0 - 10	51 - 60	0 - 10	21 - 30	51 - 60	41 - 50
	No. of green patents / No. of patents	91 - 100	0 - 10	91 - 100	0 - 10	31 - 40	91 - 100	11 - 20
	No. of radically green patents / No. of patents	91 - 100	0 - 10	91 - 100	0 - 10	11 - 20	91 - 100	11 - 20
	Revenue generated from licensing green patents (as % of total revenue)	51 - 60	0 - 10	51 - 60	0 - 10	0 - 10	51 - 60	31 - 40
	Revenue generated from licensing radically green patents (as % of total	0 - 10	51 - 60	0 - 10	51 - 60	31 - 40	0 - 10	0 - 10
	No. of green patents for new products / No. of patents for green products	91 - 100	0 - 10	91 - 100	0 - 10	21 - 30	91 - 100	21 - 30
	No. of radically green patents for new products / No. of patents for green	91 - 100	0 - 10	91 - 100	0 - 10	0 - 10	91 - 100	11 - 20
	Avg. revenue for new green products / Avg. revenue for all products	91 - 100	0 - 10	91 - 100	0 - 10	11 - 20	91 - 100	31 - 40
	Avg. revenue for radically green new products / Avg. revenue for all products	91 - 100	0 - 10	91 - 100	0 - 10	11 - 20	91 - 100	21 - 30

Figure 4.33. 7 Scenarios by Financial Performance Dimension

Green Index Sub-indicators		Scenario 1 Ideal Green Firm	Scenario 2 Best at Env. Perf. (worst at else)	Scenario 3 Best at Green Innv. (worst at else)	Scenario 4 Best at Fin. Perf. (worst at else)	Scenario 5 Friend of the Earth	Scenario 6 Green Innovator	Scenario 7 Wealth Creator
Financial Performance	Return on assets	91 - 100	0 - 10	0 - 10	91 - 100	0 - 10	31 - 40	91 - 100
	Return on equity	91 - 100	0 - 10	0 - 10	91 - 100	11 - 20	61 - 70	91 - 100
	% of green patents in the assets	41 - 50	91 - 100	91 - 100	41 - 50	11 - 20	41 - 50	41 - 50
	% of green R&D in the assets	31 - 40	0 - 10	0 - 10	31 - 40	0 - 10	41 - 50	31 - 40
	Return on investment (ROI)	91 - 100	0 - 10	0 - 10	91 - 100	31 - 40	51 - 60	91 - 100
	ROI for green products (ROIGPr)	91 - 100	0 - 10	0 - 10	91 - 100	11 - 20	41 - 50	91 - 100
	ROI for green patents (ROIGPt)	91 - 100	0 - 10	0 - 10	91 - 100	0 - 10	41 - 50	91 - 100
	ROIGPr / ROI	91 - 100	0 - 10	0 - 10	91 - 100	31 - 40	81 - 90	91 - 100
	ROIGPt / ROI	91 - 100	0 - 10	0 - 10	91 - 100	21 - 30	91 - 100	91 - 100

As a result of the application of these 7 scenarios, the Ideal Company being the Best Green Company, the scenario that exemplifies the Friend of the Earth is ranked with the highest Green Index Value of 71.78 out of 100. It is followed by Best at Environment & worst at else of 64.64, and Green Innovator with 59.89, and Wealth Creator with 56.41. In this scenario analysis, being best at Green Innovativeness or Financial Performance alone resulted in the worst Green Index ranking for those companies. The ranking order is represented in Figure 4.34 below.

Figure 4.34. Green Index Scenario Analysis Ranking

		Extremes Scenarios of Best & Worst			Balanced Scenarios		
	Ideal Green Firm	Best at Env. Perf.	Best at Green Innv.	Best at Fin. Perf.	Friend of the Earth	Green Innovator	Wealth Creator
Green Index Value	**68.41**	44.22	14.06	20.41	49.10	40.97	38.59
Green Index Achivement Level	100	**64.64**	**20.56**	**29.83**	**71.78**	**59.89**	**56.41**
		2	6	5	1	3	4

Findings of the Scenario Analysis show that:

1) Companies that have superior Environmental Performance are always ranked as Best.
2) Being Best at Financial Performance does not deliver High Green Performance by itself.
3) Being the Best Green Innovator is of no use by itself for High Green Performance, if the performance at Environmental and Financial Performance are at worst levels.
4) Being Best at Green Innovativeness delivers Green Performance advantages that are beyond being the Financially Best company.
5) Having a "balanced" Green Performance across three performance dimensions makes a company much better off than being the best at only one.
6) Integration of Desirability Values for evaluation of performance levels is critically important.

CHAPTER 5

Conclusions and Research Contributions

The integration of sustainability performance of companies has been becoming increasingly important. The recent global requirements (i.e. the Kyoto Protocol (2008 – 2012), the Doha Amendment to Kyoto Protocol (December, 2012)) for significant reduction of the negative impact of companies on the environment over the next 6 years have been putting increasing pressure on the firms, requiring them to lower the negative environmental impact of their market presence. This requirement challenges the profitable growth of the industries, business functions of the companies, given the change needed for improvement of the environmental impact of business operations.

In this dissertation, a new corporate sustainability performance measure, that focuses on the "green performance" of companies, called as "The Green Index", has been developed. The study has a holistic approach in defining, measuring and assessing the "green performance" for companies, as integrated into their market performance. Green Index has integrated Environmental Performance, Green Innovativeness and Financial Performance of the companies, by quantifying expert opinions by using Hierarchical Decision Modeling.

This dissertation uniquely has referred to the collective expert opinion of select management researchers, executive managers of corporations, high-tech companies' R&D managers, financial managers, corporate social responsibility managers, angel investors and venture capitalists in defining 29 performance measures, which are named sub-indicators for this research, under the three core performance dimensions of the Green Index. Green Index, specifically has focused on being green for high-tech companies which are manufacturing their products in-house, by paying attention to their performance outputs only.

Green Index has introduced "Green Innovativeness" in defining and measuring green performance of companies, in integration with Environmental and Financial Performance. Similarly, the index has captured the impact of worsened environmental performance by assigning negative value to it. Thus, if a company increases its environmental foot print with respect to the previous year, it gets a lower Green Index value.

The results of the study has revealed that when environmental performance is holistically integrated into green performance by taking the corporate market performance into consideration, managerial decisions have to be based on the composite interactions between current performance status of the companies and the desired levels of successful green performance.

5.1. Implications of the Green Index for Management Decisions

Green Index, enables an integrated assessment of the Sustainability Performance of a company, specifically as Green, based on the three performance dimensions: Environmental Performance, Green Innovativeness, and Financial Performance. The index provides a new perspective in defining and addressing integrated Green Performance of companies with these three performance dimensions, delivering a foundational base for future research to be conducted based on the verified dimensions, indicators and sub-indicators. From the perspective of managers, Green Index, primarily identifies the areas for improving the Green Performance of the company. The sub-indicators of the Green Index with the highest relative weights toward the Green Index calculation, single out as the areas with high / low impact on Green Performance of a company. Within this scope Return on Equity and Return on Assets are ranked as the top two performance measures with the highest impact on Green Index value of a firm, followed by the percentage change in Energy Consumption per Revenue with respect to the previous year.

Continuing from the top list of performance measures for the Green Index, those for the Environmental Performance and the Financial Performance constitute the top 10 list out of the 29 identified and prioritized. With this, Green Index, clearly points out the improvements on the Environmental and Financial Performance of the company as the top priority improvement areas, independent from the internal performance desirability levels in the company.

Green Index, similarly allows for prioritization areas inside a company with the integration of the corresponding "desirability values" inside the firm and the discrepancy each has with respect to their unique generally desired levels. In this context, the performance measure, with the maximum product value of "relative weight" and desirability discrepancy would single out as the highest impact on Green Index, for each unit of performance improvement inside the company. This allows for integrating the highest impact areas as highest improvement needs in a combinatory way.

Green Index is generalizable to any company and any industry, regardless of the size of the companies be it large corporations or new entrepreneurial companies, or even the intra-preneurial business initiatives of large corporations.

Green Index comes out as a tool for identifying the most important improvement areas for a company, if the company's strategy is to gradually transform into being more environmentally friendly, and more innovative in green products and green technologies, while maintaining and/or enhancing its profitability. It will serve as a tool to identify the most important output indicators and the desirable levels for sub-indicators for which a strategy can be developed for a gradual transitioning.

The verified output sub-indicators of the Green Index can be used to identify the processes within the company, that deliver those outcomes, and further efficiency and/or effectiveness enhancements, changes can be applied to those process based on factual validations that come from the validated Green Index. Subsequently, the input indicators for these processes can be identified with further research in the companies, to trace back the changes needed, or the validations that already exist for the betterment of integrated green performance of a company.

5.2. Implications of using the Green Index within an Industry

The development of Green Index model is generalizable to any company in any industry, meaning that the model development process can be customized for any industry that would be identified. Within a given industry, like the high-tech semiconductor industry as referred to for this study, calculation of the Green Index of a company becomes possible. With the Green

Index application, a company's Green Index value is calculated, and this allows for recognition of a company's ranking within a given industry, in comparison to other companies in the same industry.

5.3. Implications of using the Green Index for Policy Decisions

Several organizations can benefit from using Green Index for their internal and external business decisions, i.e.:

(1) Financial Institutions can develop their credit and business loan policies for companies, which are requesting financial resources for their green performance transitioning process.

(2) Governments can use the Green Index for developing environmental policies as guidelines for industry.

(3) Regional Economic Development Agencies can use the Green Index for identifying companies and industries to support for a green economy.

5.4. Green Index as a Decision Support Tool for various Stakeholders

The Green Index dissertation specifically meets the needs of a small group of stakeholders of the companies. The stakeholders who will benefit from using the Green Index for meeting their organizational missions and targets are policy makers, regional economic development agencies, research institutes all of whom have specific mission statements on improving the environmental impact of industries, companies, and fostering innovations and technologies that are green and with improved environmental impact as well as economic benefits.

In this context, the Green Index will serve as a decision support tool for policy makers, regional economic development agencies, universities, research institutes, and investors in sustainable, specifically green, businesses. The index will serve the needs of the universities and research institutes to address issues related to improving tangible outcomes of the corporate sustainability performance, in an industry, in a region, by facilitating a robust recognition of the highly preferred green performance improvement needs and areas.

5.5. Limitations

This dissertation has several limitations:

(1) The HDM has been developed for high-tech semiconductor industry. For assessing companies in other industries, industry specific environmental footprint averages would need to be identified and the desirability curves for each performance measure (sub-indicator) would need to developed.

(2) The People dimension of the Triple Bottom Line has not been integrated into the Green Index.

(3) The opinions and quantified judgments of 4 stakeholder groups' opinions have been collected, i.e. (1) Researchers, (2) Managers & engineers in companies, (3) Sustainability NGOs' representatives, (4) Angel Investors and VCs. The opinions and judgment quantification of stakeholders such as: customers, suppliers of companies, public investors of companies, governmental institutes, have not been included.

(4) Negative performance change in Green Innovativeness and Financial Performance have not been reflected in the Green Index, as it's been the case for Environmental Performance.

(5) Cultural origins of the experts on the panels have not been considered.

5.6. Future Research

The Green Index will serve as a foundational base for future research in Green Performance area are summarized below.

(1) Further data collection from companies in the high-tech semiconductor industry will allow for case study developments with a number of companies.

(2) Relationships between the Green Index and the various performance measures in a company can be analyzed.

(3) The Green Index value can be compared to other corporate Sustainability indices.

(4) The Green Index can be developed for R&D intense manufacturing industries and select services industries.

In conclusion, the Green Index delivers a robust methodological approach and solution toward integrating Environmental Performance, Green Innovativeness and Financial Performance of the companies, by using the Hierarchical Decision Model developed by Kocaoglu in 1976. With the Green Index, quantifying expert opinions toward an integrated Green Performance definition and creation of a resource allocation decision tool, by utilizing the HDM process is its first time application in the literature on corporate sustainability performance.

The results of Green Index research allow for actual application of the Resource Based View of the firm (Barney, 1997) by making a decision support tool available for resource allocation decisions of the management teams. Similarly, the external environmental costs of the activities of the firm, as in Transaction Cost Theory (Teece, 1982) become internalized and integrated into the company performance, allowing the management to have higher visibility of the company's market performance, and make management decisions with that higher awareness, when it comes to corporate green performance.

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