UNDERSTANDING THE PAYOFFS FROM SUSTAINABILITY

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Declaration

I hereby declare that this thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis.This thesis has also not been submitted for any degree in any university previously.

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Summary

There has been a continuous growth in research on enterprise sustainability, which can be broadly classified into three main streams: (1) sustainable or green IT (focused on information and communication technologies targeted at addressing environmental concerns; (2) sustainable operations (focused on environmental and social consequences of operational decisions related to production and service generating processes); and (3) business value of sustainability (business implications of social and environmental sustainability). Albeit seemingly distinct, these three streams are somewhat intertwined with each other. Moreover, there are specific research gaps in these three streams that I address in my dissertation.

Specifically, my dissertation comprises three essays on the outcomes of various sustainability initiatives related to green IT and sustainable operations, and the relationship among the dimensions of sustainability. I address each of the following research questions:

RQ1: Do shareholders favor green IT announcements? Which type of green IT announcements generates maximum shareholder value?

RQ2: What is the relationship between environmental performance (defined in terms of direct and indirect emissions, i.e., emissions classified according to the ownership of the source and operational performance (defined in terms of cost efficiency and productivity). Do environmental management systems (EMS) and quality management (QM) moderate this relationship?

RQ3: Do social sustainability and environmental sustainability directly affect economic sustainability? Does social sustainability moderate the relationship between environmental sustainability and economic sustainability (in terms of profitability and operational costs)?

In the first essay, I utilize signaling theory and event study methodology to understand the short-term business value in terms of market returns of green IT announcements. Further, I examine whether the different types of green IT announcements have different impact on market value in order to better understand the wealth effects and shareholder evaluations of the business potential of green IT investments. The business value of a technology asset also depends on the firm's capabilities. I therefore examine whether shareholders respond differently to green IT announcements from organizations with different innovative capabilities. Empirical results provide support for the impact of green IT announcements on the market value of firms, and provide important insights into the relative importance of different types of green IT announcements as perceived by shareholders.

In the second essay, by grounding the discussion in the resource consumption perspective, I disaggregate the environmental performance into emissions classified according to the ownership of their sources and examine their relationships with cost efficiency and productivity in organizations. I also examine the moderating role of QM and EMS in the relationship between environmental and operational performance. Empirical findings suggest that reducing emissions from sources owned by organizations improve cost efficiency but reduce productivity. Further reducing such emissions through QM reduces productivity. But, reducing emissions from purchased energy in the presence of QM improves productivity.

In the third essay, I examine whether social and environmental sustainability encompass conflicting objectives. Grounding this essay in two contrasting perspectives, namely the stakeholder theory and the paradox lens, I empirically test the main relationships of social sustainability and environmental sustainability as well as their interaction effect with performance measures (defined in terms of profitability and operational costs). Empirical findings suggest that the interaction effect of social sustainability and environmental sustainability is positive and significant, as far as profitability is concerned. But, the interaction effect is not significant with respect to operational cost. Our findings also suggest that while the operational cost mediate the relationship between social sustainability and profitability, it does not mediate the relationship between environmental sustainability and profitability

Taken together, the dissertation as a whole offers a broader perspective with insights drawn from secondary data, and the three essays advance our understanding of the business value of sustainability as well as the relationships among its different dimensions.

Chapter 1

Introduction

1.1. Sustainability

With the prominence of sustainability in public discourse, the focus has shifted from an emphasis on the financial performance of organizations to also include its social and environmental performance. Broadly, "sustainability" refers to "the way of utilizing resources, which meets the need of the present generation without compromising the ability of future generations to meet their own needs" (WCED 1987, pp. 41). Sustainability in an enterprise context is defined as achieving sustainable development by delivering economic, environmental and social benefits (Hart 1995). Previously, the concept of sustainability was primarily used with reference to society. However, there is an increasing emphasis on organizations as drivers of a sustainable society.

Recent estimates such as Melville (2012) peg the contributions of organizations to the total US greenhouse gas (GHG) emissions as between 39% and 47%. In addition to GHG emissions, organizations are also major consumers of natural resources (Ekins 1993) and are often responsible for generating harmful waste (Shrivastava and Hart 1995, EPA 2011a) that are hazardous to health. Thus, organizations are central to initiatives targeted at curbing the adverse environmental impact of human actions. The initiatives targeted at improving the environmental performance of organizations fall under the broad realm of "*environmental sustainability*". Beyond environmental sustainability, there is also an increasing focus on social issues such as the employment of child labor and unethical practices by organizations. The focus on the social dimension of an organization's operation falls under the broad realm of "*social sustainability*" and is an organization's response to the community's concern on value creation for society by the organization. Social sustainability and environmental sustainability constitute the two pillars of a new paradigm in the domain of organizational performance metrics. Economic sustainability constitutes the third pillar. Together, these three pillars form the "triple bottom line" (Hubbard 2009). The economic sustainability dimension comprises measures such as profitability that assesses the financial health of an organization. A recent survey suggests that environmental sustainability and social sustainability are considered as precursors to economic sustainability (Berns et al. 2009). Organizations are increasingly adopting various practices of social and environmental sustainability with the objective of improving economic sustainability.

1.2. Different Streams of Sustainability

Sustainability is an interdisciplinary concept spanning disciplines such as economics, organizational behavior, and strategy. In this dissertation, I focus on three streams of contemporary sustainability research, namely sustainable or green IT, sustainable operations, and business value of sustainability.

1. *Sustainable or green IT*

Sustainable or green IT is defined as information and communication technologies that can directly or indirectly help to reduce the adverse environmental impact of various business activities (Boudreau et al. 2008, Melville 2010, Walsh 2007). There are different perspectives on the role of IT on sustainability. Some argue that IT in general is environment friendly as it often substitutes carbon-intensive practices such as commuting. In contrast, others are of the view that IT contributes to global warming (Watson et al. 2010). Thus, there are two sides of green IT. One side focuses on IT as an environmental problem and subsequently focuses on greening the IT (reducing the harmful impact of IT) and includes IT artifacts such as a green data center. The other side focuses on the use of IT to solve environmental problems and includes IT artifact such as carbon management system (Nanath and Pillai 2014). Despite these two sides, green IT addresses environmental problems associated with or without IT (Lei and Ngai 2013).

2. *Sustainable Operations*

Sustainable operations as a research stream was conceived in the early 1980s (Kunreuther and Kleindorfer 1980). However, lately there is an increasing emphasis on sustainable operations. Sustainable operations focus on traditional operational perspectives such as profit and efficiency orientation in conjunction with an organization's environmental impact (Kleindorfer et al. 2005). Thus, the focus is on the environmental impact of organizations' manufacturing and service generation processes. It also encompasses sub-streams such as sustainable supply chain, where the focus is on the environmental impact of the entire supply chain of organizations (Linton et al. 2007).

3. *Business Value of Sustainability*

While the focus of previous two streams of research are on specific areas such as IT and operations (manufacturing and service generation processes), there is a long history of research on the environmental sustainability - economic sustainability linkage (Endrikat et al. 2014).

The research on the business value of sustainability also includes several meta-analysis. Research has predominantly focused on the payoff from environmental sustainability or payoff from aggregate sustainability (social and environmental sustainability aggregated). The focus is often on understanding whether sustainability relates to specific measures of profitability and market value. The relationships proposed and tested range from linear to U-shaped (Barnett and Solomon 2012). Lately, there is increasing focus on the business value of specific areas such as employee and product performance as well as disaggregating sustainability in terms of strengths and weaknesses (Jayachandran et al. 2013).

1.3. Literature Review

Motivated by the importance of understanding the state of research in these three streams, I review the extant literature related to these different streams.

1. *Sustainable or green IT*:

Green IT gained prominence from 2007 (Elliot 2007). Prior research has often considered green IT and green IS (technology hardware plus processes and policies) as the same (Mithas et al. 2010). Although some research (e.g., Iacobelli et al. 2010) has differentiated between them, in this dissertation, I consider green IT and green IS interchangeably.

Table 1.1 summarizes the key research on green IT. In Table, I highlight the following details: (1) research focus; (2) method; (4) level of analysis; and (4) key findings.

Table 1.1: Review of Key Research on Green IT

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
Initiation, design and implementation	Murugesan (2008)	Develop an understanding of the emergence of green IT, focus on IT artifacts	Author's perspective based on his understanding of industry practices	Organization	Green IT is vital for organizations.
	Watson et al. (2010)	Advocate a research agenda to develop the field of energy informatics with extensive focus on energy management systems	Review of many organizational practices	Organization	Need for a research stream that focuses on how IS can promote environmental sustainability.
	Melville (2010)	Develop a research agenda on IS innovations to promote environmental sustainability	Literature search of leading IS journals such as Information Systems Research, Information Systems Journal, MIS Quarterly, Journal of Management Information Systems, European Journal of Information Systems	Organization	Grounded in the belief-action-outcome, ten research questions proposed to guide the development of green IT research

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
			and OM journals and Journal of Operations Management, Production and Operations Management, Management Science, Operation Research, and Manufacturing and Services Operation Management		
	Corbett (2010)	Examination of practitioners' literature to further our understanding of green IT	Practitioners' literature specifically 20 articles published in CIO magazine from 2007 to 2010	Organization	Classify green IT into four types and propose two theoretical perspectives, namely NRBV and environmental embeddedness to examine green IT
	Elliot (2011)	Develop a framework for IT driven business transformation to promote environmental	Literature review of 140 articles published in key journals across various disciplines	Organization	Define environmental sustainability and associated challenges. Also, describe the

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		sustainability			current state of affair on efforts to address these challenges and steps required to further address them.
	Molla and Cooper (2012)	Understand the different components of greening IT	Literature review and a pilot survey mailed to 500 organizations. A leading sustainability consulting organization conducted the survey.	Organization	Develop a G-readiness (green readiness framework) for organizations.
	Hasan et al. (2012)	Develop a taxonomy of green IT	Literature review and content analysis of 15 green IT paper	Organization	Classify green IT into different categories.
	Ijab et al. (2012)	Emergence and use of green IT in organizations	Invoke theories and concepts from past research, such as a Bourdieu's theory of practice and a single organization case study	Organization	Describe the evolution of green IS field and the use of specific green IS practices.
Adoption of green IT	Kuo (2010)	Examine the antecedents of green IT adoption with specific focus on	Online survey of 43 senior managers and managers with environmental	Organization	Green IT in organizations is influenced by

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		technological constraint	responsibilities		management, bottom line considerations and institutional pressures.
	Schmidt et al. (2010)	Relationship between IT business alignment and importance of green IT	Survey of 116 CIOs, IT managers, environmental managers and staff	Organization	The importance of green IT and uncertainty around it influences its adoption.
	Molla and Abareshi (2011)	Relationships between organizational motivation and adoption of green IT	Online survey of 176 CIOs and IT managers	Organization	Eco-efficiency and eco-effectiveness motivate the adoption of green IT.
	Nedbal et al. (2011)	Antecedents of green IT adoption with specific focus on technological compatibility	Invoke Technology - Organization- Environment (TOE) framework and diffusion of innovation and transaction cost theory and single organization case study based on PROMET Business Engineering Case	Organization	Support for the theoretical model that integrates various theoretical perspectives. Findings suggest that error reduction and IT optimization are the

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
			Studies methodology.		key to environmental sustainability.
	Corbett (2012)	Antecedents of green IT adoption with specific focus on technological compatibility	Qualitative field study. Semi-structured interviews with 22 participants from 11 organizations in the electricity sector	Organization	Success of specific green IT artifacts depends on the organizational response to institutional pressures.
	Lei and Ngai (2012)	Focus on organizational resources that promote the adoption of green IT	Conceptual piece based on logical arguments and theories	Organization	Institutional factors, environmental uncertainty, and organizational resources are proposed as antecedents of adoption of green IT. Organizational resources could be moderators of the relationship between environmental

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
					uncertainty and adoption of Green IT
	Lei and Ngai (2013)	Review and classification of antecedents of green IT adoption	Literature review	Organization	Antecedents classified according to the TOE framework. The framework suggests the need for future research to focus on organizational decision makers.
	Seidel et al. (2013)	Explore how a software solutions provider implemented green IT	Single organization case study	Organization	Unravels the types of functional affordances of information systems required for sustainability.
	Marett et al. (2013)	Examines the factors behind the adoption of a bypass system (a specific green IT artifact)	Survey of 249 truck drivers from 24 US states	Individual	Economic benefits and industry pressures rather than environmental benefits positively relate to drivers' use

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
					of bypass systems, therefore suggesting that economic rationale is salient in the adoption of green IT.
	Mishra et al. (2014)	Application of the theory of reasoned action to green IT. Examine the relationships between behavioral intention and the actual use of green IT. The role of external factors such as beliefs, sector, and level of awareness in actual use of green IT are also investigated.	Survey of 182 IT professionals on issues (problems and developments) in the use of IT in organizations	Individual	Respondents with positive behavioral intentions towards actually used green IT in their work.
Benefits	Mithas et al. (2010)	Factors that influence	Archival data and survey	Organization	Top management

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		green IT implementation as well as their consequences	data obtained from a leading information technology publication group in India and a market research organization (sample size 221)		support and perceived importance of green IT influence spending on green IT in organizations. Green IT is positively related to reductions in IT energy consumption and profit .
	Watson et al. (2010)	Explore use of energy informatics to advance sustainability objectives	Single organization case study	Organization	Describes how a logistics organization developed energy informatics capabilities to reduce emissions and improve safety.
	Krishnan et al. (2011)	Relationship between IT readiness, ICT usage, and national sustainability development	Analysis of archival data from 108 countries	Country	National ICT usage mediates the relationship between government IT readiness and

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
					environmental sustainability.
	Nishant et al. (2012)	Relationship between environmental performance and organizational performance in the context of green IT organizations	Econometric analysis of archival data of 47 green IT organizations	Organization	Green IT organizations benefit financially from improving their environmental performance.
	Scott and Watson (2012)	Develop a framework to measure value of cloud computing (green IT artifact)	Case study based on three small and medium enterprises (SMEs) that extensively use or supply cloud technologies	Organization	Propose a value framework for cloud computing.
	Nishant et al. (2013a)	Relationship between different green IT assets and environmental performance	Econometric analysis of archival data of 47 green IT organizations	Organization	Different green IT assets influence different types of emissions differently.
	Loock et al. (2013)	Understand how IT promotes energy-efficient	Field experiment involving 1791 customers registered with Velix system (a	Individual	Goal setting functionality in IT promotes energy

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		behavior	web-based energy feedback system)		conservation.
	Nishant et al. (2013b)	Examine the relationships between specific green IT practices and organizational performance.	Econometric analysis of archival data of 115 organizations	Organization	Green IT is positively associated with market value and innovativeness. Extent of green IT is positively associated with profitability.

Table 1.1 shows that research in the domain of green IT can be classified into categories such as initiation, design and implementation, adoption, and payoffs from green IT (Califf et al. 2012, Lei and Ngai 2013). The studies address the question such as “what constitutes green IT/IS?” and “How green IT can be implemented in organizations. Past research introduced new concepts such as “energy analytics” (Watson et al. 2010). Initially, such research often delineated the rationale for green IT research by explaining the potential role that green IT could play in addressing environmental concerns. Research has also focused on the distinction between conventional IT artifacts and green IT (Luo and Bose 2012). They specifically focused on the environment-friendliness aspect of green IT relative to conventional IT.

Such research also focused on specific IT artifact such as cloud computing and their environment-friendliness. Specifically, the focus is on providing the rationale for membership of such IT artifacts to the green IT group. Research has also focused on classifying green IT artifacts into different classes based on specific characteristics such as objectives achieved by them (Corbett 2010). The underlying idea is to present a classification of green IT, since green IT itself is a broad term and comprises various distinct IT artifacts. However, despite the focus on distinction between green IT and conventional IT, there are many IT artifact such as cloud computing, which can be classified into both conventional IT as well as green IT. Their membership to different groups depends on the objective for which they are utilized in the organization. Research on the design of green IT outlines the steps for implementing green IT in organizations and proposes frameworks such as source-make-deliver-return framework (Schmidt et al. 2009). Specifically, they focus on the execution of specific green IT practices in organizations.

Past research on initiation, design and implementation clearly suggest that green IT is primarily focused on organizational responses to environmental concerns that emanate from various IT artifacts. In terms of its focus, green IT is unique and different from conventional IT artifacts that focus on issues such as productivity.

Studies focused on the adoption of green IT have often focused on factors that foster the adoption of green IT in organizations (Lei and Ngai 2013). Presently, research on the adoption of green IT often invoke theoretical lenses such as institutional theory to understand the antecedents of green IT. Lately, research has focused on adoption of green IT in specific sectors such as logistics (Frehe and Teuteberg 2014).

Similar to the focus in past research on understanding the value of IT assets, research is increasingly examining the business value of green IT. Specifically, the focus is on understanding the economic and environmental benefits of green IT. However, the focus is primarily on understanding the long-term business value of green IT. Therefore, past research often focuses on accounting measures such as profitability. Research such as Mithas et al. (2010) and Nishant et al. (2012) have examined the relationships between green IT with profitability and operational performance. Such research often invoke the resource-based view and the natural resource-based view (NRBV) to understand the payoffs from green IT.

Akin to the productivity paradox observed for other IT assets, it is possible that economic benefits of green IT might not be immediately visible. Hence, there could be conflicting opinions on the long-term business value of green IT. However, although short-term business value of green IT can be assessed, there appears to be less focus on it. Moreover, the short-term business value of green IT could indicate whether it is acceptable to important stakeholders such as shareholders, since shareholders would react immediately to any green IT initiatives, and their perception about green IT would be visible in terms of movement in stock-prices. This research gap is addressed in Essay 1.

2. *Sustainable Operations*:

The sustainable operations research stream focuses on specific areas such as product design, technology choice, supply chain management, and choice of the operational decisions that could influence environmental performance - organizational performance linkage. A common theme across research on these different areas is the focus on organizations' ecological efficiency. I summarize the key research in sustainable operations in Table 1.2 in terms of: (1) research focus; (2) method; (4) level of analysis; and (4) key findings.

Table 1.2: Review of Key Research on Sustainable Operations

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
Conceptualizing Sustainable Operations	Corbett and Kleindorfer (2001a)	Key factors that promote the integration of environmental management with operations	Conceptual, editorial article to develop a research agenda	Organization	Benefits such as better corporate image, improvement in revenue, requirements of regulatory compliance promote the integration of environmental management with operations.
	Corbett and Kleindorfer (2001b)	Focus on managerial practices within organizations	Conceptual, editorial article to develop a research agenda	Organization	Extant research integrates environmental and economic sustainability of industrial activities.
	Corbett and Kleindorfer (2003)	Discuss a research agenda on sustainable operations	Conceptual, editorial article that discusses 9 articles on sustainable	Organization	Environmental concerns are increasingly

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
			operations		integrated into organizations' operations.
	Kleindorfer et al. (2005)	Trace the evolution of sustainable operations as a research stream	Literature review of over 75 articles	Organization	Map the various research topics that constitute sustainable operations and potential contributions of the stream.
	Linton et al. (2007)	Conceptualize sustainable supply chain	Literature review of over 70 articles.	Supply chain	Need for variety of methodologies such as case study analysis, statistical analysis, and analytical modeling to address issues such as by-products of the supply chain, entire life cycle of the product, and

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
					focus on total cost rather than present cost.
	Sarkis et al. (2011)	Conceptualizing green supply chain (akin to sustainable supply chain)	Literature review of 156 articles	Supply chain	Categorize the literature according to the theoretical lens and propose research questions for future research.
	Drake and Spinler (2013)	How sustainable OM can endure as a discipline	Based on presentation delivered by Morris Cohen for Paul's Manufacturing and Service Operations Management Distinguished Fellows Award	Organizations	Sustainability is a key issue and OM can play an important role in addressing various concerns.
Specific issues	McDonough and Braungart (2000)	Examine the concept of eco-efficiency and examine cradle-to-cradle systems	Past literature and practitioners' perspective	Product	Present three new design principles, which could help organizations to

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
					improve their environmental performance
	Plambeck and Wang (2009)	Impact of e-waste collection regulations on new product introduction	Analytical modeling (Monopoly and Duopoly models)	Organization	Specific e-waste regulation, such as individual extended producer responsibility could promote design for recyclability in specific product categories.
	İşlegen and Reichelstein (2011)	Cost analysis of carbon capture and storage technology	Analytical modeling and economic analysis	Specific technology	Advise policy by providing an estimate of the break-even emissions price for the adoption of carbon capture and storage technology.
	Drake et al. (2012)	Optimal technological portfolio for	Analytical modeling	Organization	More benefits for organizations under

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		organizations under carbon regulation			cap-and-trade regulation than carbon tax.
	Caro et al. (2013)	Double counting of supply chain emissions	Analytical modeling (general model of joint production of GHG emissions in general supply chains) and scenario analysis	Organization	Emissions must be over-allocated to achieve desired environmental objectives.
	Demeester e al. (2013)	Links between material recycling and operations strategy with plant networks	Analytical modeling (modified optimal market area model)	Network	Material recycling, small plants and localization can constitute sustainable operations strategy.
	Cachon (2014)	Relationship between retail store density and cost of greenhouse gas emissions	Analytical model (present a model of the retail supply chain)	Network	The best alternative to reduce emissions is to improve consumer fuel efficiency.
Benefits from specific practices that constitute	King and Lenox (2001), Klassen (2001), and Delmas (2001)	Benefits from better safety, health, and environment (SHE)	Econometric analysis of archival data and survey	Organization	Better SHE delivers benefits such as improved

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
sustainable operations or sustainable operations in general					productivity, better reputation, and increase in market share
	Sroufe (2003a)	Impact of environmental management practices on perceived operations performance	Survey of 1331 managers involved in environmental initiatives.	Organization	The extent of environmental waste practices and environmental management system is positively associated with perceived operations performance.
	Melnyk et al. (2003)	Impact of formal certified and uncertified environmental management system on perceived organizational performance	Survey of 1222 managers	Organization	Formal certified EMS is positively associated with a perceived reduction in costs, lead time, and perceived position in the market.
	Montabon et al. (2007)	Relationship between	Cross-sectional	Organization	Specific

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		environmental management practices and organizational performance	analysis of archival data (sustainability reports of 45 organizations)		environmental management practices such as recycling, proactive waste reduction, remanufacturing, environmental design, and surveillance of the market for environmental issues are positively related to product and process innovation.
	Jacob and Singhal (2010)	Impact of announcements of environmental performance on stock market reactions	Event study method applied to two distinct set of announcements comprising 780 announcements that appeared in US newspapers, European dailies, and business	Organization	Announcements on voluntary emission reductions are negatively related to market reaction and announcements on IS 14001 are positively related to market

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
			wire service (Regression based methodology)		reaction.
	Delmas and Nairn-Birch (2011)	Impact of total emissions and total supply chain emissions on profitability and market valuation	Econometric analysis of archival data (2678 organization year observations)	Organization	Reduction in total emissions is negatively associated with profitability, but positively associated with market valuation.
	Kroes et al. (2012)	Relationship between environmental performance (emissions) and organizational performance under cap and trade regulation	Econometric analysis of archival data from 36 organizations	Organization	Under stringent regulation, better environmental performance is negatively associated with organizations' market performance.
	Jacob (2014)	Potential causes of mixed findings for emissions reduction-organizational	Event study method (Regression based methodology) applied to 450 announcements	Organization	Market reaction to voluntary emissions reduction has declined over time. Market

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		performance linkage	over two decades		values greenhouse gas reduction more relative to other emissions and rewards intent rather than realized reductions.

Table 1.2 shows that research in the domain of sustainable operations initially focused on conceptualizing and defining the boundary of sustainable operations. Akin to the research on green IT, research in the domain of sustainable operations initially focused on defining what constitutes sustainable operations. Past literature suggests that conventional operations management areas such as product redesign and inventory constitute sustainable operations provided their focus is on either social or environmental sustainability (Kleindorfer et al. 2005). Initially, the focus of sustainable operations was predominantly on environmental sustainability. However, recent research also focuses on social sustainability and specific issues such as child labor (Hollos et al. 2012). Sustainable operations also include sub-domains such as green supply chain or sustainable supply chain, where supply chain is the primary unit of analysis (Linton et al. 2007).

Methodologically, the studies in the domain of sustainable operations can be classified into analytical studies or empirical studies. Analytical studies develop or utilize extant mathematical models to optimize environmental performance under various constraints. Therefore, research focused on specific issues often utilizes analytical models. Such research covers a wide range of issues ranging from the plant location to the optimal technological portfolio. A key characteristic of such studies is that they are based on certain assumptions. Nevertheless, they offer rich insights to practitioners and policy makers.

In contrast, empirical studies focus on statistical analysis of past data or perceptual data to examine the relationships between specific practices and various outcomes. Empirical research focuses on either environmental outcomes or financial outcomes. However, the emphasis is predominantly on financial outcomes. Research often examines the relationship between specific initiatives such as ISO 14001 and financial performance (Delmas 2001). Lately, the focus is on deciphering specific practices that improve financial outcomes and the relationship between environmental performance and financial outcome (Montabon et al. 2007). Research has focused on both short-term as well as long-term business value of environmental performance. While the research on short-term business value has found that voluntary improvement in environmental performance has negative implication and there is a temporal pattern in return from announcements on environmental performance (Jacob and Singhal 2010, Jacob 2014), research on long-term business value suggests mixed findings. Previously, research on environmental performance - financial performance linkage often focused on aggregate measures of environmental performance such as total emissions. However, recent research such as Delmas and Nairn-Birch (2011) used relatively granular measures such as total supply chain emissions to understand the relationship between environmental performance and financial performance.

However, research rarely examined the relationships between specific types of emissions and other aspects of organizational performance, and the role of specific environmental management practices in such relationships. This research gap is addressed in Essay 2.

3. *Business Value of Sustainability*:

While the sustainable operations research stream has focused on the relationships between environmental management practices and organizational performance, there is another stream of research in the broader domain of sustainability that has examined the relationship between sustainability with organizational performance and the relationship between specific dimensions of sustainability and organizational performance. I summarize the key research in business value of sustainability in Table 1.3 in terms of following details: (1) research focus; (2) method; (4) level of analysis; and (4) key findings.

Table 1.3: Review of Key Research on Business Value of Sustainability

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
Sustainability in general (no distinction between social and environmental sustainability)	Vance (1975)	Comparison of performance of stock performance of socially responsive organizations with organizations that constitute different indices	Comparison of change in stock prices of 14 socially responsible organizations and other organizations listed in various indices.	Organization	Socially responsive organizations performed worse relative to other organizations
	Arlow and Cannon (1982)	Corporate social responsiveness-economic performance linkage	Review of 7 empirical articles	Organization	The relationship between corporate social responsiveness and economic performance is inconclusive.
	McGuire et al. (1988)	Relationship between perception of organizations' corporate social responsibility and financial performance	Analysis of survey and archival data of 131 organizations.	Organization	Organizations' prior financial performance is positively related to its corporate social responsibility.
	Griffin and Mahon	Relationship between	Review of 51 articles	Organization	Use of different

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
	(1997)	corporate social performance and organizations' financial performance	and analysis of archival data of 6 organizations		measures could influence the relationship. Potential for positive relationship between corporate financial performance and social performance in the long run.
	Hillman and Keim (2001)	Relationship between stakeholder management, social issue participation and shareholder value creation	Econometric analysis of archival data of S&P 500 organizations	Organization	Stakeholder management is positively related to shareholder value, but social issue participation is negatively related to shareholder value.
	Orlitzky et al. (2003)	Meta-analysis of relationship between corporate social performance and	Statistical analysis of results reported in 52 studies	Organization	Corporate social performance is more strongly related to accounting-based

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		financial performance			measures than market-based measures of financial performance.
	Barnett (2007)	Distinct effect of corporate social responsibility on financial performance across different organizations and different time	Review article	Organization	Contingencies such as stakeholder influence capacity could influence the relationship between corporate social responsibility and financial performance.
	Barnett and Solomon (2012)	Relationship between corporate social performance and financial performance to provide an explanation for the conflicting findings in prior research	Econometric analysis of archival data (4730 organization-year observations)	Organization	The relationship between corporate social performance and financial performance is U-shaped.

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
	Erhemjamts et al. (2013)	Relationship between corporate social responsibility and organization's investment policy, organizational strategy, and performance	Econometric analysis of archival data (17516 organization-year observations)	Organization	Corporate social responsibility strengths are positively associated with organization's investment policy, organizational strategy, and performance.
Environmental Sustainability	Friedman (1970)	Relationship between corporate environmental performance and financial performance	Opinion piece	Organization	Focus on environmental performance divert financial resources from profit maximization and therefore adversely affect organizations' financial performance
	Cordeiro and Sarkis (1997)	Relationship between corporate environmental performance and	Statistical analysis of archival data of 523 organizations		Environmental performance is negatively related to

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		financial performance			financial performance.
	King and Lenox (2002)	Relationship between environmental performance and financial performance	Econometric analysis of archival data (2837 organization-year observations)	Organization	Waste prevention is related positively to financial performance and is responsible for the positive relationship between lower emissions and profitability.
	Earnhart and Lizal (2007)	Relationship between environmental performance and financial performance	Econometric analysis of archival data (1044 organization-year observations)	Organization	Better environmental performance undermine revenue, but also lower costs.
	Horváthová (2010)	Meta-analysis of relationship between environmental performance and financial performance	Statistical analysis of results reported in past research (37 articles)	Organization	Methodology and time-lag is salient in the conflicting findings in prior research.
	Albertini (2013)	Meta-analysis of relationship between	Statistical analysis of results reported in past	Organization	Choice of measures, regional differences,

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		environmental performance and financial performance	research (52 articles)		sectors and the time-frame of the study is salient in the conflicting findings in prior research.
	Endrikat et al. (2014)	Meta-analysis of relationship between environmental performance and financial performance	Statistical analysis of results reported in past research (149 articles)	Organization	Positive and partially bidirectional relationship between environmental performance and financial performance. Choice of measures is salient in the conflicting findings in prior research.
Social Sustainability	Margolis and Walsh (2003)	Review of research on social performance - financial performance linkage and setting the research agenda for	Review article (review of 127 articles)	Organization	Propose tension between organizations' social initiatives and economic objectives.

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		social sustainability initiatives by organizations			
	Van Der Laan et al. (2008)	Relationship of disaggregated measures such as employee, human rights with financial performance	Econometric analysis of archival data of S&P 500 organizations	Organization	Findings indicate the presence of a complex relationship between corporate social and financial performance.
	Bronn and Cohen (2009)	Examine the motives for organizations' decision to engage in social initiatives	Survey of 500 Norwegian organizations	Organization	Profitability motive is salient in organizations' decision to engage in social initiatives.
	Leppan et al. (2010)	Examine the difference in perceptions of trade-offs and synergies between environmental and social sustainability	Semantic analysis (A subset of qualitative analysis) of 20in-depth interviews with officially appointed and "emergent' CSR leaders within the bank	Organization	Findings suggest that complex relationships between the social and environmental elements of sustainability exist in the minds of

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
			and NGO advisor , and forums		different stakeholders.
	Hahn et al. (2010)	Develop a framework to conceptualize tensions between social and environmental sustainability	Review article	Organization	Propose that tension between environmental sustainability and social sustainability are the norm rather than exception and trade-off exists between the two.
	Klassen and Vereecke (2012)	Conceptualize social issues in the supply chain	Review article and five organization case study	Organization	Describes capabilities and linkages that managers can leverage to address social concerns.
	Gregory et al. (2013)	Relationship between corporate social responsibility (CSR) and organization value in terms of forecasted	Econometric analysis of archival data (13089 organization-year observations)	Organization	Strengths are positively related to forecasted profitability, long-term growth and

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
		profitability, long-term growth and the cost of capital			the cost of capital, whereas weaknesses are negatively related to forecasted profitability, long-term growth and the cost of capital.
	Endrikat et al. (2014)	Meta-analysis of relationship between environmental performance and financial performance	Statistical analysis of results reported in past research (149 articles)	Organization	Although the meta-analysis is on environmental performance - financial performance linkage, it raises several issues such as a combination of several unrelated aspects such as social and environmental into corporate social performance construct in past research

Categories	Authors	Research Focus	Method	Level of Analysis	Key Findings
	Girerd-Potin et al. (2014)	Identify the dimensions that reflects an organization’s response to a social issue	Statistical analysis of archival data of 816 organizations	Organization	Findings suggest that there are three dimensions that relate to different stakeholders
	Marsat and Williams (2014)	Market response to organizations’ social expenses	Econometric analysis of archival data (8321 to 11526 organization-year observations)	Organization	Different components of social expenses are positively related to goodwill.
	Hahn et al. (2014)	Framework for tensions in sustainability	Review article	Organization	Based on paradox lens, the article proposes four tensions

Table 1.3 shows that existing research in the domain of the business value of sustainability often conceptualized corporate social responsibility and sustainability as one construct and examined its relationship with financial performance. Initially, the research focused on the relationship between aggregate sustainability and measures of profitability such as Return on Assets (ROA) and found conflicting relationships between aggregate sustainability and profitability (Barnett 2007). However, recent research such as Barnett and Solomon (2012) has found support for the **U-shaped relationship** between aggregate sustainability and profitability, and suggests it as a potential explanation for conflicting findings in past research.

Lately, past research also included empirical examination of environmental performance-financial performance relationship (e.g. King and Lenox 2002). The research on environmental performance-financial performance relationship comes under the purview of both sustainable operations and business value of sustainability. Studies focused on it often argue for resource-efficiency and cost-efficiency, which are the key operational objectives as being instrumental in environmental performance-financial performance linkage.

Such studies often invoked different theoretical lenses such as the resource-based perspective and the innovation-offset perspective, and found support for both positive and negative relationships between environmental performance and financial performance.

There have been several meta-analyses to establish the direction of the relationship, but the findings are still inconclusive and conflicting findings are attributed to measures and methodology (Horváthová 2010, Endrikat et al. 2014). The methodology varied from simple correlational approaches to econometric analyses, and measures varied from eco-ratings to aggregate emissions.

Lately, there is an increasing focus on social sustainability and past research such as Van Der Laan et al. (2008) found support for complex relationships between social sustainability and financial performance. Studies often invoke theoretical lens such as stakeholder theory to propose the relationship between social sustainability and financial performance. Research has also suggested that social sustainability encompasses distinct dimensions and each dimension could have different relationship with financial performance (Van Der Laan et al. 2008). Therefore, relationship between social sustainability and financial performance could be more complex relative to environmental performance-financial performance relationship.

Recently, there have been various theoretical studies that propose trade-offs and tensions between different dimensions of sustainability. Specifically, past research has argued for the paradox lens as an alternate theoretical lens to examine the relationship between different dimensions of sustainability and financial performance. However, empirical evidence, specifically on the relationship between environmental and social sustainability, is limited. Consequently, we investigate this research gap in Essay 3.

1.4. Research Questions

This dissertation focuses on payoffs from sustainability. Our literature review suggests three specific research gaps with respect to payoffs from sustainability. In the domain of green IT, there is a lack of research on the short-term business value of green IT. Specifically, research is silent on the market response to green IT announcements. Examining the market response to green IT announcements would indicate how such announcements are received by shareholders (a key stakeholder group). The long-term business value could not be immediately visible; therefore understanding the short-term business value would be useful in unraveling the business value of green IT. Hence, I address the following research question in Essay 1.

RQ1: Do shareholders favor green IT announcements? Which type of green IT announcements generates maximum shareholder value?

In the domain of sustainable operations, there is limited empirical evidence on the relationship between specific types of emissions and different dimensions of operational performance. Understanding this relationship is important as the operations management literature has often emphasized the linkage between operational performance and profitability. Lately, research has also suggested that reduced emissions could influence profitability through their impact on intermediate measures. There is also limited empirical evidence on the role of environmental management systems and quality management (two widely adopted operational initiatives) in emissions and operational performance linkage. Hence, I address the following research question in Essay 2.

RQ2: What is the relationship between environmental performance (defined in terms of direct and indirect emissions, i.e., emissions classified according to the ownership of the source and operational performance (defined in terms of cost efficiency and productivity). Do environmental management systems (EMS) and quality management (QM), moderate this relationships?

Finally, in the domain of the business value of sustainability, empirical evidence on the relationship between social sustainability and environmental sustainability is limited. There are theoretical and conceptual arguments that support different theoretical lens. However, there is a lack of empirical evidence that explains the relationships between social sustainability and environmental sustainability. Past research has often attributed the conflicting finding on the business value of sustainability to the use of different measures and time-lags. There is also a need to understand how social sustainability and environmental sustainability are related to profitability. Hence, I address the following research question in Essay 3.

RQ3: Do social sustainability and environmental sustainability directly affect economic sustainability? Does social sustainability moderate the relationship between environmental sustainability and economic sustainability (in terms of profitability and operational costs)?

The flow of the three essays is shown in Figure 1.1.

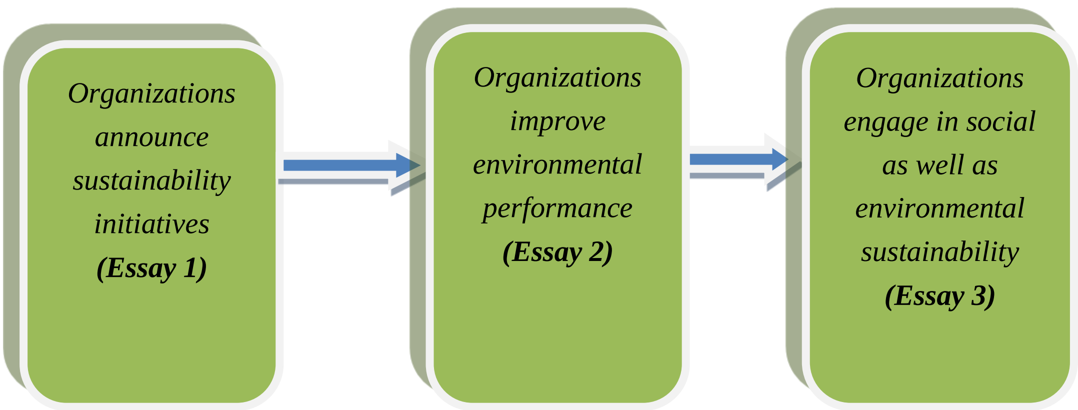


Figure 1.1. Flow of Three Essays

Framework for the Dissertation

Figure 1.2 depicts the framework for the dissertation. All essays focus on one or more aspects of environmental, social and economic sustainability. Essay 1 examines the impact of announcements targeted at environmental sustainability on the market value of organizations. Organizations perceive that their involvement in sustainability initiatives yield better market value (Berns et al. 2009, Haanaes et al. 2011), which is an integral component of financial performance (Sharma 2000, Berns et al. 2009). Thus, better market value also contributes to the economic sustainability of organizations. We use the event study methodology to examine abnormal returns for a specific type of environmental sustainability termed as green IT announcements.

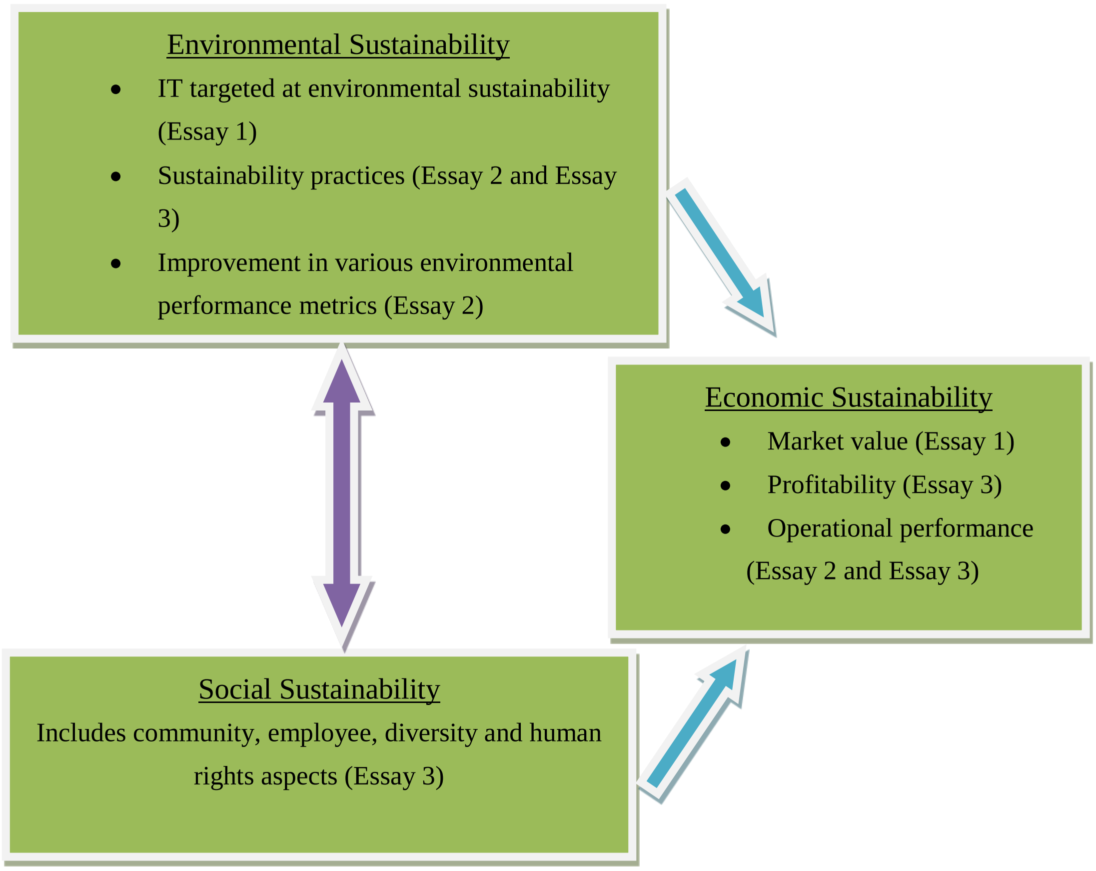


Figure 1.2. Framework for the Dissertation

Essay 2 empirically investigates an organization's journey from environmental performance to economic sustainability. Drawing from theoretical lens such as the resource consumption perspective, I examine whether different dimensions of environmental performance in terms of different types of emissions are related to different dimensions of operational performance. Extant research has theoretically recognized the business value of environmental performance (Hart 1995, Hart 1997, Hart and Dowell 2011), and used different measures of environmental performance such as capital expenditure on technology (Nehrt 1996), emissions of toxic chemicals (Hart and Ahuja 1996), log of total facility emissions of toxic chemicals (King and Lenox 2001), eco-efficiency ratings (Blank and Daniel 2002), and absolute level of air-pollutant emissions (Earnhart and Lizal 2007). However, such measures are often aggregated measures, e.g., aggregate emissions. Emissions are the end result of consumption of different energy sources, and the use of an aggregated measure makes it difficult to determine the underlying cause, which might be salient in environmental performance-operational performance linkage. Essay 2 addresses this issue. In doing so, the results provide empirical evidence that different measures of environmental performance have distinct impact on different dimensions of operational performance. Prior research such as Wade and Hulland (2004), and Benitez-Amado and Walczuch (2012) argue for investigation of the business value of initiatives at the level of intermediate variable, which in turn lead to better organizational performance (economic sustainability). Thus, operational performance is the intermediate variable between the environmental performance and profitability (economic sustainability). Therefore, Essay 2 focuses on operational performance.

Essay 3 brings social sustainability into focus. Due to the increasing importance of sustainability, organizations need to move beyond profit-maximization, and focus on the social and environmental dimensions (social sustainability and environmental sustainability) (Porter and Kramer 2011). Such a pursuit requires the effective allocation of organizational resources. Further, engagement in social sustainability and environmental sustainability is targeted at different stakeholders with conflicting demands (Donaldson and Preston 1995). The focus on the triple bottom-line involves tension among social, environmental, and economic sustainability. Due to limited resources, organizations often have to select between choices that may adversely impact environmental performance, but improves financial performance, or choose between social initiatives such as community development and environmental initiatives such as financing a new clean product development. However, research is silent on the empirical investigation of tensions among environmental, social, and economic sustainability. Essay 3 builds on the Essay 2, by examining the interaction between environmental and social sustainability. The contributions from various essays are summarized in Table 1.4.

Table 1.4: Key Contributions of Different Essays

Essays	Findings from the Prior Research	Contributions from Essays
1	• Negative returns from measures to improve environmental performance, such as a voluntary reduction in emissions, or membership in the EPA climate leaders program (Jacob et al. 2010, Fisher-Vanden and Thorburn 2011) • Positive returns from technology announcements or new products announcements (Sood and Tellis 2009, Lin and Chang 2011)	• First study to provide empirical support for the impact of green IT announcements on the market value of organizations • Provides important insights on the relative importance of the different types of green IT announcements as perceived by investors • Provides insights on whether investors view green IT announcements by innovative and non-innovative organizations differently
2	• Past research on environmental performance and organizational performance linkage has often used one or two aggregated measures of environmental performance, such as pollution performance and compliance with environmental regulations (Margolis et al. 2007, Delmas and Nairn-Birch 2011) • Despite extensive focus on the financial implications of environmental performance, prior research has rarely focused on the link with operational performance (Albertini 2013,	• Examines the relationship of specific dimensions of the environmental performance in terms of emissions with operational performance • Specifically, we show that whether firms benefit from better environmental performance also depends on the ownership of the sources of emissions. • The essay shows that whether organizations benefit from improving their environmental performance depends not only on environmental performance but also on other factors such as environmental management and quality management that may attenuate or strengthen the relationship

	Endrikat et al. 2014)	
3	• Research such as Barnett and Solomon (2012) have often hypothesized sustainability as a homogeneous concept comprising social, environmental, and corporate governance aspect, and empirically examined the relationship between sustainability and corporate financial performance. However, the hypothesized relationships are often linear or U-shaped • Failure to capture the complexity and distortion of joint effects of different dimensions of sustainability	• Conceptualizes social and environmental sustainability as distinct dimensions of sustainability and captures their joint effect on the various measures of organizational performance, which are proxies for economic sustainability • Examines how social and environmental sustainability influence each other • Examines the optimum setting for social sustainability and environmental sustainability to achieve maximum economic sustainability

Each essay in this dissertation is self-contained in terms of literature review, hypotheses development, and implications for research and practice. The essays together contribute to the emerging body of knowledge in the field of sustainability research and practice. The research hypotheses for all the three essays are summarized in Table 1.5.

Further, Tables 1.6 presents the research questions and key findings for Essays 1, 2 and 3 respectively.

Table 1.5: Hypotheses for Three Essays

Essays	Hypotheses
Essay 1: Do Shareholders Value Green Information Technology Announcements?	*H1: Green IT announcements result in positive abnormal returns for firms*[1]. *H2: Green IT announcements result in increased trading volume.* *H3: Green IT announcements on information to support decision-making (ITDSS) is positively associated with abnormal returns for firms.* *H4: Green IT announcements on direct IT assets and infrastructure (ITASSETS) are positively associated with abnormal returns for firms.* *H5: Green IT announcements on sustainable products and services (SPDTSVC) are positively associated with abnormal returns for firms.* *H6: Green IT announcements result in higher abnormal returns for innovative firms compared with noninnovative firms.*
Essay 2: Toward a Better Understanding of Environmental–Operational Performance Nexus	*H1a: Direct emissions are negatively associated with cost efficiency.* *H1b: Direct emissions are positively associated with productivity.* *H2a: Indirect emissions are negatively associated with cost efficiency.* *H2b: Indirect emissions are not associated with productivity.* *H3a: Direct emissions and cost efficiency have a stronger relationship in organizations with EMS than in organizations without EMS.* *H3b: EMS does not influence the relationship between direct emissions and productivity.* *H3c: Indirect emissions and cost efficiency have a stronger relationship in organizations with EMS than in organizations without EMS.* *H3d: EMS does not influence the relationship between indirect emissions*

[1] I use firms and organizations interchangeably

Essays	Hypotheses
	and productivity. *H4a: Direct emissions and cost efficiency have stronger relationships in organizations with QM than in organizations without QM.* *H4b: Direct emissions and productivity have stronger relationships in organizations with QM than in organizations without QM.* *H4c: Indirect emissions and cost efficiency have stronger relationships in organizations with QM than in organizations without QM.* *H4d: Indirect emissions and productivity have stronger relationships in organizations with QM than in organizations without QM.*
Essay 3: The Nexus between Social Sustainability and Environmental Sustainability with Economic Sustainability	*H1: Social sustainability is positively associated with economic sustainability.* *H2: Environmental sustainability is negatively associated with economic sustainability.* *H3: The interaction between social sustainability and environmental sustainability is positive such that social sustainability attenuate the negative effect of environmental sustainability on economic sustainability.*

Table 1.6: Research Questions and Key Findings for Three Essays

Essay	Research Questions	Key Findings
Essay 1: Do Shareholders Value Green Information Technology Announcements?	***RQ1.1****: How much do green IT announcements affect (a) market value and (b) trading volume?* ***RQ1.2****: Do shareholders react differently to different types of green IT announcements?* ***RQ1.3****: Do shareholders view green IT announcements by innovative and noninnovative firms differently?*	• Empirical support for the impact of green IT announcements on the market value of firms • Shareholders react to different types of announcements differently • Green IT announcements help firms to build positive impression • Green IT announcements on specific IT artifacts that aid decision-making and IT assets from firms with better environmental performance are viewed more positively
Essay 2: Toward a Better Understanding of Environmental–Operational Performance Nexus	***RQ2.1****: Is environmental performance associated with operational performance?* ***RQ2.2****: Do different dimensions of environmental performance in terms of direct and indirect emissions have different relationships with different measures of operational performance in terms of cost efficiency and productivity?* ***RQ2.3****: Do EMS and QM strengthen or weaken*	• Reduced direct emissions (emissions from the sources owned by firms) reduce COGS/revenue • Whether organizations benefit from improving their environmental performance depends not only on environmental performance but also on other factors such as EMS and QM that may attenuate or strengthen the

Essay	Research Questions	Key Findings
	the relationship between environmental performance and operational performance?	relationship • EMS and QM diverge in their impact on operational performance
Essay 3: The Nexus between Social Sustainability and Environmental Sustainability with Economic Sustainability	***RQ3.1****: Does economic sustainability increase when social sustainability and environmental sustainability increase?* ***RQ3.2****: What is the nature of interaction between social sustainability and environmental sustainability with economic sustainability?*	• Social sustainability offsets negative relationship of environmental sustainability with profitability • Unlike findings for profitability, environmental sustainability reduces operational costs, and social sustainability and environmental sustainability neither strengthens nor diminishes each other's relationship with operational costs • While employee relations and diversity dimensions are positively associated with profitability, employee relations and community dimensions are negatively associated with operational costs.

Chapter 2

Do Shareholders Value Green Information Technology Announcements?[2]

Summary

Despite the growing acceptance of the role of information technology (IT) in addressing environmental issues, prior research has not investigated shareholder reactions to green/sustainable IT announcements. Results based on the event study methodology, specifically the Fama-French four-factor (FFM4) model, showed that green IT announcements generated positive abnormal returns, thereby providing empirical evidence that shareholders view green IT as beneficial. In addition, trading volume increases, which indicate divergent views on green IT announcements. Moreover, the results indicate that shareholders viewed different types of announcements differently. Firms announcing initiatives on *information to support decision-making* (ITDSS) obtained more positive stock market reactions compared with other types of announcements. There is an assymetric effect where announcements on IT as a solution have stronger effect relative to greening of IT. Further, the number of announcements is positively correlated with firm reputation. Firms with good environmental performance benefitted more from announcements on ITDSS and *direct IT assets and infrastructure* (ITASSETS) compared to announcements on *sustainable products and services* (SPDTSVC). Implications for research and practice are discussed.

[2] An earlier version was the finalist for best paper award at Pacific Asia Conference on Information Systems, 2011.

2.1. Introduction

With the proliferation of green IT (defined as information and communication technologies that can directly or indirectly help to reduce the adverse environmental impacts of various business activities (Walsh 2007, Boudreau et al. 2008, Melville 2010, Lei and Ngai 2013), researchers have often focused on its business value (Mithas et al. 2010, Thambusamy and Salam 2010, Nishant et al. 2012) but have not evaluated shareholder reactions to green IT. To bridge this gap, we investigate the value shareholders place on green IT. Market value is generally better than accounting measures for indicating business value (Chatterjee et al. 2002). Hence, similar to the role of market value in delineating change in business value (Ranganathan and Brown 2006), change in market value following green IT announcements should also indicate the business value of such technologies. Moreover, market-based measures tend to be leading indicators whereas accounting measures tend to be lagging indicators.

There are different perspectives on IT. Some argue that IT in general is environment friendly as it often substitutes carbon-intensive practices such as commuting. In contrast, others are of the view that IT contributes to global warming (Watson et al. 2010). For instance, the carbon footprint of Apple iPhone 5s is about 70 kg CO_2equivalent (Porter 2013). Consequently, there are two sides of green IT. One side focuses on IT as an environmental problem and subsequently focuses on greening the IT (reducing the harmful impact of IT) and includes IT artifacts such as green data center. The other side focuses on the use of IT to solve environmental problems and includes IT artifacts such as carbon management system

(Nanath and Pillai 2014). Despite these two sides, green IT addresses environmental problems associated with or without IT (Lei and Ngai 2013). In this study, we focus on green IT in general.

Prior research (e.g., Jacobs et al. 2010, Jacobs 2014) has examined the business value of environmental performance in terms of the market responses to emissions reduction, certifications, and corporate initiatives such as business strategy, philanthropic activities, or the use of renewable energy. Although prior research focused on the broader concept of environmental performance, we focus on the IT component of corporate environmental initiatives.

Following prior research that has used signaling theory to examine stock market response to announcements such as CEO certification (Zhang and Wiersema 2009), innovation (Sood and Tellis 2009), environmental disclosure (Magness 2009), and joining global platforms such as the UN global compact (Janney et al. 2009), we use signaling theory to examine stock market responses to green IT announcements. Announcements signaled various firm characteristics or capabilities, which shareholders rewarded or penalized.

Green IT announcements can improve brand equity by signaling to shareholders that the firm cares about reducing costs, enhancing resource efficiency, and addressing environmental issues plaguing the planet. Shareholders' response would indicate whether they view green IT announcements favorably. Moreover, trading volume (number of shares traded during a given time period) would indicate whether positive sentiments about the firm, after green IT announcements, were widespread.

Green IT announcements encompass different IT artifacts that could address different environmental concerns. Some green IT announcements are related to investments in energy-efficient assets; others are related to new earth-friendly products or services. Thus, they constitute different IT solutions for environmental sustainability. We examine whether the different types of green IT announcements have different impact on market value in order to better understand the wealth effects and shareholder evaluations of the business potential of green IT investments. In addition, the business value of a technology asset also depends on the firm's capabilities (Aral and Weill 2007). We therefore examine whether shareholders respond differently to green IT announcements from organizations with different innovative capabilities. Hence, we investigate the following research questions:

RQ1.1*: How much do green IT announcements affect (a) market value and (b) trading volume?*

RQ1.2*: Do shareholders react differently to different types of green IT announcements?*

RQ1.3*: Do shareholders view green IT announcements by innovative and noninnovative firms differently?*

We make several contributions through this study. First, we use an event study method, widely validated in the management literature (e.g. Singhal and Hendricks 2002, Singhal 2005) to measure shareholder viewpoints regarding the value of green IT announcements. While previous research has examined the effect of corporate social responsibility announcements (Flammer 2012), green business announcements (Videen 2011), and environmental performance (Jacob 2014), they have not examined these announcements in the context of technology. In a similar vein, past research has often examined the business value of IT (Bharadwaj et al. 2009), but short-term business value of green IT is yet to be established. Research on the business value of sustainability suggests that shareholders penalize announcements on environmental outcomes such as voluntary emissions reduction (Jacob et al. 2010), but rewards responsible behavior toward the environment (Flammer 2012). Further, prior research has provided support for positive market response to IT investments (Bharadwaj et al. 2012). However, green IT is not merely a generic IT investment, but a specific type of IT targeted at environmental objectives. The business value of IT-enabled environmental objectives has not been established. Our study is the first to provide empirical support for the impact of green IT announcements on the market value of firms. Hence, we contribute to the literature on green IT and to the general body of literature on sustainability. In addition, we also examine if the market response to green IT announcements was widespread or restricted to a small segment.

Second, our results provide important insights into the relative importance of different types of green IT announcements as perceived by shareholders. In other words, we empirically demonstrate that shareholders react to different types of announcements differently. Such insights could help practitioners better select suitable green IT for investment. Our results demonstrate that greening through IT is preferred by shareholders relative to greening of IT. Thus, our findings indicate that shareholders assign supportive role to IT. IT has been often considered as a supporting function that could help organizations improve their productivity. Perhaps, shareholders are associating IT with greening of organizations' operations, but are less evangelical about greening of IT itself.

Third, while innovation has been viewed as increasingly crucial for the long-term survival of firms, it is currently unclear as to whether shareholder perceptions of innovativeness of firms play a significant role in their market value. Consequently, we examine whether shareholders view green IT announcements by innovative and noninnovative firms differently by analyzing their market returns from such announcements.

Fourth, we also carried out a series of post-hoc analysis to probe deeper into our results. We show that the number of announcements is positively correlated with firms' reputation. Perhaps, green IT announcements help firms to build positive impression and thus evoke positive sentiments from other stakeholders apart from shareholders. Our analysis also suggests that firm's past environment record often influence shareholders' perception of green IT announcements. Specifically, green IT announcements from firms with better environmental performance are viewed more positively and considered credible by shareholders.

The paper is organized first with a review of the literature on green IT and signaling theory. Next, we present our hypotheses, describe our datasets, and present our analysis procedures. Thereafter, we present and discuss the results, followed by implications for research and practice, and concluding remarks.

2.2. Background

Defining Green IT

Although green/sustainable IT has been defined in several ways (Table 1), one consistent theme is the role of different IT artifacts in reducing adverse environmental impacts. Such conceptualizations emphasize the impact of IT artifacts on the environment as the criterion for calling them *green IT*. Thus, generic knowledge management systems do not fit the category of green IT, but knowledge management systems for pollution prevention do (Melville 2010). Likewise, IT solutions that capture general data such as ERP do not qualify, but IT artifacts that capture environmental data do (Jenkin 2011). The focus is on IT artifacts that reduce a firm's adverse environmental impacts.

The literature has classified IT into different types based on their characteristics. For example, IT assets can be classified based on their infrastructural, transactional, informational, and strategic objectives (Weill and Broadbent 1998, Aral and Weill 2007). Infrastructural IT includes hardware such as servers, networks, laptops, and other assets such as databases and applications; transactional IT assets automate business processes; informational IT assets provide information for the effective management of firms and include decision support systems, planning, and sales analysis; and strategic IT assets include the development of new products and services. Past research suggests that different types of IT assets have different impact on different measures of firm's performance. We therefore classify green IT into different types and examine their business value.

Corbett (2010) analyzed green IT topics discussed in CIO magazines and suggested four main types of green IT based on their underlying technological characteristics: *information to support decision-making* (ITDSS), *direct IT assets and infrastructure* (ITASSETS), *collaboration*, and *sustainable products and services* (SPDTSVC). ITDSS includes business intelligence applications, enterprise asset management, manufacturing systems controls, analysis of operations, processes, functions and calculators for carbon-footprint or environmental impacts. ITDSS is analogous to informational IT assets as both provide information for decision making. ITASSETS, analogous to infrastructural IT assets, include data centers, energy efficient hardware, server virtualization, monitoring systems, and cloud computing. Collaboration includes IT applications to foster collaboration without increasing carbon-footprint, such as telecommuting, and is analogous to transactional IT assets as both use technology to improve work efficiency. SPDTSVC include the creation of new earth-friendly products such as new online services and are analogous to strategic IT assets as both focus on enhancing capabilities to provide goods and services for the long term.

These different types of green IT are in fact information systems solutions to address various environmental concerns. ITDSS provides information on the state of environment inside a firm and thus could help executives in making appropriate decisions to address potential environmental concerns. ITASSETS addresses the environmental concerns associated with IT artifacts such as energy consumption and emissions. Collaboration addresses the environmental issues that emanate from commuting. SPDTSVC addresses the adverse environmental impact associated with IT artifacts. Therefore, ITDSS and Collaboration are associated with greening through IT (IT as a solution), whereas ITASSTS and SPDSVC are associated with greening of IT (addressing issues associated with IT (IT as a problem)) (Lei and Ngai 2013).

Table 2.1: Sample of Key Research Defining Green/Sustainable IT

Study	Defining Green/Sustainable IT	IT Artifacts Discussed in the Study
Elliot (2007)	"The design, production, operation and disposal of ICT and ICT-enabled products and services in a manner that is not harmful and may be positively beneficial to the environment during the course of its whole-of-life" (p. 107)	All IT artifacts that have a less adverse environmental impact or contribute positively to the environment such as less e-waste (through effective disposals), using less toxic materials in the production of IT assets, and IT assets with less carbon-footprint (emissions)
Fuch (2008)	Ecologically sustainable ICTs and ecologically destructive ICTs	Recyclable and reusable IT artifacts
Chow and Chen (2009)	Green computing is defined as use of computing resources to minimize environmental pollutions	Disposal of IT waste, and energy efficient IT artifacts
Melville (2010)	IS for environmental sustainability defined as "IS-enabled organizational practices and processes that improve environmental and economic performance" (p.2)	Knowledge management systems for pollution prevention and remediation, and decision support system that systemize cost-benefit analysis and improves environmental risk management
Watson et al. (2010)	Energy analytics is defined as the systems that can increase efficiency of energy demand and supply system	Information systems that can collect and analyse energy datasets such as sensors systems
Bose and Luo (2011)	The use of IT resources in an energy-efficient and cost-effective way	Process virtualization, cloud computing, and telecommuting
Butler (2011)	It artifacts that are designed with environmental sustainability in mind	IT-based systems to manage environmental compliance and related organizational risks. Green IS to support sense-making, decision making and knowledge creation

Study	Defining Green/Sustainable IT	IT Artifacts Discussed in the Study
		around environmental sustainability
DesAutels and Berthon (2011)	Green IT as a component of sustainability. Sustainability is defined as integrating financial performance measures with environmental and social performance measures	EPEAT rated, or Energy Star rated notebooks and desktop computers
Elliot (2011)	Environmental sustainability of IT is defined as "activities to minimize the negative impacts and maximize the positive impacts of human behavior on the environment through the design, production, application, operation, and disposal of IT and IT-enabled products and services throughout their life cycle" (p. 208)	Technology-enabled data and knowledge repositories on the environment
Jenkin et al. (2011)	Initiatives/programs targeted at addressing environmental sustainability in the firm	Energy efficient servers, IS to capture environmental data, videoconferencing, telepresence, and collaboration tools (as an alternative for travel)
Zhang et al. (2011)	"The study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems, efficiently and	All IT artifacts if they are energy efficient and have minimal adverse environmental impact

Study	Defining Green/Sustainable IT	IT Artifacts Discussed in the Study
	effectively with minimal or no impact on the environment'' (p. 83)	
Herzog et al. (2012)	Energy efficient hardware and software that have minimal adverse impact on the environment	Server virtualization and hardware cooling
Cai et al. (2013)	"Focus on the use of IT resources in an energy-efficient and cost-effective manner" (p.493)	IT equipment e.g., data centers

As Corbett's typology is generally consistent with prior research on IT asset classes, we adopt it to classify green IT announcements. Moreover, Corbett's typology lists specific IT artifacts under different quadrants (see Appendix A) that facilitate classification of green IT announcements into unique categories. Recent research on green IT has utilized this typology and its underlying classifications (Molla and Abareshi 2011). Moreover, unlike other classifications solely focused on software (e.g., Forrester 2011), the typology focuses on both IT hardware and software. It is important to note that Corbett's typology is rather broad because IT artifacts with potential environmental benefits may be deployed for reasons other than environmental considerations. This calls for our more nuanced and focused classification of green IT artifacts in which we consider IT artifacts as green/sustainable only when firms emphasize their environmental aspects in their announcements.

Business Value of IT

The resource-based view (RBV) has examined IT value by theorizing that a firm creates sustained competitive advantage through resources and capabilities that are valuable, rare, inimitable, and non-substitutable (Barney 1991). Capabilities are defined as ‘‘information-based tangible or intangible processes that are firm-specific and developed over time through complex interactions among the firm's resources" (Bharadwaj et al. 2009: 68).

Green IT is also a valuable resource that enables firms to develop capabilities that competitors cannot easily acquire, develop and use because of institutional barriers (Molla et al. 2009), culture and strategy (Chen et al. 2009), and technological prowess (Berns et al.

2009). Nevertheless, IT is not rare; it is pervasive (Vinekar and Teng 2012). Competitors can easily adopt green IT artifacts such as green data centers. However, through green IT, firms may develop capabilities for using environment-friendly technologies, integrating them with existing interfirm technologies, and developing and deploying processes to harness them. They may also improve sales and expand market share by attracting environmentally conscious consumers (Haanaes et al. 2011). Although green IT may not create sustained competitive advantage, it brings about other benefits.

Announcements of societal initiatives such as corporate social responsibility (Doh et al. 2010), reputation rank (Deephouse 2000), and IT investment (Dos Santos et al. 1993, Rangannathan and Brown 2006) are associated with significant abnormal returns (actual returns – expected returns). Green IT is at the confluence of societal and IT initiatives and is expected to have both social and financial benefits. Thus, green IT announcements can positively impact abnormal returns.

Although green IT can provide benefits, it also requires capital investment such as in green data centers. Moreover, IT still has a somewhat ambiguous role; some view IT as an environmental problem rather than a solution (e.g., Boccaletti et al. 2008), and expect IT to become the world's major greenhouse gas emitter by 2020. Put simply, the current public discourse on IT is divided about whether IT is potentially a cause or a solution to environmental problems (Lei and Ngai 2013). Thus, green IT is an emerging phenomenon that can generate benefits such as reduced cost and increased revenue. However, the initial set-up cost may be high, and potential environmental benefit is still debatable. Hence, shareholders may or may not favor green IT announcements. These ambiguities in the business value of green IT makes it interesting to examine the effects of green IT announcements.

Signaling Theory

Signaling theory explains that one party communicates or signals information and the other party interprets the signal. For instance, when young firms appoint renowned directors to their board of governors, they signal that they have legitimacy and buy-in from renowned leaders (Certo 2003). Signaling theory includes two key actors: *signalers* (e.g., firms) who disseminate signals such as news about top management and CEO certification (Zhang and Wiersema 2009), and *receivers* who are interested in gaining access to that information (Connelly et al. 2011) and who then interpret and evaluate the signals conveying, perhaps, information about the strategic direction and financial health of the firm.

Signaling theory is often used to examine stock market responses to announcements such as CEO certification (Zhang and Wiersema 2009), innovation (Sood and Tellis 2009), environmental disclosure (Magness 2009), and joining global platforms such as the UN global compact (Janney et al. 2009). In these studies, various announcements signaled various firm characteristics or capabilities, which investors rewarded or penalized. Firms also convey signals to build their reputation and enhance their image. Announcements related to environmental sustainability can also signal sustainability leadership, which can enhance corporate image as well as demonstrate good corporate citizenship and commitment to societal concerns (Janney et al. 2009). In the IT context, signals are often used to influence stakeholders' perception of the firm's current and future capabilities and performance outcomes (Zmud et al. 2010), and hence may have some effect on market return, depending on how shareholders view the announcements.

Green IT Announcements as a Signaling Strategy

Green IT announcements signal reputation-enhancing commitment to environmental sustainability and intentions such as preparedness and intent to embrace technologies that potentially reduce energy costs and optimize resource usage. Shareholders evaluate the future ramifications and respond accordingly. For example, firms that behave responsibly towards the environment experienced significant increase in stock price compared to other firms (Flammer 2012). When shareholders evaluate a signal, the stock market response is seen on the day of the announcement in the deviation of the actual stock return from the expected stock return based on the performance of the overall market. Market event studies term this deviation *abnormal return* (Bharadwaj et al. 2009, Zhang and Wiersema 2009). It is also possible that green IT announcements signal risk to a distinct group of shareholders. However, another group of shareholders could perceive such announcements with optimism and reward it with an increase in share price, which would be reflected in high share price after the announcements.

Shareholders may favor green IT announcements because they suggest that the firm is undertaking ethical initiatives that may have positive financial ramifications. Sustainability initiatives may generate better brand reputation and market value (Berns et al. 2009, Haanaes et al. 2011). Green IT announcements related to new product or service launch may indicate efforts to create or cater to new markets of environmentally conscious customers, and signal preparations for competing in new markets. Green IT is also adopted to give impetus to reduce technology-related expenditures, achieve resource efficiency (Burt 2010, Haanaes et al. 2011) and contribute to competitive advantage (Cai et al. 2013). Thus, green IT announcements may also indicate confidence about leveraging green IT to improve operational performance. Green IT announcements about new internal environment-friendly initiatives may suggest reduced waste and better resource utilization for reducing operational expenditures. Consequently, shareholders, being more confident about the firm's current state and future growth prospects (expectation of better financials in future), will give positive returns above the returns due to market conditions. Hence:

H1: Green IT announcements result in positive abnormal returns for firms.

While green IT announcements could result in positive abnormal return (share price appreciation) for firms, a question remains whether there is a consensus regarding the value of green IT announcements. Prior research suggests that price reactions (abnormal returns) reflect changes in the expectation of the whole market (Bamber et al. 2011). However, they do not reveal the change in expectation of individual shareholders.

There is still a lack of clarity on the environmental and business value of green IT announcements. Therefore, different shareholders may interpret green IT announcements differently. For some shareholders, green IT announcements could signal initiatives with potential to improve future performance. For others, it is a risky initiative with no assurance on returns. Different interpretations of announcements that result in different expectations about firms' future financials tend to increase trading volume (Bamber et al. 1999). Shareholders disposed favorably toward such announcements will buy shares of firms announcing green IT initiatives, whereas shareholders that consider such announcements risky will tend to sell shares of firms announcing green IT initiatives. Thus, trading volume of shares will increase. It follows that:

H2: Green IT announcements result in increased trading volume.

Different Types of Green IT Announcements as Signals

Green IT announcements often differ in cost of acquisitions and characteristics. The difference in cost of acquisitions and characteristics may result in distinct expectations about the outcome of such initiatives. We use Corbett's (2010) green IT quadrants to categorize green IT announcements. The first type, *information to support decision-making* (ITDSS), comprises IT artifacts such as business intelligence (BI) applications, and enterprise asset management for improving environmental performance. Prior research found that IT assets and firm performance are positively associated, even in the short term (Aral and Weill 2007). Similarly, BI and firm performance are positively associated across sectors (Elbashir et al. 2008). Executives increasingly recognize BI as being instrumental in enhancing effectiveness (Watson and Wixom 2007). These observations suggest that ITDSS may positively affect firm performance in the near future.

Shareholders may expect that, like other BI success stories, green IT applications for ITDSS will improve both environmental and operational performance through better asset utilization. For example, carbon-footprint calculators make business processes more visible, enabling better efficiency. Moreover, they require relatively simple web design, require minimum capital investments, and can increase customer awareness that can then be leveraged to sell green products or services. Thus, firms can benefit from deploying as well as offering such tools. When firms employ BI tools to improve environmental performance, they extend their enterprise-wide information. Although the use of specific information tools to gather environmental performance information is relatively new, enterprise-wide information tools such as enterprise resource planning (ERP) have been used for more than two decades and thus are less ambiguous regarding their benefits. Moreover, various institutional pressures are making it more common and necessary to report environmental performance. Green IT applications analyzing operational processes can devise leaner processes that reduce waste and wasteful expenditures. Manufacturing system controls include such tools as asset management, optimization, and performance management (Galloway and Hancke 2013) that can improve environmental performance by optimizing energy and water use. Although traditionally used for controlling large-scale processes, the tools are now also used for measuring environmental performance. Such tools have both hardware and software components and, like BI tools, their benefits are less ambiguous and may be deployed to meet corporate reporting requirements. Thus, shareholders may consider announcements on ITDSS as signaling enhanced firm performance in the near future. Further, such announcements may signal the firm's capability and commitment to various institutional requirements, such as better responsiveness and control mechanisms, and thus combine both economic and ethical elements. Hence:

H3: Green IT announcements on information to support decision-making (ITDSS) is positively associated with abnormal returns for firms.

Green IT announcements on *direct IT assets and infrastructure* (ITASSETS) comprise announcements on IT hardware such as green data centers, virtualization software and hardware, installation of monitoring systems (e.g., smart grids), and moving IT infrastructure to cloud computing platforms to reduce carbon footprint. The deployment of such IT assets signals preparedness to target the market for green products and may reap benefits such as lower lifecycle costs (Environmental Leader 2011).

IT hardware such as green hardware can be both financially and environmentally efficient by reducing energy consumption (Toledo and Gupta 2010). Cloud computing/virtualization replaces the dedicated data center and shared infrastructure. Smart grids improve the environmental performance of electric grids through communication between service providers and users.

Despite potential future benefits, IT assets still encounter concerns and opposition regarding their service levels. For example, many IT experts are skeptical about the reliability and performance of cloud computing. Privacy advocates are concerned about consumer data and smart grid insecurity. Such assets may bring environmental benefits but still generate concerns that may adversely affect IT asset diffusion and disrupt possibilities of growth in market share.

Further, such assets are relatively capital intensive. IT assets such as data centers may require short-term high set-up costs (Aral and Weill 2007) and long gestation periods before benefits are realized. Smart grids require investments in expensive supplementary assets such as power system stabilizers (IEEE 2007). The costly nature of direct IT assets and infrastructure makes announcements on them a high quality signal (Spence 1973) suggesting that the firm's balance sheet is strong enough to permit such investments. Thus, the deployment of direct IT assets and infrastructure creates positive impressions in the minds of investors. The announcements of ITASSETS as an offering may also signal the technological prowess of a firm to shareholders. Thus, positive abnormal returns for the organization arise from the announcements on green IT assets and infrastructure. It follows that:

H4: Green IT announcements on direct IT assets and infrastructure (ITASSETS) are positively associated with abnormal returns for firms.

Collaboration comprises technology tools facilitating telecommuting and teleconferencing targeted at eliminating commuting by allowing technology-facilitated virtual meetings. We examined various announcements relating to collaboration and found that firms rarely publicized adoption of telecommuting or teleconferencing in conjunction with environmental benefits. Some, such as CISCO, announced launching collaborative tools such as teleconferencing and telepresence, but emphasized productivity rather than environmental benefits. Our sample comprised some announcements of videoconferencing/ teleconferencing as IT artifacts but they came from only a few firms. Consequently, considering the small sample, we did not hypothesize relationships between *collaboration* and abnormal returns. Prior research such as Bidgoli (2012) and Al-Busaidi (2014) suggests that collaborative tools are predominantly used by firms to improve their productivity.

Announcements on *sustainable products and services* (SPDTSVC) pertain to new products or services that have minimal adverse environmental impact such as new online services, product stewardship initiatives, and customer incentives to promote environment-friendly practices. Product stewardship initiatives include introducing less toxic products and take-back programs allowing consumers to return used products for effective disposal. By conveying new information about the firm's future, new product announcements shape shareholder perceptions about the firm's market value (Chen et al. 2002), signaling that the firm has created differentiation from its competitors and has increased the potential for competitive advantage (Chen et al. 2002, Lin and Chang 2011). Further, SPDTSVC may open a new market segment and improve revenue.

It could also signal to shareholders that the firm has sufficient cash reserves to invest in new product development and sufficient manufacturing, marketing, and distribution capabilities to engage in new product launches. Such announcements may reinforce shareholders' confidence in the technological prowess of the firm. A firm's announcements on initiative such as the take-back program signal to shareholders that the firm has sufficient capital to meet the expenses associated with such initiatives. Besides, such announcements portray the firm as a socially responsible entity, thus enhancing its reputation (Fombrun 2005). Thus, such announcements convey both strong economics as well as ethical signals. Hence:

H5: Green IT announcements on sustainable products and services (SPDTSVC) are positively associated with abnormal returns for firms.

Quality of Signaler

The characteristics of signalers, as the key actors in signaling theory, determine the strength of signals (Busenitz et al. 2005, Arthurs et al. 2008) and their interpretation (Connelly et al. 2011). Further, firm characteristics (such as innovativeness) affect market returns from new product announcements (Lee and Chen 2009).

Innovation includes the application of knowledge to create new knowledge and products (Cho and Pucik 2005). IS innovation includes new digital computer applications and communication technologies (Swanson 1994). Green IT involves application of communication technologies to reduce a firm's adverse environmental impacts through new products and changes in extant processes (new knowledge). Innovative firms tend to have strong technological capabilities for exploring and exploiting technologies (Cho and Pucik 2005). Their chances of success with new technologies could be higher (Dollinger et al. 1997). Further, innovative firms are known to be able to reap economic benefits from new technologies. Consequently, they send credible signals and shareholders reward the announcements with high abnormal returns. Conversely, noninnovative firms are perceived as less technologically able, so their green IT announcements may be viewed as less credible and even as risky. Thus:

H6: Green IT announcements result in higher abnormal returns for innovative firms compared with noninnovative firms.

2.3. Method

Sample Preparation

Following previous research (Glascock et al. 1987, Sood and Tellis 2009), we searched news reports from Factiva and Lexis-Nexis. We also included websites dedicated to corporate social responsibility and sustainability, and press release sections on firms' websites. For multiple news reports with identical information, we used the earliest news report as an announcement.

Our sample selection and coding method comprised four steps (Table 2.2). First, we gathered news announcements based on the search terms related to the firm's environmental practices. We dropped green IT announcements in close proximity with other key announcements (e.g., capital announcements, damage suits, dividends, executive changes, earning announcements, merger and acquisition activities) to prevent confounding their impact (Konchitchki and O'Leary 2011).

Corbett's green IT quadrant is rather broad; thus, we focus on the IT artifacts for improving environmental performance in organizations. If the announcements involve IT artifacts but the focus is not on the environment, we drop such announcements. We examine if the environmental objectives such as energy efficiency, energy saving, low energy usage, less emission, substitution of a traditional way of conducting business with an environment-friendly approach, and a new product that replaces conventional environmentally detrimental existing product is salient in announcements (Table 2.3). This approach allows us to eliminate announcements that are broad without any emphasis on the environment from our sample. Thus, our final sample comprises announcements with IT artifacts that focuses on the environment.

We observed that the announcements most frequently use words such as *energy, data, power, data center, technology, efficiency, customers*. Firms often did not explicitly relate teleconferencing adoption to environmental benefits. Thus, although some IT artifacts might have environmental benefits, firms did not predominantly consider them as green IT artifacts. The coding in terms of the green IT types (Corbett 2010) was done by one of the authors and a practitioner[3]. The values of the Perrault and Leigh (1989) reliability index for the different types were above 0.8, indicating high inter-rater reliability.

[3] Practitoner has seven year of experience working in one of world's largest IT firm. The classification scheme focused on presence of specific IT artifacts (refer Appendix A) and environment specific words in the entire announcements.

Table 2.2: Coding Methodology

Steps	Details
Step 1: Identification of sources and search terms	• Websites dedicated to environment initiatives, news database (Factiva, Lexis-Nexis Academic)
Step 2: Identification of announcements	• News gathered from different sources for period 2004 – 2011
Step 3: Identification of green IT announcements	• Announcements classified into green IT announcements based on the presence of IT artifacts and emphasis on environmental objectives in the announcements • Announcements made on the same day of other announcements such as dividends, earnings were dropped • 137 announcements remained • Green IT announcements coded into the various types the various types by one of the authors and a practitioner. The coding showed high inter-rater reliability (Perrault and Leigh reliability index = 0.95)
Step 4: Collection of stock-price data	• Stock price data for a 2-day event window (-1, 0) and 230 days estimation window (-260, -30) for firms with announcements extracted from the CRSP database • Market portfolio returns data for the CRSP index extracted from CRSP database

Table 2.3: Classification of Announcements into Green IT

News Announcement	Key Words	Green IT
Apple launches free computer take-back program (31May, 2006)	**computer, recycle**	**Yes**
AMD unveils virtualization platform (30 March 2005)	virtualization, server, solutions, processor, virtual technology	No (since no explicit mention of environment-related terms in full text)

Announcement Sample

Our final sample comprised 137 green IT announcements for 58 firms (2.36 announcements per firm). Our sampled firms predominantly belong to *sectors such as industrial and commercial machinery and computer equipment, electronic, electrical equipment and components, business services, and communications*, suggesting that green IT is more common in IT and allied sectors. Table 2.4 shows a sample classification of the green IT types. Our sample size is comparable to sample size reported in prior IS research (Konchitchki and O'Leary 2011), and prior research on corporate social responsibility such as Flammer (2012).

We classified announcements with IT artifacts that disseminate information such as carbon management tools, calculators, software to reduce environmental costs, environmental management system as ITDSS. Announcements with IT artifacts such as data centers, smart grids, cloud computing, servers, and computers were classified as ITASSETS. Announcements comprising IT artifacts such as computers along with initiatives such as recycling programs, take-back programs, or online services with environmental benefits were classified as SPDTSVC. We therefore classified announcements into distinct categories.

Table 2.4: Classification of Announcements into Different Types of Green IT†

News Announcement	Type of Green IT
Autodesk chooses SAP(R) carbon impact on-demand solution 5.0 to meet its overall sustainability goals (20 September, 2010)	Information to support decision-making
Emerson builds new energy-efficient data center (3 Sep, 2008)	Direct IT assets and infrastructure
Goodwill, Dell expand free computer recycling partnership to Canada (6 April, 2010)	Sustainable products and services

† *(Average number of words per announcement: 529).*

Operationalization of Firm Characteristics

We operationalized innovativeness using two measures. First, we used an objective measure of patents applied for in the year before the announcement. This measure is consistent with previous studies that found patent count to be a good proxy for innovativeness (e.g., Joshi et al. 2010).

Second, we classified firms as innovative and noninnovative using FastCompany's 50 most innovative firms list for 2008 to 2010 (www.fastcompany.com), BusinessWeek's innovative firms list for 2005 to 2011 (www.businessweek.com), and Fortune's most admirable companies (www.fortune.com) (it covers aspects such as innovation and social responsibility). Unlike patent count, such rankings are often based on the perception of industry experts and practitioners such as senior executives. It also takes into account analysis of firms' characteristics as well as financial performance. While the number of patents applied for include patents in general (both IT and non-IT), for classification based on ranking, we also checked if the firms ranked for innovation are innovating in the ICT domain by examining initiatives listed in their annual sustainability reports to ensure that our classification reflect firms' innovativeness in the ICT domain. Thus, our second measure of innovativeness also tests the robustness of our first measure.

Control Variables

We controlled for firm size by using the logarithm of the number of employees as well as the logarithm of revenue in the year before the announcement. We controlled for the growth rate because a firm's historical growth rate may also influence shareholders' evaluation of an announcement. Firms' profitability may also influence evaluation, so we controlled for profitability using return on assets (ROA) in the year before the announcement. The National Bureau of Economic Research (USA) recognizes the period between December 2007 and June 2009 as recessionary years. We therefore controlled for this variation in macroeconomic environment by creating a binary variable for *economic cycle;* the period between December 2007 and June 2009 was coded as *recession*, and outside this period was coded as *normal*. This classification has been used in previous studies using event study methodology (e.g., Otim et al. 2012).

In addition, we included the annual return from S&P 500 as a control variable for the volatility in the stock market due to macroeconomic conditions. We controlled for industry competition using the Herfindahl-Hirschman Index (HHI), computed as the sum of the squared fraction of the sales of each firm in the industry. We used the four-digit SIC code as an identifier for the industry. A higher HHI implies a less competitive industry. We also controlled for other industry-specific characteristics using industry dummies based on the two-digit SIC code. Table 2.5 summarizes the variables and their measures.

Table 2.5: Variables and Their Measurements

Variable	Data Type	Measures	Source
CAR	Continuous	Difference between expected return based on prior trading window and actual return	CRSP database
Information to support decision-making (ITDSS)	Categorical	Absence/ Presence of information to support decision-making = 0/ 1	Factiva, Lexis-Nexis and websites
Direct IT assets and infrastructure (ITASSETS)	Categorical	Absence/ Presence of direct IT assets and infrastructure = 0/ 1	Factiva, Lexis-Nexis and websites
Sustainable products and services (SPDTSVC)	Categorical	Absence/ Presence of sustainable products and services = 0/ 1	Factiva, Lexis-Nexis and websites
Innovativeness	Count Categorical	1.Patents applied for in the year prior to the year of announcement 2. Noninnovative=0, Innovative=1	USPTO, Google patent search, Rankings
Firm size	Continuous	1. Log of number of employees 2. Log of revenue in prior year	Compustat, Wolfram alpha
Firm growth rate	Continuous	Change in annual sales computed in the fiscal year prior to event date.	Compustat
Firm profitability	Continuous	ROA = net income / total assets	Compustat
Industry Competition	Continuous	Sum of the squared fraction of sales of each firm in the industry	Compustat
Sector	Dummy	Membership of specific SIC code=1, else 0	2-Digit SIC code
Economic Cycle	Categorical	From December 2007 – June 2009 = Recessionary (1), otherwise normal (0)	
Annual return from S&P 500	Continuous	Change in S&P 500 relative to prior year	S&P 500 Indices

Event Study Methodology

We used the Fama-French Four-Factor (FFM4) model to estimate the abnormal returns associated with green IT announcements. Event studies in IS have primarily used the efficient market model of daily stock price returns (MM Model), which computes the abnormal returns based on the assumption that the market portfolio is the benchmark for returns (McKinlay 1997). However, the MM model has been criticized for omitting other stock market factors (e.g., firm size and book-to-market equity) that influence returns in addition to the market portfolio factor (Fama and French 1993). The FFM4 model includes four factors: market portfolio, market capitalization, value, and Carhart's (1997) price-momentum factor. Size was captured by market capitalization, value was captured by the book-to-market factor, and the price-momentum factor accounted for the persistence effect in returns (which identifies the tendency of stock prices to trend in the same direction (Jegadeesh and Titman 1993)).Our FMM4 model specification was:

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i}SMB_t + \beta_{3i}HML_i + \beta_{4i}UMD_i + \varepsilon_{it}$$
$$E[\varepsilon_{it}] = 0,\ Var[\varepsilon_{it}] = \sigma^2_{\varepsilon it},\ where$$

t: Index for estimation window (we use various event windows to check the robustness of our estimates)

i: Subscript for announcement

R_{it} *: Returns to announcement i on day t*

R_{mt}*: Returns to corresponding daily equal-weighted CRSP 500*

R_{ft}*: Theoretical rate of return attributed to an investment with zero risk*

SMB: Returns on a portfolio of small stocks minus returns on large stocks (covers factors related to size)

HML: Returns on a portfolio of stocks with high book-to-market ratio minus the returns to a portfolio of stocks with low book-to-market ratio (covers factor related to book-to-market equity)

UMD: Carhart's price-momentum factor that captures one-year momentum in returns

ε_{it} *: Error terms,* α*,* β*: Parameters to be estimated*

The risk-free return captured the interest from a risk-free investment over a specific time period. The interest rate on a 3-month US treasury bill was used as a proxy for the risk-free return as “short-term government issued securities have virtually zero risk of default” (Sood and Tellis 2009, p. 446). We estimated the abnormal return (AR) for stock i on day t as $AR_{it} = R_{it} - E(R_{it})$ where, R_{it} is the observed return on stock i on day t; $E(R_{it})$ is the expected return for the stock based on its relationship with an equal-weighted S&P 500. The final specification for the abnormal return was:

$$AR_{it} = R_{it} - R_{ft} - [\alpha^{\wedge}_{i} + \beta^{\wedge}_{1i} (R_{mt} - R_{ft}) + \beta^{\wedge}_{2i}SMB_{t} + \beta^{\wedge}_{3i}HML_{i} + \beta^{\wedge}_{4i}UMD_{i}]$$

We selected a short event window (-1, 0) comprising the event day and the previous day to better reflect the impact of specific announcements (Bharadwaj et al. 2009). We used an estimation window (-260, -30) of 260 trading days prior to the event and ending 30 days before the event to estimate the abnormal return. The average of the daily abnormal returns over a two-day event window for the portfolio of N announcements provided the average cumulative abnormal return (CAR) for the sample. Hence, the empirical specifications for the CAR and the average CAR were:

$$CAR_{i} = \sum_{t=-1}^{t=0} ARit \quad \text{and average } CAR_{i} = \sum^{N}_{i=1} \sum_{t=-1}^{t=0} ARit / N$$

We used the Student’s t-test to determine whether the average CAR was significantly different from zero. In addition to the average CAR, we also computed the median CAR to examine the extent of variation in the returns from announcements. The median CAR indicates whether a few outliers drive the mean results. We used different market indices such as CRSP value-weighted, CRSP equal-weighted index, and CRSP equal-weighted +

value-weighted as the benchmark index. The equal-weighted index has equal weightage for each stock; the value-weighted index has weightage based on market capitalization for each stock. Our results showed that the average CAR was similar across different benchmark indices.

Our primary estimation method for computing abnormal return was OLS estimation. However, for robustness checks, we also used the generalized autoregressive conditional heteroskedasticity (GARCH) method, exponential GARCH (EGARCH), and Scholes Williams estimation to compute abnormal returns. We computed abnormal volume in place of abnormal returns to test H2. For volume study, we used the ordinary least square market model and used log-transformation of raw volume data (similar to Barnhart and Rosenstein (2010). The empirical specification for our remaining hypotheses (H3-H6) was:

$CAR_{i,j} = \alpha + \beta_1(ITDSS)_{i,j} + \beta_2(ITASSETS)_{i,j} + \beta_3(Innovativeness)_{i,j} + \beta_4(Firm\ size)_{i,j} + \beta_5(Firm\ growth\ rate)_{i,j} + \beta_6(Industry\ competition)_{i,j} + \beta_7(Sector\ dummy)_{i,j} + \beta_8(Economic\ Cycle)_{i,j} + \beta_9(ROA)_{i,j} + \varepsilon_{i,j}$, *where subscripts refer to announcement i and firm j respectively.*

Our main variable of interest is a categorical variable for the different types of announcements. There are three categories; hence, we have two classes in our econometric specification. For analysis, we had an unbalanced panel data linear model, as we had different number of observations for different firms. Serial correlation was also possible within a panel as the return from an announcement might be linked to earlier announcements. We addressed those issues through regression models with clustered robust standard errors for two reasons. First, the observations for the same firm might not be independent, and second, by using robust standard errors, we ensured that our estimates were robust against heteroscedasticity and were not biased. We used a variety of regression techniques to ensure that our estimates were robust against various assumptions. We used generalized linear models (GLM), panel regression and OLS regression to examine the various relationships. The GLM technique allows non-normal distribution of the dependent variable. Panel regression is often employed for panel data analysis, whereas OLS regression is the basic model used for such analyses. We used various control variables such as firm size, annual return from S&P 500, and macroeconomic scenario. Our event study method (FFM4) also controlled for size and volatility. This approach controlled for various sources that might influence the relationships between our independent and dependent variables.

2.4. Results

RQ1 (a): How much do green IT announcements affect market value?

The average CAR for green IT announcements based on the estimation window (-30, -260) and CRSP value-weighted index for event window (-1, 0) is 0.55% (p <0.01), and median CAR was 0.45% (p < 0.01). The average CAR based on the CRSP equal-weighted index was 0.53% (p < 0.01) and median CAR was 0.27% (p < 0.01). The average CAR based on a 2-day event window (-1, 0) was positive and significant. The average CAR based on a 3-day event window (-1, 1) was also positive and significant (average CAR = 0.65%, p < 0.01, median CAR = 0.30%, p <0.05). Thus, our results supported H1.

The average annual return from the S&P index for 2004-2010 was 13.10% (Standard and Poor's 2011), which implied that daily return was about 0.05%. Therefore, the magnitude of abnormal return from green IT announcements over a 2-day period was about five times the return from the S&P index. As the majority of the firms announcing green IT initiatives are from the technology sector, we compare the returns from green IT announcements with technology specific indices. Unlike the S&P index, which comprises 500 top publicly traded US firms, technology specific indices focus on technology firms. The average daily returns from the various technology indices varied from -0.08% to 0.12%; Thus the return from green IT announcements is higher compared to the return from their peers.

If the average abnormal returns before and after the event window (-1, 0) are similar to the return for the event window, it indicates that firms' characteristics rather than green IT announcements are salient in returns for the event window. Conversely, a reversal in returns over time pre- and post-announcement suggests that information related to the firm's fundamentals is not salient in returns from such announcements. We examined the returns over a 60-day period including the event window. Table 2.6 showed that average returns pre- and post-event window were not significantly different from zero, whereas the return for the event window was positive and significant. For pre- and post-event window, the number of negative returns exceeded the number of positive returns. The significant positive CAR during the event window and insignificant returns for other time windows indicated that green IT announcements resulted in positive abnormal returns. The average CAR from stocks over a 60-day period was similar for different market indices. Further, we examined the trend for days pre- and post-event window (Figure 2.1). The average CAR was maximum for the event window. This supported our findings that shareholders favored green IT announcements.

We tested the robustness of our estimates using different approaches. We dropped 19 announcements that weakly emphasized environment or IT artifact or where there were ambiguity on classification of announcements. The average CAR for the sample was 0.65% (p<0.01). When we excluded announcements with very high or very low CAR (+/- 3σ), the average CAR was 0.39% (p<0.05). These results further supported our hypothesis that shareholders favored green IT announcements.

Table 2.6: Average CAR for 60-Day (-30, 30) Period Based on Value-weighted Index

Time Window	Average CAR (%)	Median CAR (%)	Count of Positive Return	Count of Negative Return
(-30, -11)	-0.27	-0.29	66	71
(-10, -2)	-0.01	-0.59	62	75
(-1, 0)	***0.55****	***0.45****	**80**	**57**
(2, 10)	-0.09	-0.09	66	71
(11, 30)	-0.19	-0.72	62	75

Note: * p<0.05 (one tail)

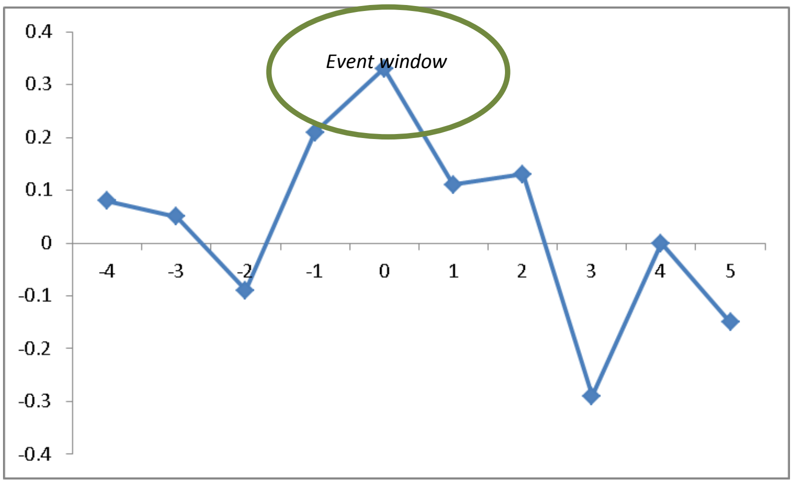


Figure 2.1 CAR Trend

Robustness checks for Average CAR Computation

Because of our small sample, we conducted nonparametric tests such as signed-rank test to examine whether our CAR estimates were robust against the normality assumption. The signed-rank test (observed sum ranks for positive abnormal return = 5801, expected sum ranks = 4726.5, $p<0.05$) supported positive abnormal returns. Market indices such as CRSP equal- or value-weighted indices often incorporate dividends from the constituent stocks while computing returns from the index. Thus, we compared our estimates using indices that included and excluded dividends; our estimates were similar, thus supporting the robustness of our results. The estimates for average CAR based on other alternative windows such as (-270, -6), (-270, -2), (-200, -6), and (-120, -2) were similar to our initial estimates. The estimates for the average CAR based on the other models such as comparison-period mean adjusted return model (1.17%, $p < .01$), and market-adjusted returns model (0.69%, $p<0.01$) (McKinlay 1997) were also positive and consistent with our estimates.

Errors often occur in clusters for financial data (Campbell 1997): larger returns follow large returns, and smaller returns follow small returns. This suggests serial correlation in returns. We therefore checked the robustness of our estimates (computed using OLS estimation method) with GARCH and EGARCH estimation method. The estimates were 0.58 % ($p<0.01$) and 0.59% ($p< 0.01$) respectively, thus supporting the robustness of our estimates against serial correlation. The daily price of stocks quoted in financial databases is the *closing price* of the last transaction for the specific stock on that day. Thus, closing prices for different stocks are not set simultaneously as their last trading occurs at different times. Therefore, the trading is nonsynchronous, which introduces an econometric problem of errors in variables (Scholes and Williams 1977). We therefore tested the robustness of our estimates using Scholes-Williams beta and obtained an average CAR of 0.55% (p<0.01), consistent with our earlier results.

The FFM4 model uses a time-series approach. However, returns from different stocks for identical periods are possibly not independent (Ibbotson 1975). We therefore applied the Ibbotson Return across Trade and Securities (RATS) methodology with Fama-French factors. In this methodology, the FFM4 model is cross-sectionally estimated across a sample of firms on a daily basis. The estimate for average CAR for event window (-1, 0) based on this method was 0.71% (p<0.01). Hence, our estimates were positive and significant for both time-series as well as cross-sectional approaches. The estimates were also similar for general method of moments (GMM) estimation and weighted least square (WLS) estimation. The results of the Fama-French calendar-time portfolio regression (OLS as well as GMM estimation method) were also similar, thus supporting the robustness of our estimates. We also dropped announcements made within 10 days of the prior green IT announcements by the same organization. The average CAR was positive and significant (average CAR=0.52%, p<0.01), thus providing credence to our estimates. In addition, our announcements period spanned about 8 years, thus ensuring no systematic bias in the sample. Unsystematic bias (if any) would cancel out for the overall sample.

RQ1(b): How much do green IT announcements affect trading volume?

Stock price and trading volume are two indicators to understand the market implications of announcements. Positive abnormal return indicated upward movement in stock-price after green IT announcements. This suggests that the market, on an average, reacts positively to green IT announcements. In addition, we also examined the change in trading volume after green IT announcements. The mean cumulative abnormal relative volume (CARV) for the event window (-1, 0) according to the market model and equal-weighted index was positive and significant (98.56%, $p < .05$). Thus, CARV increased an average of 49.28% daily. In our sample, an average of 75% of stocks showed positive CARV whereas remaining (25%) showed negative CARV. In other words, our sample primarily comprised appreciating stocks. Significant and positive CARV indicate that trading volume of shares of firms with green IT announcements increased. Thus, H2 is supported. This suggests that there is considerable "buzz" around green IT announcements. Shareholders are buying and selling the shares of firms post green IT announcements. Perhaps, there are shareholders who view green IT announcements favorably and therefore bought shares. In contrast, there are shareholders that do not view green IT announcements favorably and hence sold shares. We derived the same conclusion when we used different indices. Overall, the findings indicate that green IT announcements are an effective signal noticed by the overall market.

RQ2: Do shareholders react differently to different types of green IT announcements?

Table 2.7 shows the descriptive statistics and correlation matrix. We conducted panel data regression and the Hausman test to find the best panel regression model. The *p*-value was not significant, thereby ruling out the choice of the fixed effects model. We computed the estimates for different models using random effects regression, followed by GLM and OLS regression with clustered robust standard errors. We used stepwise regression techniques, where we included various control variables sequentially in our analyses. Our estimates were consistent. We showed the estimates for the full model in Table 2.8. The estimates were similar across the various techniques. We discussed our findings based on the estimates from the random effects panel data model with clustered robust standard errors. Our econometric model comprised three categories (three types of green IT announcements). In our empirical estimation, we made SPDTSVC our reference group. Thus, our empirical estimates would indicate whether the ITDSS and ITASSETS were significantly different from SPDTSVC.

Table 2.7: Correlation Matrix

Variables	Mean	S D.	1	2	3	4	5	6	7	8	9	10	11
1. CAR (%)	0.55	2.60	1.00										
2. ITDSS	0.25	0.43	0.06	1.00									
3. ITASSETS	0.55	0.50	0.02	-0.57	1.00								
4. SPDTSVC	0.20	0.40	-0.09	-0.38	-0.54	1.00							
5. Innovativeness (patents applied for)	754	1268	-0.10	-0.03	0.03	0.00	1.00						
6. Innovativeness (based on rankings)	0.76	0.43	0.01	-0.19*	0.15	0.02	0.28*	1.00					
7. Growth rate	0.10	0.21	0.01	-0.05	0.14	-0.12	-0.18*	0.01	1.00				
8. Organization size (log #employee)	4.86	0.64	0.09	-0.08	0.08	-0.02	0.46*	0.38*	-0.19*	1.00			
9. Organization size (log of revenue)	10.22	0.57	0.12	-0.22*	0.14	0.07	-0.05	0.18*	-0.09	0.58*	1.00		
10. Industry competition (HHI)	0.35	0.24	0.03	-0.17*	0.00	0.18*	-0.04	0.18*	-0.09	0.27*	0.40*	1.00	
11. ROA	0.07	0.08	-0.02	0.04	-0.03	0.00	0.27*	0.26*	0.06	0.18*	-0.04	0.19*	1.00
12. Annual return	-0.01	0.23	-0.14	0.02	-0.09	0.09	-0.03	-0.10	-0.16	-0.28*	-0.19*	-0.09	-0.11

Note: * p <0.05 , correlation for categorical variables are tetrachoric correlation, Bonferroni adjusted correlation are similar

Table 2.8: Estimates for Returns from FFM4 Model

Hypotheses	Random Effect	OLS	GLM
Information to support decision making (ITDSS) (H3)	**1.52*** **{0.89}**	**1.55*** **{0.89}**	**1.55*** **{0.78}**
Direct IT assets and infrastructure (ITASSETS) (H4)	0.16 {0.76}	0.19 {0.77}	0.19 {0.67}
Innovativeness (classification based on rankings) (H6)	-0.15 {0.83}	-0.09 {0.83}	-0.09 {0.73}
Innovativeness (number of patents) (H6)	0.00 {0.00}	0.00 {0.00}	0.00 {0.00}
Growth rate	1.07 {1.46}	0.95 {1.45}	0.95 {1.28}
Organization size (number of employees)	0.48 {0.60}	0.45 {0.58}	0.45 {0.51}
Organization size (Revenue)	-0.16 {0.52}	-0.27 {0.52}	-0.27 {0.45}
Industry competition (HHI)	-0.73 {1.93}	-0.36 {1.91}	-0.36 {1.67}
Profitability (ROA)	-2.38 {2.32}	-2.35 {2.35}	-2.35 {2.07}
Annual return	-0.78 {2.06}	-0.89 {2.00}	-0.89 {1.76}
Economic cycle	0.32 {1.02}	0.29 {0.99}	0.29 {0.88}
R^2	0.23	0.23	Not applicable

Notes. * p <0.05 (one-tailed), *Standard errors are in parentheses. Industry dummies were included in the regressions, but their estimates are not shown for the sake of brevity.*

The coefficient for ITDSS (β=1.52, p<0.05) was positive and significant. This indicated that ITDSS was significantly different from SPDTSVC. The other type of green IT - ITASSETS (β=0.16, p>0.05) was not significant. Thus, ITASSETS was not significantly different from SPDTSVC. We checked the relationship between average CAR and SPDTSVC by solely including it in our regression models. The estimate was insignificant (β=-0.52, p>0.05). In support of H3, announcements on ITDSS obtained CAR 1.52%, higher than announcements on SPDTSVC. The average CAR for announcements on ITASSETS did not obtain significantly higher CAR compared with SPDTSVC, thus H4 was not supported. Likewise, the insignificant relationship between SPDTSVC and average CAR did not support H5. We further tested the validity of our interpretation by separately examining the relationships of average CAR with IDSS and ITASSETS. The estimates supported our interpretation.

RQ3: Do shareholders view green IT announcements by innovative versus noninnovative firms differently?

The coefficients for the different measures of innovativeness (Table 2.8) were not significant (β=-0.15, p >0.05, β=0.00, p>0.05); thus H6 was not supported. Among the control variables, profitability (β=-2.38, p >0.05), growth rate (β=1.07, p>0.05), size (revenue (β=-0.16, p>0.05), employee strength (β=0.48, p>0.05)), industry competition (β=-0.73, p>0.05), annual return (β=-0.78, p>0.05), and economic cycle (β= 0.32, p >0.05) were not significant. A few of the industry dummies were significant. This finding is consistent with Zmud et al. (2010) who found that the number of IT signals varied across different industries (depending on the role of IT). Consequently, we can also expect market reactions to announcements to vary across industries.

We checked the robustness of our regression results using additional measures that might influence the CAR. We included the number of green IT announcements in a given year prior to the announcement as a covariate. The underlying rationale is that the number of prior announcements in a given year might bias the shareholders' perception of green IT announcements. The estimates were similar, thereby providing support for the robustness of our results. Firms' past environmental performance record might also bias the shareholder's perception of green IT initiatives. We therefore included past environmental record as an additional control variable. We constructed a measure of environmental performance based on data from Kinder, Lydenburg and Domini (KLD) database, where environmental performance = Total number of environment strengths − Total number of environment concerns. Firms with negative performance were coded as poor performers, whereas those with positive performance score were coded as good performers. The estimates were similar, thus further supporting the robustness of our results. Table 2.9 summarizes the results of hypotheses testing.

Table 2.9: Summary of Hypotheses Testing

Hypothesis	Proposed relationship	Hypothesized effect	Supported
H1	**Green IT announcements -> returns**	**+**	**Yes**
H2	**Green IT announcements -> trading volume**	**+**	**Yes**
H3	**Green IT announcements *on information to support decision-making* -> returns**	**+**	**Yes**
H4	Green IT announcements *on direct IT assets and infrastructure* -> returns	+	No
H5	Green IT announcements *on sustainable products and services* -> returns	+	No
H6	Innovativeness of the organization -> returns	+	No

Notes. Supported hypotheses are in bold

2.5. Post-hoc Analyses

Does past environmental record indirectly influence CAR?

Our robustness check showed that past environmental record alone did not influence CAR. However, it is possible for past environmental record to influence the returns from ITDSS and ITASSETS. Hence, we included interaction terms of ITDSS and ITASSETS in our empirical model. The estimates for both *ITDSS*EnvironmentalPerformance* and *ITASSETS*EnvironmentalPerformance* (random effect model) were positive and significant (β=2.78, p<0.05, β=5.23, p<0.05). We graphed the significant interaction effects (Figure 2.2 a-b) as recommended by Cohen and Cohen (1983). In addition, we also conducted a simple slope analysis. The slopes for poor environmental performance lines were not significant (2.2(a): t= 0.947, p> 0.05; 2.2(b): t=-0.300, p >0.05) for both Figures 2.2a and 2.2b. Hence, the slopes for both lines were not significantly different from zero. In short, whether the announcement is on ITDSS or ITASSETS is immaterial. However, organizations with good environmental performance realize higher CAR from ITDSS and ITASSETS (2.2(a): t=3.736, p< 0.05; 2.2(b): t=4.929, p< 0.05).

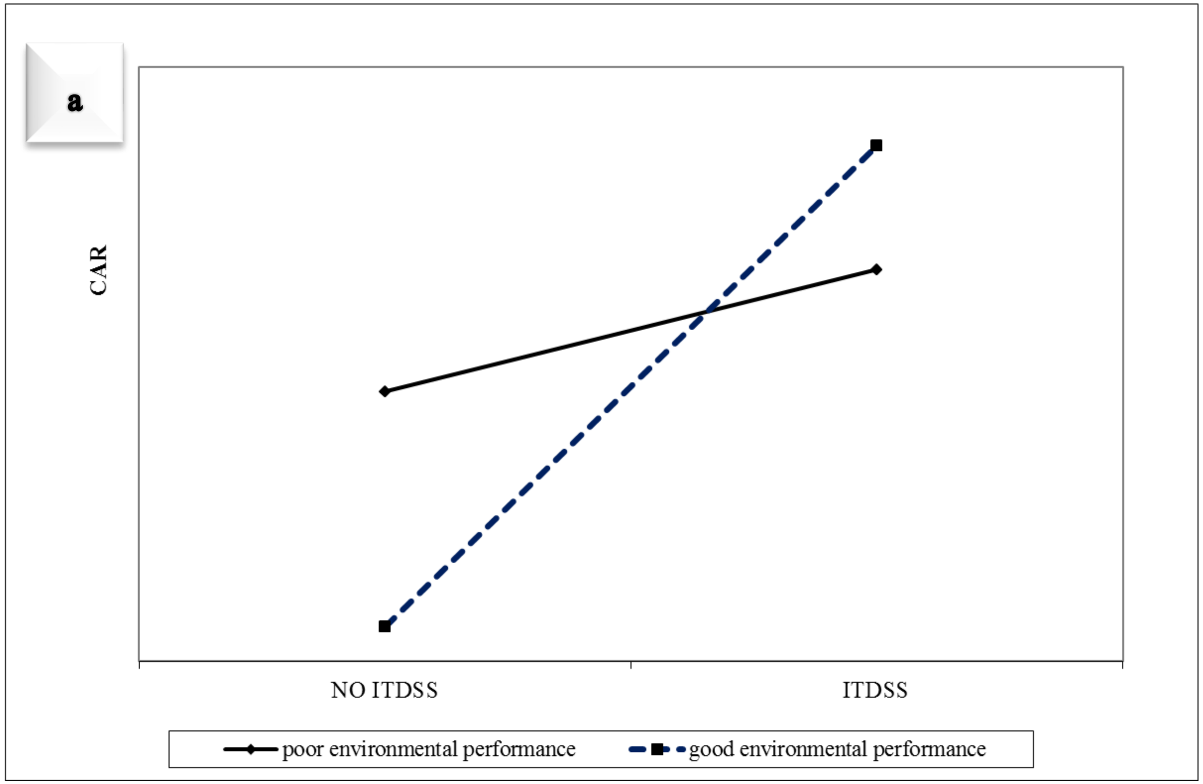


Figure 2.2(a) Interaction Plots

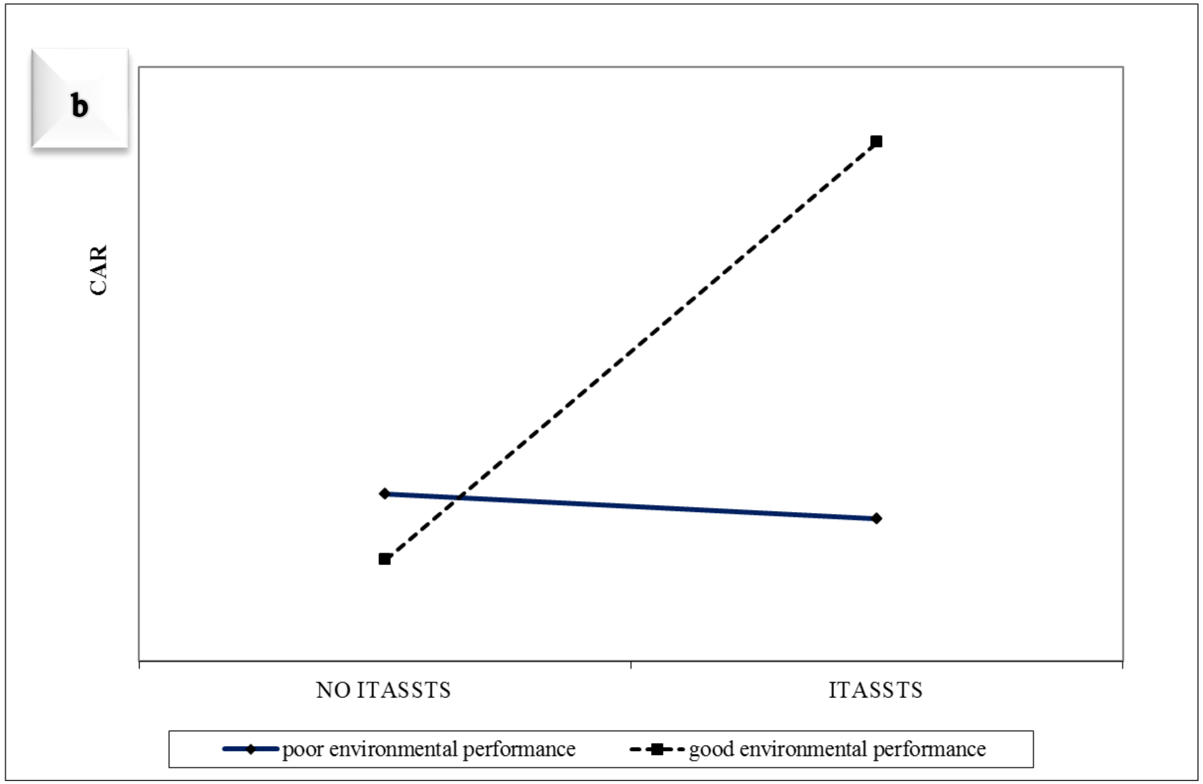


Figure 2.2(b) Interaction Plots

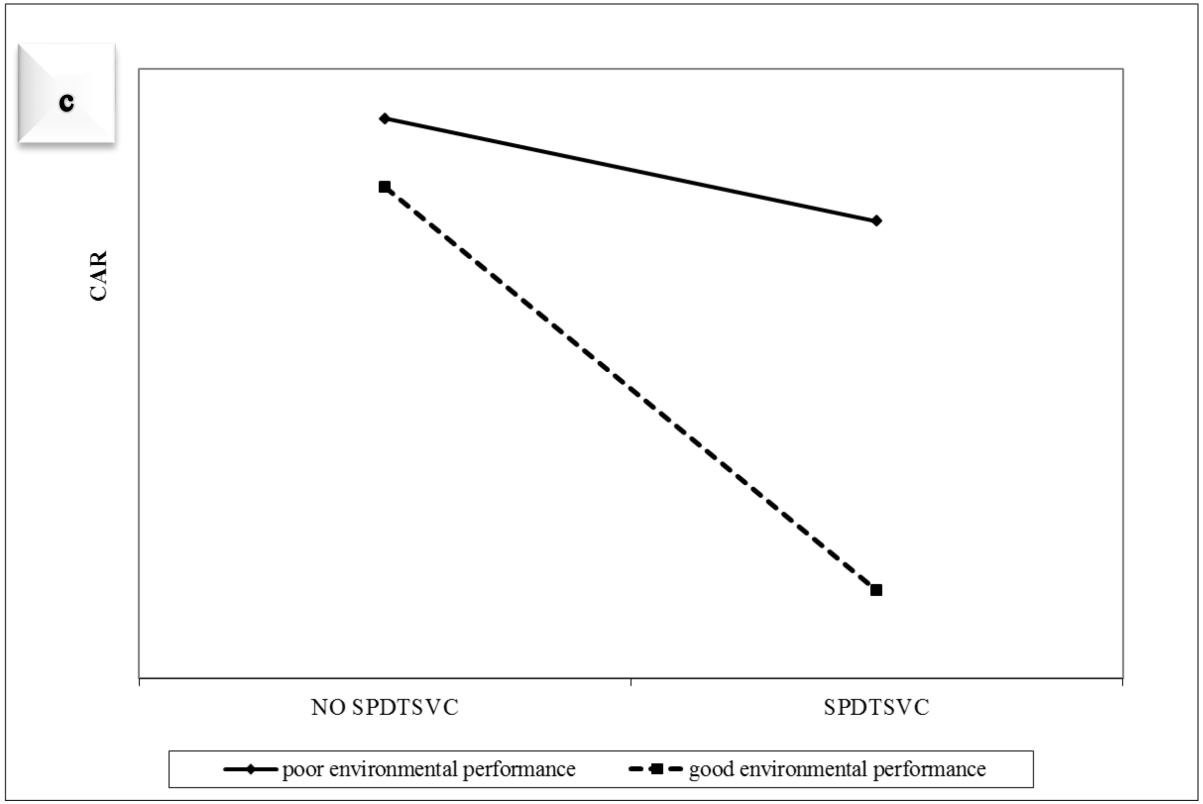


Figure 2.2(c) Interaction Plots

Due to our empirical specification (three categories and SPDTSVC being a reference group), we could not examine whether past environmental record influences the returns from SPDTSVC. Hence, we tested a separate model, where we made ITDSS our reference group. We included interaction terms such as *ITASSETS*EnvironmentalPerformance* and *SPDTSVC*EnvironmentalPerformance* in this model.

The estimate for *SPDTSVC*EnvironmentalPerformance* was negative and significant (β=-2.79, $p<0.05$). The slope for the low environmental performance line (Figure 2.2c) was not significant (t=-0.95, $p>0.05$). However, the slope for high environmental performance line was significant (t=-3.74, $p<0.05$). Thus, for firms with poor environmental performance, SPDTSVC announcements were inconsequential. However, for firms with good environmental performance, shareholders penalized SPDTSVC announcements with lower CAR. The R^2 for our interaction models were higher than the main model (0.34 compared to 0.23 for main model), thereby providing support for interaction effects. We also checked the robustness of our interaction model by including additional control variables such as time dummies to control for any time trend in the relationships. The findings from the extended model provide support for the robustness of our inferences with respect to the interaction between past environmental record and different types of green IT announcements.

The results suggested that only firms with good environmental record benefitted from ITDSS and ITASSETS. Perhaps, shareholders only trust such announcements from firms with good environmental records. For firms with poor environmental records, it is plausible that shareholders perceived such announcements as green washing and thus did not reward such announcements. However, firms with good environmental record did not benefit from announcements on SPDTSVC. Perhaps, shareholders construed such announcements to be wasteful expenditures as such firms already had good environmental record. The line for poor environmental performance was above the line for good environmental performance when firms did not announce ITDSS and ITASSETS. Perhaps, shareholders expected such announcements from firms with good environmental performance. Unlike ITDSS and ITASSETS, for firms with SPDTSVC (Figure 2.2c), the line for poor environmental performance was above the line for good environmental performance. This was due to the decline in CAR when firms announced SPDTSVC. Together our findings indicated that shareholders expected announcements on ITDSS and ITASSETS from firms with good environmental performance and reward them. However, they did not value announcements on SPDTSVC from such firms.

Is there any relationship between green IT announcements and corporate reputation?

Like other sustainability initiatives, green IT announcements could also signal firms' concern toward broader social issues such as climate change and global warming. Thus, firms may improve their reputation. To examine if this is the case, we examined whether firms with improvement in reputation score made more green IT announcements. We used the reputation score from Fortune world's most admired companies, which rate the companies on various categories such as social responsibility, product/service quality and number of green IT announcements (between 2006 and 2011) for our analysis. We computed the change in reputation score between 2006 and 2012. Firms with improvement in reputation score announced more (4.17 announcements) relative to firms that witnessed decline in reputation score or did not feature in the ranking in 2012 (2.19) ($t = 1.94$, $p < 0.05$, *one-tail*). Our findings suggested that reputation scores were positively correlated with green IT announcements.

Summary

We found that shareholders favored green IT announcements, but the impact was limited. Positive abnormal returns occurred when firms made green IT announcements, with an average CAR value of 0.55%. The average CAR from green IT announcements was slightly higher than effects observed in other event studies of IT investment announcements where average CAR values ranged from 0.09% to 0.36% (Bharadwaj et al. 2009). In addition, there was an increase in trading volume, thereby indicating the presence of divergent opinions on such announcements (Kalaignanam et al. 2013). Overall, our findings indicate that green IT announcements which comprise announcements on information system solutions for environmental sustainability evoke strong positive response relative to return from other IT artifacts studied in past research, but from a small group of shareholders.

Green IT announcements on ITDSS elicited more positive shareholder response than announcements on ITASSETS and SPDTSVC. This suggests that shareholders bestow more value to “greening through IT” (IT as a solution) relative to “greening of IT” (IT as a problem). In addition, shareholders generally did not discern between innovative and noninnovative firms. Among the control variables, few industry sectors were significant, concurring with previous event study findings. Interestingly, size measured in terms of revenue was not significant. Our post-hoc analyses suggested that green IT announcements with explicit benefits resulted in higher returns. We also showed that more announcements were correlated with enhanced reputation and past environmental record affected returns from green IT announcements.

2.6. Implications for Research and Practice

Although sustainability research has been ongoing for some time, research on green IT is still relatively new. This event study examined the effect of green IT announcements on abnormal returns. However, we focused on the wealth effects of positive abnormal returns, so future research could explore the significance of the risk effects (e.g., Dewan and Ren 2011). As more firms invest in green IT, it would be interesting to examine whether risk effects are stronger than wealth effects. Further, we have rather limited news on failure and risks associated with green IT. As more news becomes available, it will be interesting to compare the impact of positive and negative news on the magnitude of market returns.

Overall, our results showed that green IT announcements were associated with positive abnormal returns and such announcements significantly affected trading volume. These results indicate that shareholders generally view green IT favorably and there are divergent views, possibly because of two subsets of shareholders. One subset interprets green IT as signaling prudent economic decisions and ethical orientations, despite divergent views about risks and rewards. The other subset avoids the stocks because they are wary that the initiatives are risky. Ours findings are in contrast with Videen (2011) who found that corporate environmental announcements had no effect on abnormal returns. One plausible reason why the presence of IT artifacts matters is that IT enables firms to more effectively "green" their business operations.

An analysis of the different types of green IT found that ITDSS was positively associated with CAR, while the other types of green IT showed insignificant relationships with CAR, suggesting that shareholders considered costs and benefits when assessing green IT initiatives. This finding supports our conjecture that shareholders reward green IT announcements due to the presence of IT that could enable firms to green their business as ITDSS is targeted at greening through IT. Perhaps shareholders also perceived that ITDSS could be derived from less expensive technologies with higher return on investment and well-established benefits.

On the other hand, shareholders were indifferent to announcements of ITASSETS, possibly because such technologies are still evolving and expensive, and benefits may be elusive and take some time to be realized. Apparently, shareholders were also indifferent to SPDTSVC because they might be still wary about cost effectiveness and market acceptance. Further, it is difficult for shareholders to assess the impact of such investments on the firm's existing models of profitability (Videen 2011). In contrast, the benefits from ITDSS are more quickly achieved. This result extends Flammer (2010) findings that stock price increases are associated with firms that behave responsibly towards the environment by showing that the nature of green IT investments matter. In addition, researchers and practitioners should note that not all types of green IT investments are viewed equally despite their common goal of helping the firm to behave responsibly towards the environment. Further, firms might invest in green IT not to solely satisfy shareholders but other stakeholders who view environmental initiatives as an important part of the firm's identity. Future research could investigate more deeply, why certain types of green IT announcements have higher abnormal returns. Executives and top management could use such knowledge to justify greater investments in specific types of green IT initiatives. Thus, firms can adopt such IT artifacts specifically intending to improve environmental performance and evoke positive shareholder reactions. Better decision making in dealing with environmental issues could decrease costs, enhance revenue, increase profitability, and enhance competitive advantage.

In terms of Corbett's (2010) green IT quadrants, we were able to adopt the classification of three of the four quadrants. We found that announcements relating to *collaboration* are more often linked to productivity benefits than environmental benefits. Consequently, the announcements relating to *collaboration* (with emphasis on the environment) were too few to analyze its effect. Thus, Corbett's typology did provide a succinct classification of green IT. Specifically, it provides a list of specific IT artifacts that facilitate objective and distinct classification of various IT artifacts. Future research using a larger sample (as more data becomes available) could further refine Corbett's green IT quadrants.

Our study also has some rather surprising insignificant findings. For example, we found no support for the relationship between organization size in terms of revenue and abnormal returns, although prior studies (e.g., Bharadwaj et al. 2009) found a positive relationship between organization size and CAR. Perhaps both small and large firms face similar risks in new green technologies. Further, the advantage of size is mitigated by the need to be agile and respond quickly to environmental trends. In other words, although size is often associated with having more resources, it is also often associated with greater bureaucracy. Another reason is that shareholders may not care much about organization size as they expect all firms to do their part in taking care of the environment. Future research could further examine the situations under which size might be important.

Our results also indicated that industry competition measured in terms of HHI was not significant, perhaps because the risks and rewards associated with such announcements were similar for both less- and more-competitive industries. The annual return from the S&P index was not significantly associated with CAR, which indicated that bearish or bullish markets did not matter. Perhaps shareholders evaluated such initiatives independently from market conditions. Future research could examine other reasons for the insignificant findings.

We also found no empirical support for the relationship between innovativeness and abnormal returns. Green IT falls under the category of IS innovation, and hence we might expect innovative firms to be rewarded more than noninnovative firms. However, even innovative firms may fail to effectively deploy IT (Lindič et al. 2011). Green IT might also entail the commercialization of products and technologies, which could pose significant risks for both types of firms, thereby leading to insignificant results. Another reason is that shareholders might have higher expectations of innovative firms, such that only ground-breaking announcements would engender effects on market returns. Further, shareholders might be used to announcements from innovative firms such that their effects are muted. In contrast, shareholders might be wary of announcements by noninnovative firms as they are unsure whether such firms could deploy green IT effectively. Rather than focusing on the impact of innovativeness on abnormal returns, practitioners should be aware that the market does not differentiate between innovative and noninnovative firms when judging green IT announcements.

Our post-hoc analyses suggest that it is more important to focus on past environmental record as it assures shareholders that firms are serious about sustainability, when they make announcements on green IT. Thus, only firms with good environmental record benefit from announcements on ITDSS and ITASSETS. However, such firms do not benefit from announcements on SPDTSVC.

2.7. Concluding Remarks

This study contributes to research on green IT by empirically examining the impact of green IT announcements on market valuation. Our results empirically establish the role of green IT announcements in evoking positive reactions as well as increasing trading volume. We show that among the green IT types, only *information to support decision-making* (ITDSS) evokes a positive shareholder response. Further, we find no significant difference between innovative and noninnovative organizations in terms of the CAR from green IT announcements. Green IT announcements are also positively correlated with firm reputation. Overall, our study is the first to provide empirical evidence that green IT announcements relating to ITDSS positively affect market returns, thereby reassuring firms that such investments , specifically the investments in “IT as a solution” or “greening through IT" are worthwhile.

Chapter 3

Toward a Better Understanding of Environmental–Operational Performance Nexus

Summary

While organizations continue to adopt sustainable practices to improve their environmental performance, research is divided on the impact of environmental performance on organizational performance. In this paper, we use secondary data to examine the relationship between environmental performance in terms of direct and indirect emissions with operational performance in terms of cost efficiency and productivity. We also examine the role of environmental management systems (EMS) and quality management (QM) in moderating the relationships. Our results indicate that reducing direct emissions improves cost efficiency but negatively impact productivity. Further, reducing direct emissions through QM diminishes productivity. In contrast, reducing indirect emissions in the presence of QM improves productivity. Our findings suggest that demand-based emissions and utility supplier-based emissions have distinct effect on the payoffs from improvement in environmental performance. Implications for research and practice are discussed.

3.1. Introduction

Broadly speaking, *sustainability* refers to "the way of utilizing resources, which meets the need of the present generation without compromising the ability of future generations to meet their own needs" (WCED 1987:41). In the enterprise context, sustainability refers to delivering economic, environmental, and social benefits (Hart and Milstein 2003), a three-pronged benefits approach called *triple bottom line* that extends the economic benefits of organizational performance to social and environmental benefits. Organizations, as major consumers of natural resources (Ekins 1993), often generate harmful wastes (Shrivastava and Hart 1995, EPA 2011a) that pose significant health hazards. Consequently, organizations are increasing their efforts to reduce their harmful environmental impact, as reflected in the growth in sustainability-related investments (Haanaes et al. 2011), the proliferation of initiatives targeted at changing the composition of outputs to reduce their adverse environmental impacts, the substitution of less-environmentally harmful materials, and the development of clean technologies.

Environmental sustainability initiatives strive to achieve cost and resource efficiency (Berns et al. 2009, Haanaes et al. 2011). In addition, concerns are growing abound on the harmful ramifications of industrialization development and urbanization on climate change and global warming. The Intergovernmental Panel on Climate Change (IPCC), formed by the United Nations (UN), suggests that greenhouse gases (GHGs) are responsible for global warming (National Geographic 2011). Organizational operations are a major force behind GHG emissions.

Current research on environmental sustainability has often examined the relationship between environmental performance and financial measures such as profitability and market value (Horváthová 2010, Delmas and Nairn-Birch 2011). While some studies suggest that improving environmental performance benefits organizations (Konar and Cohen 2001), other studies suggest that enhanced environmental performance does not necessarily enhance organizational performance (Cordeiro and Sarkis 1997). Hence, research is still unclear about the organizational implications of environmental performance. If environmental performance fails to improve organizational performance, then environmental sustainability is questionable because investments such as cleaner facilities and technologies are costly. If environmental performance and organizational performance are unrelated, better environmental performance cannot benefit organizations. To encourage sustainability practices, governmental policies must provide the needed support and incentives.

Moreover, research is often silent on the relationship between environmental performance and operational performance, whereas research in operations management has often emphasized the relationship between operational performance and profitability (Tsikriktsis 2007). The focus has been predominantly on the relationships between specific practices such as green supply chain practices (GSCM) and perceptual measures of performance (Golicic and Smith 2013). Further, the key objective behind environmental sustainability initiatives is to achieve cost and resource efficiency (Berns et al. 2009, Haanaes et al. 2011) as reflected in operational performance (Corsten et al. 2011). To bridge this gap, we examine the relationship between environmental performance in terms of direct and indirect emissions and operational performance in terms of cost efficiency and productivity.

Certain organizational factors could affect environmental and operational performance. For example, quality management (QM) could influence the relationship between environmental practices and organizational performance (Zhu and Sarkis 2004). QM could also influence operational performance (Samson and Terziovski 1999), and therefore the relationship between environmental performance and operational performance. Likewise, environment management systems (EMS) could strengthen or weaken the relationships between environmental performance and operational performance. Against this background, we examine three key research questions:

RQ 2.1*: Is environmental performance associated with operational performance?*

RQ 2.2*: Do different dimensions of environmental performance in terms of direct and indirect emissions have different relationships with different measures of operational performance in terms of cost efficiency and productivity?*

RQ 2.3*: Do EMS and QM strengthen or weaken the relationship between environmental performance and operational performance?*

This study makes several contributions. First, the literature has recognized the business value of environmental sustainability (Hart 1995, 1997, Hart and Dowell 2011), and has empirically examined distinct measures of environmental performance using various approaches such as capital expenditure on technology (Nehrt 1996), emissions of toxic chemicals (Hart and Ahuja 1996), log of total facility emissions of toxic chemicals (King and Lenox 2001), eco-efficiency ratings (Blank and Daniel 2002), and absolute level of air-pollutant emissions (Eamhart and Lizal 2007). These studies often operationalize environmental performance as aggregate measures and include metrics such as aggregate emissions. In contrast, we disaggregate emissions into direct and indirect emissions to show that different types of emissions may have different effects on operational performance, and consequently may require different strategies.

Second, despite extensive focus on the financial implications of environmental performance, prior research has rarely focused on the link with operational performance (Albertini 2013, Endrikat et al. 2014). We mainly depart from past research by asking whether improved environmental performance in terms of direct and indirect emissions improves operational performance in terms of cost efficiency and productivity. We hope our empirical analyses will contribute to the debate on the business value of sustainability.

Third, we show that whether organizations benefit from improving their environmental performance depends not only on environmental performance but also on other factors such as EMS and QM that may attenuate or strengthen the relationship. We also show that EMS and QM diverge in their relationships with cost efficiency and productivity. Moreover, they influence the relationships between different types of emissions with cost efficiency and productivity differently. We suggest that the environmental performance–operational performance nexus may be more complex than previously envisaged, and factors that affect this relationship must be considered to resolve the conflicting findings in the literature

In the rest of the paper, we review the relevant literature streams. We then propose our framework and hypotheses; describe our datasets and analysis procedure; and then provide results, discussion, implications for research and practice, limitations, and conclusions.

3.2. Background

Organizations often ask whether or when it pays to be green. From a research perspective, scholars are interested in unraveling the relationship between environmental performance and profitability. The past three decades have seen a stream of research on environmental performance as it impacts organizational performance (Bansal and Hoffman 2011), with conflicting findings (Horváthová 2010, Delmas and Nairn-Birch 2011).

Researchers have three distinct views on the relationship between environmental performance and organizational performance. The neoclassical theory argues that environmental performance negatively impacts organizational performance (Palmer et al. 1995) because it is costly (Cordeiro and Sarkis 1997, Stanwick and Stanwick 1998).

The innovation-offsets view argues that environmental and organizational performance are positively related (Porter 1991, Porter and Van Linde 1995). Specifically, appropriately designed environmental regulations lead to innovations that offset compliance costs because pollution indicates economic inefficiency, and reduced pollution indicates better performance (e.g., King and Lenox 2001, Konar and Cohen 2001).

A third view is that the relationship cannot be exactly ascertained (Wagner 2005, Earnhart and Lízal 2007). Environmental performance may be insignificantly related to organizational performance because it depends on various other factors. Overall, studies of environmental performance and organizational performance have inconclusively reported mixed results (Horváthová 2010). While empirical studies using simple correlation-based approaches and portfolio studies found support for negative relationships (Horváthová 2010), studies involving a single or aggregated measure of environmental performance such as pollution performance and compliance with environmental regulations found support for positive relationships (Margolis et al. 2007, Horváthová 2010). In fact, a meta-analysis provided inconclusive results (Horváthová 2010), possibly because different studies used different methods and different performance constructs.

Lately some studies have used panel data methods (multiple time-period data) to investigate environmental performance-organizational performance linkages, but have predominantly failed to find support for the linkages (Horváthová 2010). Like many cross-sectional studies, those studies also primarily used aggregated measures of environmental performance such as aggregate emissions.

Other research has used frameworks to classify emissions into Scopes 1, 2, and 3 emissions to derive total and supply chain emissions (e.g., Delmas and Nairn-Birch 2011). Scope 1 emissions are direct emissions from organization-controlled/owned sources. Scope 2 are indirect emissions from consuming purchased electricity, heat, or steam. Scope 3 emissions are other indirect emissions such as from transmissions and distribution losses, GHG emissions from a vendor's supply chain, outsourced activities, and site remediation activities.

Although such measures are more granular than earlier aggregate emissions measures, their limitations could bias the analysis. For example, federal reporting requirements make it optional for organizations to report Scope 3 emissions (EPA 2012). Also, organizations may freely determine which Scope 3 emissions they want to include in their reports, making inter-organizational comparisons difficult (The Greenhouse Gas Protocol Initiative 2011). Moreover, Scope 3 calculations are uncertain because supply chain emissions are often associated with measurement issues such as double-counting (Caro et al. 2013). Typically as suppliers work with multiple customers, it is difficult to apportion emissions to unique original equipment manufacturers (CDP 2011, p. 7). Another potential issue is that such measures conceal emission sources. For example, supply chain emissions also depend on supplier location. Organizations in Europe can procure materials from nearby suppliers and reduce transportation emissions (optional emissions), but they might obtain less expensive materials from India or China. Thus locational factors rather than an organization's operations may influence relationships between supply chain emissions and financial performance.

Notably, studies have often used accounting measures such as return on assets (ROA) or market-based measures such as Tobin's Q as potential organizational outcome of improved environmental performance (Lioui and Sharma 2012). They argue that the effects of environmental performance could be realized in the medium to long term, and Tobin's Q reflects investor perceptions of future growth potential. However, the profitability impact of environmental performance may not be immediately visible (Horváthová 2012).

Those observations suggest that whether environmental performance influences organizational performance depends on various factors that are reflected in different performance metrics. Moreover, cost implications predominantly drive the relationship. We therefore focus on operational performance measures that reflect cost and resource efficiency in organizations.

3.3. Theoretical lenses

The literature has often used the resource-based view (RBV) to examine the organizational implications of corporate environmental performance (Horváthová 2012) and the relationship between environmental performance and profitability (Russo and Fouts 1997). The resource-based perspective suggests that organizations, endeavouring to improve their environmental performance, acquire resources that affect their ability to generate profits, outperform their rivals, and attain competitive advantage (McWilliams and Siegel 2011). Thus, better environmental performance could translate to better organizational performance. However, metrics of financial performance such as profitability are also vulnerable to various factors such as macroeconomics. Further, environmental performance fails to directly affect accounting or market-based measures of profitability (Lioui and Sharma 2012), so it may be better to examine intermediate effects in the absence of direct relationships between two variables (Benitez-Amado and Walczuch 2012). Those observations provide support for our focus on operational performance and underline the need to examine the relationship from a different perspective.

Resource-Consumption Perspective

From the resource-consumption perspective, the consumption of resources and their consequences are salient to environmental performance. Research in operations management has often debated the organizational implications of resource efficiency (Modi and Mishra 2011), arguing that excess resources represent waste that should be reduced (Modi and Mishra 2011). Emissions, in general, indicate inefficient combustion processes and therefore inefficient resource utilization (EPA, 2011d). Thus, reduced emissions indicate that energy resources yield higher usable output to input ratios and, consequently, generate less waste, indicating energy efficiency and less pollution (Worrell et al. 2009).

Resource efficiency has been shown to be positively associated with financial performance (Modi and Mishra 2011). Similarly, emissions could also affect financial performance. However, environmental performance does not directly influence financial performance (Lioui and Sharma 2012), but it could influence operational performance. Domains focused on environmental policies have often emphasized that resource productivity or the value generated per resource unit is the key to sustainability. The operations management literature also associates reduced emissions with resource productivity (Montabon et al. 2007). Higher usable output to input reflected in lower emissions could result in more energy available for the product/service generation process and consequently improve resource productivity.

Those observations suggest that resource efficiency and productivity are salient in environmental performance. Therefore, we focus on how emissions reflect resources consumed in an organization's operations and on how operational performance reflects resource consumption.

To complement the literature regarding sustainability and operations management, we investigate the relationship between environmental performance and operational performance by explicitly considering the different categories of emissions classified according to their sources and the measures of operational performance that reflect cost efficiency and productivity.

Understanding Environmental Performance

The Global Reporting Initiatives (GRI) guidelines, directed toward establishing an effective framework for sustainability reporting, emphasize reducing emissions and waste, and conserving water, fuel, and electricity as critical environmental performance metrics. Emissions are consequences of organizational operations and are a critical environmental performance metric. Emissions also reflect fuel and electricity usage (EPA 2011a) that are part of operational costs. Thus, we focus on emissions. The key objectives behind sustainability initiatives are to achieve cost and resource efficiency (Berns et al. 2009, Haanaes et al. 2011), so decreased operational costs could be the immediate outcome of environmental performance.

Emissions are measured as GHG, referring to the discharge of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases, measured and tracked using a protocol developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD; The Greenhouse Gas Protocol Initiative 2011) and adapted to the organizational context by the U.S. EPA (2011b). Organizational emissions emanate from energy usage such as fuel consumption, process-related emissions, refrigeration, and electricity purchases. Based on the sources of operations, emissions are classified as direct, indirect, and optional (EPA, 2011b).

Direct emissions refer to emissions from organization-owned/controlled resources, including fossil fuel combustion in stationary sources such as boilers, furnaces, turbines, or generators, in manufacturing or processing of chemicals and other materials, in the combustion of fuels in mobile transport modes, in refrigeration, equipment leaks, air conditioning equipment, and methane leakages from gas transport. However, direct emissions exclude biomass emissions or GHGs such as chlorofluorocarbons (CFCs) applicable to a few specific sectors. Hence, by changing processes and equipment, organizations can control direct emissions coming from processes under their control.

Indirect emissions refer to emissions that come from the organizations' processes or activities but are owned or controlled by another entity. Such emissions include emissions from the utilities purchased by the organization, such as electricity, steam, and hot/cold water (EPA, 2011c). It excludes electricity bought for resale. Thus, organizational initiatives and practices are salient in indirect emissions

Optional emissions refer to emissions from sources that are not organization-owned/controlled and are not core emissions. They include emissions from the transportation of materials, non-fleet vehicles used for employee business travel, employees commuting to work, and nonstandard sources such as purchased heat in heat transfer fluid and resale processes in utility organizations, disposal of solid products, and disposal of wastes generated in operations, and production of purchased materials (EPA 2011c).

Very few organizations report their optional emissions as it is not mandatory to do so. Consequently, we focus only on direct and indirect emissions in this study. Conventional wisdom on the environmental performance focuses on aggregate emissions without distinguishing between whether emissions emanate from demand based on organizations' processes or carbon intensity of utility services providers' energy . In contrast, we distinguish the sources of emissions. While direct emissions reflect emissions emanating from organizations' processes or sources under their control, indirect emissions reflect emissions from purchased energy and therefore is dependent on the utility services providers' energy generation processes and sources of energy, and are beyond the control of the focal organization.

Environmental Performance and Operational Performance

Operational performance can be assessed in terms of cost efficiency and productivity (Jiang et al. 2006). *Cost efficiency* reflects the outcome of reduced operating costs. *Productivity* reflects assets utilized to generate output. In general, cost efficiency (defined as COGS/revenue, operating expense/revenue) indicates lower costs or expenses. Both COGS and operating expenses are expenses. However, COGS is focused on expenses incurred from sales, whereas operating expenses are fixed monthly costs of operations irrespective of sales.In contrast, higher productivity indicates greater output for input (costs). To improve environmental performance and cost efficiency (Jiang et al. 2006), organizations can use several means such as energy efficient technologies and conservation of energy and resources used in production or service generation processes. Emissions from some sources can be more easily controlled than from others, so some emissions might affect cost efficiency differently. Conserving resources could allow organizations to generate more sales per dollar in assets and hence improve productivity. However, different emissions contribute differently to assets and sales, and thus impact productivity differently.

3.4. Research Model and Hypotheses

Figure 3.1 presents the research model, which hypothesizes the relationship between environmental and operational performance, with EMS and QM as moderators.

Organizations can reduce direct emissions through initiatives and actions aimed at manufacturing and service-delivery processes. To reduce emissions from stationary combustion sources, such as process heaters, turbines, flares, and incinerators, and to improve mineral processing, they can improve, redesign, or adopt more sophisticated, cleaner technologies such as IR heating, UV curing, or recover heat and process insulation. Reducing emissions from stationary sources often causing significant direct emissions reflects significantly improved resource utilization. Further, new technologies and processes could significantly reduce labor costs. To reduce emissions from mobile combustion sources such as fossil fuels in organization-owned vehicles, they can use anti-idling strategies, clean variants of fossil fuels, high-mileage vehicles, and oxidation catalyst and non-catalyst emissions control (EPA 2008). Reducing emissions from mobile combustion sources often requires fuel-efficient vehicles (EPA 2011b). Companies can adopt new chemical processes that leave smaller carbon footprints (EPA 2012). Better maintenance or technologies such as differential absorption light detection and ranging can reduce fugitive emissions from leaks in pressurized equipment (Chambers et al. 2008). Organizations can reduce emissions emanating from their stationary combustion sources by improving their efficiency and consequently reducing resource consumption. In summary, improved processes and technologies can improve resource utilization and reduce raw material costs i.e., reduced direct emissions can improve operating costs.

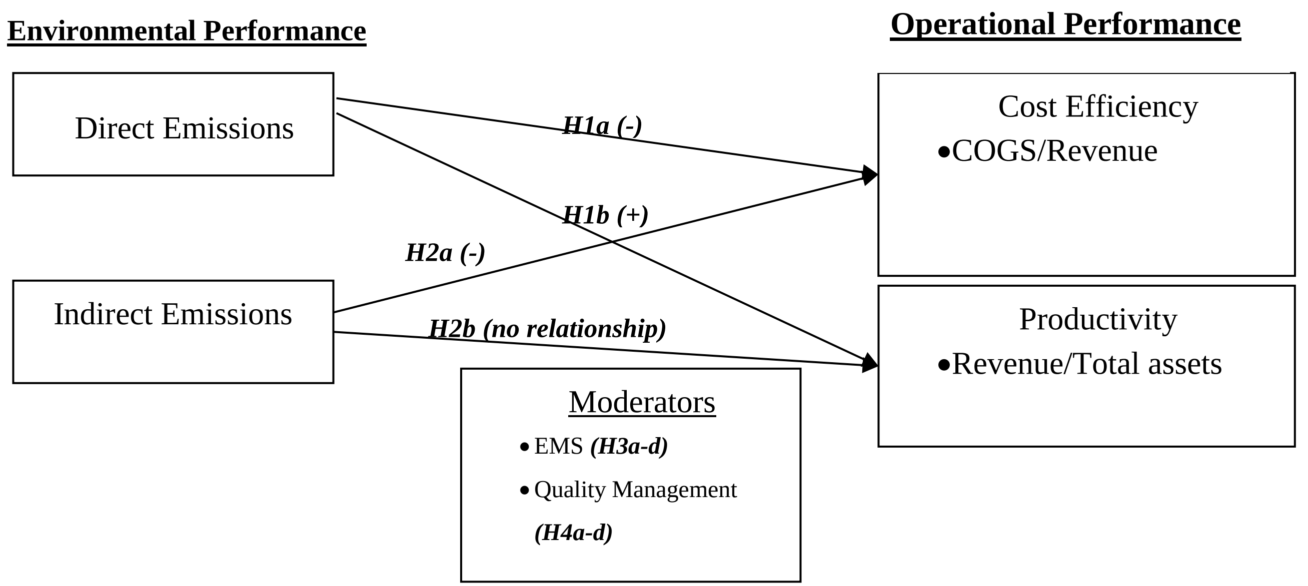


Figure 3.1 Research Model

Although the literature broadly agrees that better environmental performance through resource efficiency reduces costs (Kroes et al. 2012), the impact on productivity is unclear. One broad view is that better environmental performance through technological innovation yields higher productivity (Porter 1991, Hart and Dowell 2011), enhances technological assets and processes, reduces total assets required to generate output, and increases output levels (Brynjolfsson 1993).

The opposing view is that technology does not necessarily enhance productivity. Instead, productivity depends on many other factors (Tambe and Hitt 2012) such as improving output (demand for product or services reflected in revenue) or reducing input required for generating similar output levels (asset). However, in the organizational context, several factors unrelated to environmental performance such as better marketing campaigns and better products impact the demand for products and services. In fact, better environmental performance and subsequent better reputation do not necessarily increase demand for products and services. Therefore, better environmental performance has a limited role in improving output.

On the input side, technological assets that reduce direct emissions could increase capital expenditure and asset value. Consequently, revenue (output) relative to assets (input) could also decline. In contrast, increased direct emissions could indicate improved output level. Organizations could also increase direct emissions by adhering to legacy technologies and avoiding investments in new technologies. Legacy technologies would depreciate in value over time, whereas organizations could continue to maintain similar production or service generation levels. Consequently, revenue relative to assets would increase. Therefore, we posit:

H1a: Direct emissions are negatively associated with cost efficiency.

H1b: Direct emissions are positively associated with productivity.

For many organizations, 80-90% of total emissions are indirect emissions (Zimmerman 2009), which can be reduced in two notable ways. First, organizations can develop processes that use fewer purchased electricity sources such as heat, steam, and hot/chilled water. Second, they can purchase cleaner, renewable energy, although it may not be cheaper and may be less available where organizations are located (Lazard 2013). However, reduced purchased electricity would require the development of energy-efficient processes that generate the same level of products or services but use less electricity than conventional processes and legacy technologies.That is, organizations must often invest in energy-efficient technology, energy conservation, onsite co-generation plants (EPA 2005), and efficient boilers (EPA 2011c). Because energy costs account for a significant proportion of operating expenses, reduced energy use and consequent reduction in indirect emissions could improve cost efficiency and additionally reduce expenses incurred in purchasing other energy sources such as steam, hot, and cold water.

The development and deployment of energy-efficient processes and technologies can predominantly reduce operating costs by reducing indirect emissions. However, whether energy-efficient technological resources improve productivity depends on whether the organization's products or services are in demand since productivity is defined in terms of the ratio of output (revenue) to input (total assets). Energy-efficient technologies could increase the energy available for production or service delivery by reducing energy consumption, but they could not increase the demand for energy. Thus, reduced indirect emissions could not improve output. In addition, organizations do not control indirect emissions; rather, suppliers and partners do. Accordingly, we expect that reduced indirect emissions would not be associated with improved productivity. Hence, we posit:

H2a: Indirect emissions are negatively associated with cost efficiency.

H2b: Indirect emissions are not associated with productivity.

Moderators in the Environmental Performance and Operational Performance Nexus

Role of Environmental Management Systems (EMS)

The preceding hypotheses postulate direct relationships between environmental performance and cost efficiency and productivity, but other factors also influence the relationships. A recent meta-analysis delineated factors that attenuate or strengthen the environmental–organizational performance relationship (Albertini 2013). By examining moderating factors, we improve the validity of the findings and the precision of theorizing (Goldsby et al. 2013).

Research in operations management has often examined the impact of QM (quality management) on operational performance (Zhu and Sarkis 2004). Studies focused on sustainable operations have often examined the performance impact of EMS (environmental management systems) (Wu et al. 2008). Drawing from the extant literature on QM and EMS performance impacts, we examine their role in strengthening the relationship between environmental performance and operational performance.

EMS provides a structure for systematically monitoring and evaluating environmental impacts (Darnall and Edwards 2006), therefore potentially enhancing practices such as green service delivery that minimize resource consumption and waste (Wong et al. 2013). Both certified EMS such as ISO 14001 and uncertified EMS (captive EMS) positively impact the relationship between green practices and cost performance (Wong et al. 2013). Further, certified EMS provides better monitoring of processes (Boirol 2007). Because both practices and processes cause direct and indirect emissions, better monitoring would curtail waste so that saved resources could be better utilized. Consequently, we expect EMS to strengthen the relationships between emissions and cost efficiency.

EMS-caused improvements are primarily technical and administrative (Wong et al. 2013). Further, they alone cannot improve operational performance such as lead time and quality (Wu et al. 2008). Improving product quality is crucial to increasing the demand for products and services (Kaynak 2003). In addition, competitors can easily imitate EMS implementation (Wu et al. 2008), and therefore it may not necessarily create a reputation that outshines competitors. Actual environmental practices indeed enhance reputation and image (Narasimhan and Schoenherr 2012). Consequently, we expect that EMS, unable to increase demand for products and services, would not influence the relationships between emissions and productivity. It follows:

H3a: Direct emissions and cost efficiency have a stronger relationship in organizations with EMS than in organizations without EMS.

H3b: EMS does not influence the relationship between direct emissions and productivity.

H3c: Indirect emissions and cost efficiency have a stronger relationship in organizations with EMS than in organizations without EMS.

H3d: EMS does not influence the relationship between indirect emissions and productivity.

Role of Quality Management (QM)

Quality management (QM) and operational performance factors such as efficiency and environmental outcomes have been shown to be related (Zhu and Sarkis 2004). Environmental performance is intrinsically linked to operational activities, which QM influences (Zhu and Sarkis 2004). QM is broadly defined as encompassing quality certifications such as ISO 9000 standards certification and total quality management (TQM) programs. TQM as a philosophy encompasses continuous improvement in various organizational functions (Kaynak 2003). Environmental management standards and certifications such as ISO 14001 also borrow heavily from generic quality standards such as ISO 9000.

QM strengthens the positive relationship between green supply chain management (GSCM) practices and economic performance (Zhu and Sarkis 2004). Such practices include the design of products for reuse and recycle, green packaging, cleaner production, waste avoidance, and minimized resource consumption, all resulting in better environmental performance (Montabon et al. 2007) and affecting emissions. Often internally focused, QM helps organizations to improve their operations. King and Lenox (2001) found that organizations with QM are more likely to focus on environmental management. Thus QM enhances organizational attention on operations, environmental performance, and economic performance, which could strengthen the relationship between environmental performance (a consequence of operations) and operational performance (a component of economic performance). Therefore, QM can influence relationships between emissions and operational performance. Specifically, QM improves operational performance by minimizing defects and wasteful resource consumption through continuous improvement and rigorous process documentation required in ISO 9000 standards. Reduced emissions reflect better used resources. Thus, QM can strengthen the negative relationship between emissions and cost efficiency.

QM practices also promote customer satisfaction and, consequently, higher demand (Benner and Tushman 2003, Griffin et al. 2012). Higher demand translates to higher output, perhaps reflected in higher productivity. We hypothesized a positive relationship between direct emissions and productivity. QM could further improve productivity by enhancing demand. We also hypothesized no significant relationship between indirect emissions and productivity. QM strengthens economic performance and even reduces negative consequences of environmental management practices (Zhu and Sarkis 2004). In the specific context of indirect emissions, reduced indirect emissions alone cannot improve productivity. However, QM could cause increased demand and subsequent increased output level because of improved customer satisfaction arising from QM practices. Energy efficient technologies that reduce indirect emissions could make energy for increasing production more available. Thus, organizations with both reduced indirect emissions and QM could show improved productivity. It follows that:

H4a: Direct emissions and cost efficiency have stronger relationships in organizations with QM than in organizations without QM.

H4b: Direct emissions and productivity have stronger relationships in organizations with QM than in organizations without QM.

H4c: Indirect emissions and cost efficiency have stronger relationships in organizations with QM than in organizations without QM.

H4d: Indirect emissions and productivity have stronger relationships in organizations with QM than in organizations without QM.

3.5. Data and Measures

We compiled emissions data from the EPA Climate Leaders Program (2011), the Climate Registry Program (TCR), and California Climate Action Registry Program (CCAR). Following prior research (e.g., Kroes et al. 2012), we conducted the Chow test to examine whether we could pool data from different sources. The test statistics for different models were insignificant ($p > 0.05$), indicating that parameters for data from different sources were synchronistic and could be combined. Conceptually, our variables of interest are different types of emissions, so choice of data sources should not influence the parameters. We compiled a list of publicly listed organizations with published GHG inventory for at least 2 years from the EPA Climate Leaders Program website, TCR, and CCAR. Under the EPA Climate Leaders Program, initiated in 2002 and based on industry–government partnership, organizations worked with the EPA to set emissions goals, track their progress, and measure and report emissions. GHG inventories published through the program followed EPA-established standard guidelines based on the World Resource Institute (WRI) framework, and provided details on types of emissions. The program was discontinued in 2011. TCR is a nonprofit collaboration among North American states, provinces, territories and native sovereign nations (Climate Registry 2013). Like the EPA Climate Leaders program, TCR verifies reported GHG emissions. Moreover, TCR is the only program recognized by all U.S. states and Canadian provinces, and its guidelines are well-respected (Baier 2010). CCAR, a nonprofit organization formed in California to help California-based organizations measure their GHG emissions, was discontinued in 2010, and organizations are transitioning to TCR. We compiled information on organizational performance from the COMPUSTAT database. Figure 3.2 summarizes the data selection process, and Table 3.1 summarizes our constructs, measures, and data sources. We have 442 observations for 96 organizations (about 4.60 observations per organization).

Environmental Performance

Analogous to Kroes et al. (2012), we measured environmental performance in terms of emissions, specifically direct and indirect emissions. Direct emissions include emissions from sources such as stationary combustion sources, mobile combustion sources, and operating processes. Indirect emissions are from purchased and used electricity such as steam and water. We log-transformed emissions to reduce skewness in our data.

Figure 3.2 Data Selection Process

Cost efficiency

We operationalized cost efficiency as the ratio of cost of goods sold (COGS) to revenue (Bharadwaj, 2000). Prior studies (e.g., Zhu and Kraemer 2002) used COGS alone as a measure of operational performance. However, the ratio of COGS to revenue is a better measure of cost efficiency as it indicates expenses to revenue generation. Enhanced revenue generation increases operational expenses.

Productivity

Productivity is conventionally measured in terms of the ratio of outputs to inputs. We operationalize productivity as the ratio of revenue to total assets (asset turnover) (Jiang et al. 2006).

EMS and QM

We compiled data on EMS and QM from the Kinder, Lydenburg, and Domini (KLD) database. EMS measures whether organizations have environmental management systems, whether they are certified to third-party standards such as ISO 14001, and whether they monitor and manage their environmental practices. KLD provides information on EMS from 2006. We compiled information on earlier years from firms' sustainability reports (if available). QM measures efforts to improve the safety and health aspects of products/services and broadly covers improvement in various functions such as whether organizations proactively manage quality by achieving certification, undertake product testing, build better processes, address quality concerns to manage the risk of major product recalls, and proactively improve chemical contents of their products. KLD provides information on QM from 1991 and thus provide information for all the available years in our sample.

Controls

We used firm size, year-on-year growth in revenue (include sales/turnover), year (time dummies), and industry (dummies) as control variables. We measured size as the log of the number of employees and the log of total assets[4], and captured industry type using the 2-digit industry classification code. By controlling for size and growth, we controlled for the influence of output level on emissions. As, it is possible that change in operational performance is due to changes in output level rather than emissions, the use of controls addresses such endogeneity concerns.

By using the dummies for industry type, we controlled for industry-specific characteristics such as industry concentration, regulations, and variations in organizational performance. By controlling for time, we controlled for year-specific macro-economic factors that might influence organizational performance, such as economic downturns, and other effects such as non-stationarity of technology during the time period. In our sample, certain organizations collaborated with specific environmental agencies to develop, set, and pursue aggressive GHG reduction goals. Developing and setting such aggressive goals could influence their organizational initiatives targeted at improving their environmental performance and subsequently could influence their operational performance. Thus, we controlled for

[4] While different measures of size are correlated, VIF for them is less than permissible limit of 10 (Kutner 2004). Thus, multicollinearity is not an issue.

aggressive goal setting. The use of various controls addressed the issue of endogeneity from omitted variables bias, and the use of lagged dependent variables addressed the issue of reverse causality.

We controlled for the extent of reporting of environmental performance. Under the CLP, TCR, and CCAR, organizations can report their global emissions in locations apart from their U.S./North America operations. We coded as global only organizations that reported global emissions for every business division. Organizations that report global emissions are expected to have higher emissions compared with U.S.-specific emissions reporting. Organizations based and predominantly operating in the United States were coded as global. In case of indirect emissions, low energy prices in emerging nations could negate the potential effect of reduced energy expenses. Therefore, we controlled for such potential effects by including interaction terms of direct and indirect emissions with the extent of reporting. Prior research that focused on sustainability (e.g., Bansal 2005) used a similar approach to measure the direct and moderating effects of variables.

Table 3.1:Constructs and their Measures

Construct	Data Type	Measures	Data Source
Direct emissions	Continuous	Log of Absolute emissions	GHG Inventory/TCR/CCRA
Indirect emissions	Continuous	Log of Absolute emissions	GHG Inventory/TCR/CCRA
EMS	Categorical	0: No, 1: Yes	KLD
QM	Categorical	0: No, 1: Yes	KLD
Cost efficiency	Continuous	COGS/Revenue	COMPUSTAT
Productivity	Continuous	Revenue/Total Assets	COMPUSTAT
Size	Continuous	Log of employee strength Log of Assets	COMPUSTAT
Extent of reporting	Categorical	0: Local, 1: Global	GHG Inventory/TCR/CCRA
Year-on-year growth in revenue	Continuous	Change in annual revenue computed as (sale(t) – sale (t-1))/sale (t-1)	COMPUSTAT
Goal setting	Categorical	0: No aggressive goal development 1: Aggressive GHG reduction goal development	EPA Center for Corporate Climate Leadership

Econometric Specifications

We tested two models to investigate the relationship between environmental performance and organizational performance. Model 1 tests the relationship between direct and indirect emissions with cost efficiency; Model 2 tests the relationship between direct and indirect emissions with productivity. Prior research (e.g., Aral and Weill 2007) analyzed the relationship between the measures of organizational performance and explanatory variables separately. We followed that research by testing the relationship between the measures of operational performance and environmental performance separately. We lagged the measures of operational performance by a year to address potential reverse causality. The econometric specifications are as follows:

Model I

$$\textit{COGS/Revenue Percentage}_{i,t+1} = \beta_0 + \beta_1(\textit{direct emissions})_{i,t} + \beta_2(\textit{indirect emissions})_{i,t} + \beta_3(\textit{EMS})_{i,t} + \beta_4(\textit{QM})_{i,t} + \beta_5(\textit{direct emissions*EMS}) + \beta_6(\textit{indirect emissions*EMS}) + \beta_7(\textit{direct emissions*QM}) + \beta_8(\textit{indirect emissions*QM}) + \beta_9(\textit{employee}) + \beta_{10}(\textit{asset}) + \beta_{11}(\textit{growth}) + \beta_{12}(\textit{sector}) + \beta_{13}(\textit{year}) + \beta_{14}(\textit{extent of reporting})_{i,t} + \beta_{15}(\textit{direct emissions*Extent}) + \beta_{16}(\textit{indirect emissions*extent of reporting}) + \varepsilon_{i,t}$$

Model II

$$\textit{Productivity}_{i,t+1} = \beta_0 + \beta_1(\textit{direct emissions})_{i,t} + \beta_2(\textit{indirect emissions})_{i,t} + \beta_3(\textit{EMS})_{i,t} + \beta_4(\textit{QM})_{i,t} + \beta_5(\textit{direct emissions*EMS}) + \beta_6(\textit{indirect emissions*EMS}) + \beta_7(\textit{direct emissions*QM}) + \beta_8(\textit{indirect emissions*QM}) + \beta_9(\textit{employee}) + \beta_{10}(\textit{asset}) + \beta_{11}(\textit{growth}) + \beta_{12}(\textit{sector}) + \beta_{13}(\textit{year}) + \beta_{14}(\textit{extent of reporting})_{i,t} + \beta_{15}(\textit{direct emissions*extent of reporting}) + \beta_{16}(\textit{indirect emissions*extent of reporting}) + \varepsilon_{i,t}$$

Note that higher COGS/revenue ratio imply a decline in operational performance. High COGS/revenue indicate cost inefficiency. We include interaction terms to examine the combined effect of environmental performance, EMS, and QM on cost efficiency and productivity. Following Aiken and West (1991), we centered continuous variables before computing the interaction terms. As it is possible to have first order autocorrelation and heteroskedasticity across the panels in our data, we estimate the coefficients using a GLS specification which assumes that residuals are heteroskedastic and contemporaneously correlated across the panels. Prior research such as Kroes et al. (2012) have used similar approach.

3.6. Results

Descriptive statistics and intercorrelations are shown in Table 3.2. The results of panel data analyses are shown in Table 3.3. Direct emissions had positive relationships with COGS/revenue [COGS/revenue (β=0.020, $p < 0.01$)], thereby supporting H1a, which indicates that increased direct emissions cause COGS relative to revenue thus suggesting a decline in operational performance. Moreover, direct emissions were related to productivity (β=0.023, $p < 0.01$), thus providing support for H1b.

Indirect emissions and COGS/revenue (β=-0.002, $p > 0.05$) showed no significant relationship. This suggests that increased indirect emissions do not significantly change COGS relative to revenue and operating expenses relative to revenue. Hence, H2a was not supported. The results also showed no relationship between indirect emissions and productivity (β= 0.004, $p >$0. 05). Thus, the null hypothesis (H2b), that indirect emissions and productivity have no relationship, was not rejected. The estimates for direct emissions*EMS indicated insignificant relationship with COGS/revenue ($\beta=-0.0013$, $p>0.05$), failing to support H3a.

As hypothesized, the estimate for productivity was negative and significant ($\beta=-0.008$, $p<.05$), failing to support H3b. The results support a significant relationship between indirect emissions*EMS with COGS/ revenue ($\beta=0.029$, $p<0.05$), thus supporting H3c. The estimate for productivity was insignificant ($\beta=0.0047$, $p>0.05$); thus, H3d was not rejected.

Table 3.2: Intercorrelation

	Mean	SD	1	2	3	4	5	6	7	8	9	10
1.Direct emissions	12.51	3.06	1									
2.Indirect emissions	11.88	3.09	0.33*	1								
3. EMS	0.28	0.45	0.07	0.26*	1							
4. QM	0.12	0.32	0.06	0.18*	0.43*	1						
5.COGS/revenue	0.61	0.20	0.25*	0.16*	-0.08	0.02	1					
6. Productivity	0.73	0.49	-0.09	0.16*	0.13*	0.19*	0.18*	1				
7. Size (Log of employee)	10.19	1.44	0.28*	0.49*	0.21*	0.26*	0.03	0.19*	1			
8. Size (Log of assets)	9.89	1.76	0.33*	0.37*	0.04	0.06	0.04	-0.32*	0.76*	1		
9. Growth	0.08	0.29	0.00	-0.27*	-0.09	-0.02	-0.06	-0.07	-0.07	-0.02	1	
10. Extent of reporting	0.53	0.50	0.32*	0.12*	0.08	-0.09	0.19*	-0.01	-0.03	0.03	-0.11	
11. Goal setting	0.68	0.47	0.08	0.21*	0.20*	0.20	-0.06	0.15*	0.19*	0.30*	-0.11*	0.21*

*Notes: * $p<0.05$; correlations for binary/categorical variables are tetrachoric correlations*

The estimates for direct emissions*QM indicate an insignificant relationship with COGS/revenue, ($\beta = -0.000$, $p > 0.05$), failing to support H4a. However, the estimate for productivity was significant ($\beta = 0.029$, $p \approx 0.05$), supporting H4b. The results supported the significant relationship between indirect emissions*QM with COGS/revenue ($\beta = 0.015$, p 0.05), thus supporting H4c. The estimate for productivity was negative and significant ($\beta = -0.061$, $p < 0.05$), suggesting that when indirect emissions decreased in organizations with QM, productivity improved. Thus, H4d was supported.

Table 3.3: Results

Dependent Variable	COGS/Revenue	Productivity
Direct emissions	**0.020**** **{0.005}**	**0.023**** **{0.005}**
Indirect emissions	-0.002 {0.003}	0.004 {0.005}
EMS	**-0.055**** **{0.015}**	-0.004 {0.019}
QM	-0.015 {0.017}	**0.099*** **{0.048}**
*Direct emissions*EMS*	-0.001 {0.005}	**-0.008*** **{0.003}**
*Indirect emissions*EMS*	**0.029**** **{0.010}**	0.005 {0.011}
*Direct emissions*QM*	-0.000 {0.005}	**0.029*†** **{0.018}**
*Indirect emissions*QM*	**0.015*** **{0.009}**	**-0.061*** **{0.027}**
Size (Log of employee)	**0.061**** **{0.010}**	**0.175**** **{0.019}**
Size (Log of asset)	**-0.072**** **{0.010}**	**-0.198**** **{0.019}**
Growth	0.003 {0.027}	0.008 {0.014}
Goal setting	**-0.089**** **{0.015}**	-0.006 {0.028}
Extent of reporting	**0.055**** **{0.012}**	**0.088**** **{0.015}**
Direct emissions*extent of reporting	**-0.008*** **{0.004}**	**-0.032**** **{0.005}**
Indirect emissions*extent of reporting	0.000 {0.010}	-0.004 {0.006}
Model Fit: χ^2	**1605.20****	**8241.24****
p-value	0.00	0.00

*Notes: **p<0.01, *p<0.05 (one-tailed). Null hypotheses are tested using two-tailed tests. Standard errors are in parentheses. Dummy coded controls for time and industry were included in the regressions, but their estimates are not shown for the sake of brevity.*

Among the control variables, the estimates for firm size were significant for operational performance and productivity. Increase in the number of employees reduced cost efficiency (COGS/revenue: β=0.061, p <0.01) but improved productivity (β=0.175, p <0.01). In contrast, increase in assets diminished productivity (β= -0.198, p <0.01) but improved cost efficiency (COGS/revenue:β= -0.072, p <0.01). Perhaps increased assets indicate acquisitions of better technological assets that increase output and reduce per unit cost but are capital-intensive, and therefore reduce output to assets ratio. However, increase in the number of employees probably substitutes for productive technical assets, but could increase per unit cost of production.

Few of the estimates for year dummies were significant for the measures of operational performance, suggesting a salience of macroeconomic variables in operational performance. Most estimates for industry dummies were significant. This suggests that industry sectors influence cost efficiency and productivity.

Likewise, the estimates for the extent of reporting with cost efficiency [(COGS/revenue: β=0.055, p <0.01; Productivity: β=0.088, p <0.01)] were significant, indicating that the diffusion of environmental practices and breadth of reporting influenced cost efficiency and productivity. Interestingly, the estimates for growth in sales were insignificant. Perhaps sales growth did not significantly increase cost relative to revenue. Aggressive goal development influences only COGS/Revenue. Perhaps aggressive GHG reduction goals also increase focus on input costs and subsequently reduce COGS/Revenue.

The estimates for the interaction term (direct emissions*extent of reporting) with cost efficiency (β=-0.008, p <0.05) and productivity (β=-0.032, p <0.01) are negative and significant. Thus, reporting of direct emissions globally improves cost efficiency, but reduces productivity. When direct emissions reduce globally, it could indicate declined output and consequently declined productivity. Direct emissions can be attributed to organizational processes. Perhaps the decline could be attributed to the decline in throughput cost, which forms a part of operating expense. The estimate for EMS with cost efficiency is negative and significant (β=-0.055, p <0.01), whereas the estimate for QM with productivity is positive and significant (β=0.099, p <0.01), thereby indicating a dichotomy in performance impact of EMS and QM.

We observe that the χ^2 values for model with main effect (interaction terms not included in the model) as well as model with main effects and interaction terms were significant. Thus, the set of direct effects as well as interaction terms had statistically significant explanatory power in our models.

Graphing the Interaction Effects

We graphed the significant interaction effects (Figure 3.3 a-c) as recommended by Cohen and Cohen (1983). We also conducted simple slope analysis. Figure 3.3 [a (1)] shows that COGS/Revenue is high when organizations have EMS. The slope for EMS line is significantly different from zero (t-value = 2.636). In other words, in the absence of EMS, whether indirect emissions are low or high is immaterial. However, in the presence of EMS, low indirect emissions improve cost efficiency.

Conversely, slope analysis for Figure 3.3 [a(2)] suggests that the slopes for both no QM line and QM lines are not significantly different from zero (No QM: t-value = -0.762, QM: t-value =1.344). In other words, whether indirect emissions are low or high is *immaterial*.

However, significant and positive interaction term, and the interaction plot suggests that organizations with QM have higher COGS/Revenue and consequently lower operational performance. This suggests that QM increases demand and subsequently need for purchased electricity.

The slope for the QM line in Figure 3.3 [b(1)] is negative and significantly different from zero (t=-2.024, $p < 0.05$), whereas the slope for the No QM line is not significant (t=0.827, $p > 0.05$). Figure 3.3(b) shows a substantial difference in productivity values between low indirect emissions and high indirect emissions in favor of low indirect emissions when organizations have QM.

The slope for the QM line in Figure 3.3 [b (2)] is positive and significantly different from zero (t=2.779, $p < 0.01$). It shows a substantial difference in productivity values between low direct emissions and high direct emissions in favor of high direct emissions when organizations have QM.

a

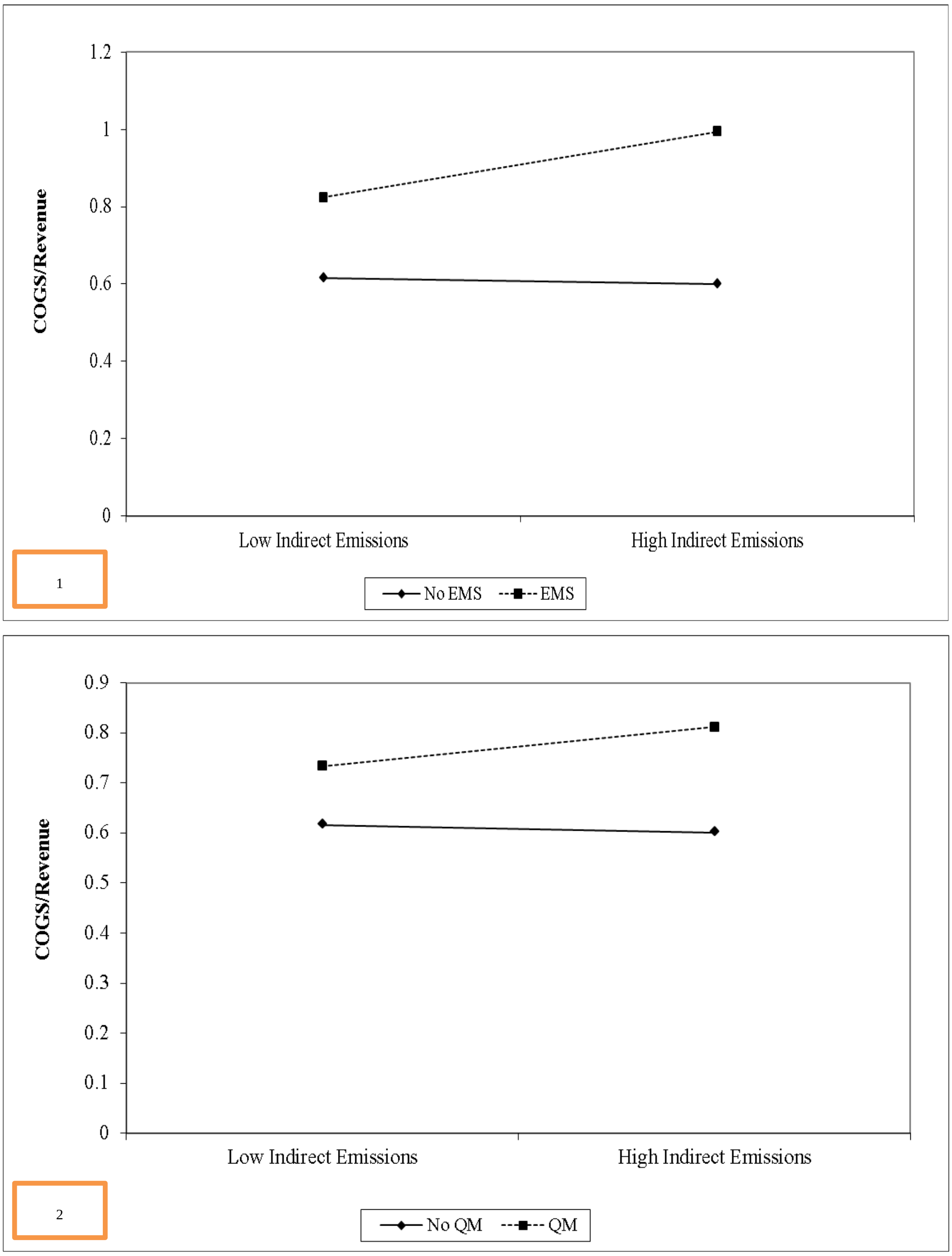
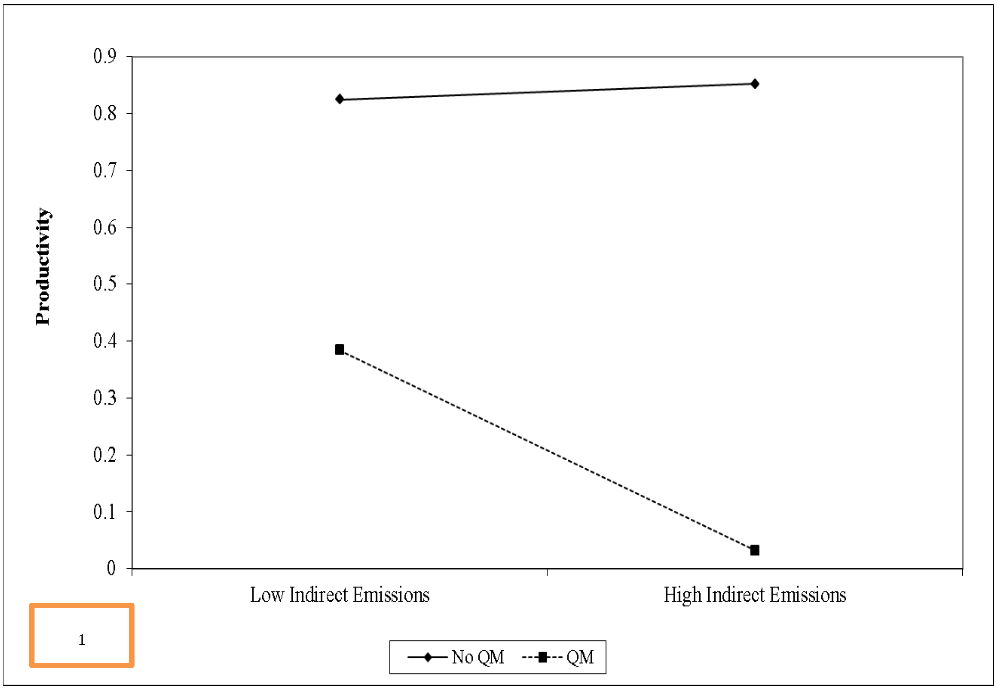


Figure 3.3(a) Interaction Plots

b



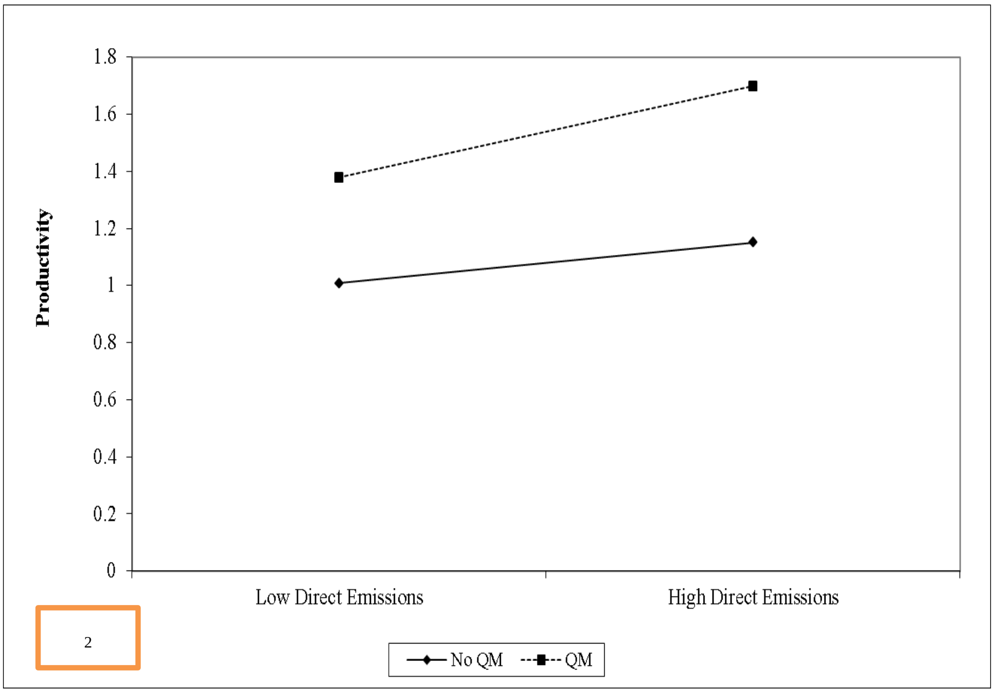


Figure 3.3(b) Interaction Plots

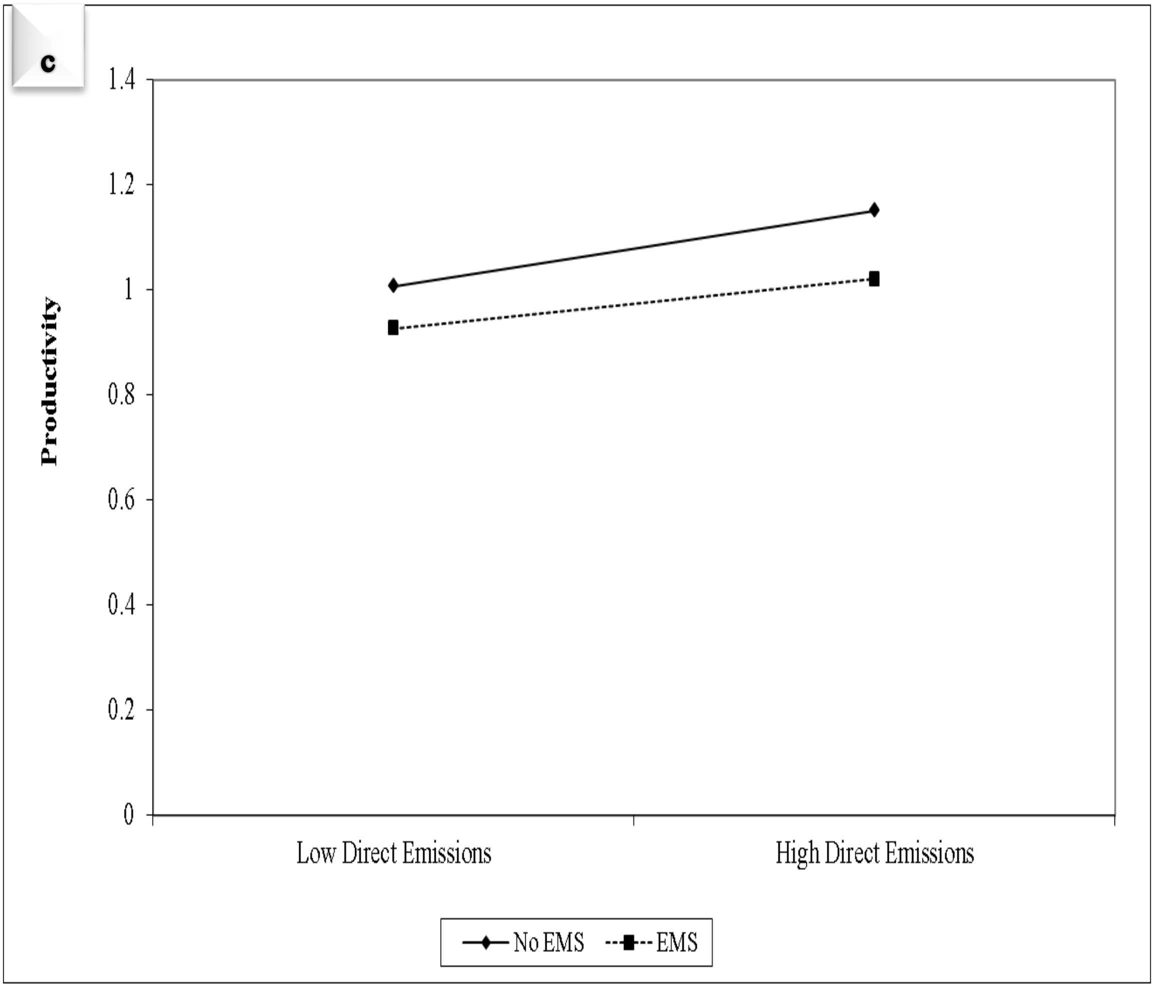


Figure 3.3(c) Interaction Plots

The slope for the EMS line as well as no EMS line in Figure 3.3(c) are positive and significantly different from zero (No EMS:t=4.931, $p<0.01$; EMS : t=2.426, $p< 0.01$). It shows a substantial difference in productivity values between low direct emissions and high direct emissions in favor of high direct emissions.

3.7. Robustness Checks

We tested the robustness of model I using alternative measure for cost efficiency such as operating expense ratio. Operating expense ratio measures financial efficiency and proportion of income used to cover operating expenses. Operating expense includes costs incurred on organizations' daily operations such as salary, depreciation, and rent. It is not directly associated with production. The estimates supported our findings that reducing direct emissions improves cost efficiency. Support for the positive impact of reduction in direct emissions in operating expense ratio indicates that there could be spillover effect, where reduction in production related expenses also reduce expenses not directly associated with production.

We tested the robustness of our estimates using OLS regression with clustered robust standard errors. We also tested the robustness of our findings using Panel corrected standard error (PCSE) regression, which is robust against issues associated with small size (Kroes et al. 2012). The estimates broadly supported our findings. In addition to the panel data measures, we also used seemingly unrelated regressions (SUR) as the dependent variables in our models could influence each other (Zellner 1962). SUR broadly supported our findings. We also dropped different controls such as indirect effect of extent of reporting to examine the robustness of our estimates. The results supported the robustness of our estimates.

We also empirically tested the direction of relationships between direct emissions, indirect emissions, cost efficiency, and productivity. For the aforementioned objective, we employ conventional Granger test. Our results in conjunction with our findings from main analysis suggest that direct emissions indeed causes change in cost efficiency measures such as COGS/Revenue and relationship is not bidirectional. We summarize the results of hypotheses testing in Table 3.4.

Table 3.4: Summary of Results

Hypothesis	Proposed Relationship	Hypothesized Effect	Results
	Main Effects		
H1a	**Direct Emissions → Cost efficiency**	**Negative**	**Supported**
H1b	Direct Emissions → Productivity	Positive	**Supported**
H2a	Indirect emissions → Cost efficiency	Negative	Not supported
H2b	**Indirect emissions → Productivity**	**No relationship**	**Not rejected**
	Interaction Effects		
H3a	Direct Emissions * EMS → Cost efficiency	Strengthen	Not supported
H3b	Direct Emissions * EMS → Productivity	No influence	Not Supported
H3c	**Indirect Emissions * EMS → Cost efficiency**	**Strengthen**	**Supported**
H3d	**Indirect Emissions * EMS → Productivity**	**No influence**	**Not rejected**
H4a	Direct Emissions * QM → Cost efficiency	Strengthen	Not Supported
H4b	**Direct Emissions * QM → Productivity**	**Strengthen**	**Supported**
H4c	**Indirect Emissions * QM → Cost efficiency**	**Strengthen**	**Supported**
H4d	**Indirect Emissions * QM → Productivity**	**Strengthen**	**Supported**

3.8. Discussion

Because quantitative empirical research examining the environmental performance and operational performance nexus is so limited, we were motivated to examine the relationships between direct and indirect emissions and operational performance. In particular, we focus on cost efficiency and productivity. Further, we examine the moderating role of EMS and QM on the relationship between emissions and operational performance. Our analyses generate several findings that deserve mention.

Table 3.4 shows that reduced direct emissions reduce COGS/revenue. One plausible reason is that direct emissions are reduced because of more efficient production processes. Consequently, the cost per unit of production decreases. Moreover, operating expenses also decline. Possibly efficient processes reduce fixed costs such as labor required for turning inventory into throughput. Recent industry surveys support this relationship: almost a quarter of organizations have identified that the greatest benefits of sustainability initiatives are reduced costs from resource efficiency (Haanaes et al. 2011). Thus, our finding is consistent with past research.

However, our results also show that reduced indirect emissions do not reduce COGS/revenue, perhaps because indirect emissions represent purchased electricity and other energy sources, which may be crucial, but make minor contributions to the costs of direct raw materials, supplies, and indirect materials. Instead, labor expenses perhaps account for most operating expenses. These findings contradict the prevalent view emphasizing reduced indirect emissions (Zimmerman 2009), which can be a major proportion of the carbon-footprint but reflect resources that do not account for most costs. Moreover, it is possible that organizations in energy-intensive sectors have captive power plants to meet their energy needs. Thus, majority of emissions from energy consumption is part of direct emissions. Our findings suggest the salience of ownership in environmental performance-operational performance linkage.

The environmental economics literature often emphasizes price differentials among resources (Berck and Roberts 1995, Groot et al. 2012). Thus, financials would also depend on resources consumed. If organizations consume relatively less-expensive resources, they could reduce costs and consequently improve margins. In this light, our findings indicate that indirect emissions may have a major impact on organizations' carbon-footprints, but organizations would hesitate to address indirect emissions voluntarily because of the insignificant impacts on cost efficiency. Perhaps the insignificant relationship between indirect emissions and cost efficiency also explains previous conflicting findings for environmental performance–profitability linkage (e.g., Horváthová 2010, Albertini 2013). The aggregate measures used in prior research often reflect different proportions of indirect emissions in sampled organizations and consequently could lead to conflicting findings.

Indirect emissions depend on the carbon intensity of the fuels used for energy generation. With reduction in the levelized cost of cleaner energy sources such as wind energy and solar energy, indirect emissions as well as expenses incurred on clear energy could reduce, thereby strengthening the relationship between indirect emissions and operational costs. The cost of indirect emissions due to its underlying source would also vary across nations, and thus samples from different countries could report different relationships.

In line with our expectations, direct emissions are positively associated with productivity. Our findings suggest that the neoclassical view that better environmental performance has negative consequences for organizations (Palmer et al. 1995, Cordeiro and Sarkis 1997, Stanwick and Stanwick 1998) is indeed valid in the context of productivity. Taken together with the results for cost efficiency, our findings indicate that better environmental performance improves cost efficiency, but not productivity: it impacts input and is also determined by the output level. At present, it seems that better environmental performance could achieve resource efficiency, but there is no evidence for resource productivity. Increase in emissions owned by organizations and output are positively correlated, thereby indicating that higher output level and higher emissions still goes hand in hand.

Also, research must consider performance dimensions such as operational performance rather than adhering to profitability and market value as in the past to better understand the performance implications of environmental sustainability.

In terms of interaction effects, our findings suggest that QM strengthens the positive relationship between direct emissions and productivity. Practices that improve the quality of products and services increase demand and enhance productivity. Interestingly, indirect emissions are not significantly associated with productivity, but QM and indirect emissions together are negatively associated with productivity. This indicates that organizations improve productivity when they have decreased indirect emissions and QM. Reducing indirect emissions by purchasing fewer utilities could release additional resources for production or service delivery, while QM improves demand. Thus, reduced indirect emissions allows organizations to benefit from QM by better utilizing resources. Our findings suggest that organizations should use different practices to target different levers for cost and demand.

The interaction graphs in Figures 3.3(b) and 3.3(c) rather interestingly show that with QM, direct and indirect emissions affect productivity differently.

In contrast, EMS does not significantly interact with productivity in the context of indirect emissions. The different roles of QM and EMS may explain the differences. QM focuses on general quality and tends to have broader effects than EMS, which focuses more specifically on environmental management. Consequently, QM tends to more broadly impact the quality of products and services and to reduce waste. Better quality increases customer demand and revenue. QM tends to increase productivity because direct emissions are from firm-owned or controlled sources. In contrast, indirect emissions are from purchased utilities, so QM may reduce the quantum of purchased utilities needed, with consequent reduction in indirect emissions and increase in productivity. Interestingly, for indirect emissions, the productivity line is rather flat in the absence of QM but falls in the presence of QM (Figure 3.3(b)), perhaps because without QM, no factor promotes demand. Therefore, productivity is flat, irrespective of low or high indirect emissions. Organizations without QM could also lack technological assets, an underlying rationale for the absence of quality management programs such as TQM leading to lower asset value and higher productivity.

Our results also suggest that organizations with EMS improve cost efficiency. Center to this relationship is that EMS facilitates systematic monitoring and evaluation of environmental performance. EMS enables effective monitoring of the use of purchased electricity resources and emissions from various processes and therefore can reduce the cost of materials.

Although EMS improves cost efficiency, it does not influence productivity, an outcome occurring perhaps because EMS may not influence demand. In contrast, QM does not influence the cost efficiency, but improves productivity, perhaps through improving demand for products. Thus, EMS and QM diverge in their impact on operational performance. Both might require long-term outlooks before investments and benefits are recovered.

3.9. Implications for Research and Practice

This study has several implications for research. First, our results show that direct and indirect emissions affect cost efficiency and productivity differently. Specifically, as hypothesized, reduced direct emissions significantly and positively impact cost efficiency, but reduces productivity. This suggests that processes to reduce direct emissions can decrease costs, while capital expenditure on improved processes can affect productivity. Increase in output level and direct emissions concur. Future research can examine the time frame to realize productivity benefits.

Second, the study shows that indirect emissions are insignificantly related to operational performance, a noteworthy finding because indirect emissions, often accounting for most of organizations' carbon-footprints, must be curtailed to combat global warming. Consequently, we need proper pricing mechanisms for utilities to promote reduced indirect emissions. We hope our empirical findings contribute to the debate about whether price subsidies or penalties are more effective. Similarly, future research can explore effects of decreased costs of cleaner energy on indirect emissions and operational performance, conduct sensitivity-analysis (change in use with respect to change in prices) of various technologies that reduce direct and indirect emissions, and examine relationships between dimensions of environmental performance and operational performance. Future research could also investigate whether the insignificant findings for indirect emission could be attributed to captive power generation. Such analysis would further develop our understanding of relationship between environmental performance and operational performance. From a regulatory perspective, research can investigate the effect of legislation targeted at improving environmental performance of the utility sector, and institutional practices that promote the use of cleaner energy on the relationship between indirect emissions and operational performance. From a policy perspective, a fruitful avenue for research is the effect of environmental laws and environmental protection agencies on the relationships between emissions and operational performance in emerging economies.

Third, we focus on environmental performance in terms of direct and indirect emissions, and on operational performance in terms of cost efficiency and productivity. Because we found that dimensions of environmental performance can have different effects on operational performance, future research can examine other measures of environmental and operational performance.

Fourth, the interaction graphs suggest that environmental performance and operational performance may have a more complex relationship than previously envisioned. Future research can also examine the role of other moderating variables in the environmental performance–operational performance relationship.

Fifth, our study shows that factors such as the extent of reporting can influence specific performance measures such as operational performance. Prior studies often used aggregate emissions data from the Toxic Release Inventory (TRI) to examine financial implications of environmental performance (Albertini 2013). However, the TRI is limited in that researchers cannot classify emissions according to the source, and the TRI reports only U.S. toxic chemical releases and waste activities. Future research should consider the extent of reporting in examining financial consequences of environmental performance.

This study also has implications for practice. First, we provide empirical evidence that better environmental performance improves cost efficiency. However, we find that only direct emissions have a positive impact. Business executives and top management usually use cost-benefit analyses in selecting technologies, but our findings indicate that they should focus on technologies that reduce direct emissions in seeking enhancements for operational performance. Thus decision makers should compare the reduction of direct emissions in terms of cost of ownership and then choose whether the means are appropriate based on constraints such as costs.

Second, our findings provide some support that EMS and QM have positive impacts. Specifically, the interaction plots provide insightful implications for practice. However, we caution practitioners that environmental performance and operational performance may have more complex relationships than previously envisioned. Specifically, interaction graphs provide some insights for better understanding the environmental performance–operational performance relationship, which we hope could enhance decisions about investments for enhancing environmental performance.

Third, our findings also suggest that aggressive emissions-reduction goals have limited impact because they merely reduce COGS/revenue. Lately, organizations are increasingly setting aggressive GHG reduction goals to benefit from better environmental performance. For instance, HP recently became the first IT organization to set an aggressive supply chain GHG reduction goal (HP newsroom September 23, 2013). However, aggressive goals yield limited economic benefits; they are difficult to achieve and may divert limited resources from cost-effective practices to more expensive practices.

3.10. Limitations

This study has two key limitations. First, our sample of 96 organizations is small because of the difficulty in obtaining disaggregated environmental performance data reported under government agency supervision. If more environmental performance audits are available, future research could overcome information availability constraints.

Second, a caveat to generalizing our findings is that our study is primarily restricted to U.S.-based organizations or global organizations with headquarters in the United States. It will be interesting to examine the environmental performance–operational performance nexus in emerging countries such as India and China.

3.11. Concluding Remarks

Our findings contribute to research on sustainability by providing empirical evidence for the effect of dimensions of environmental performance on dimensions of operational performance, and the role of QM and EMS practices in moderating the relationships. Further, our findings extend previous research on environmental performance–organizational performance relationships by examining direct and indirect emissions. We suggest that past studies have found conflicting results because they considered aggregated emissions rather than direct and indirect emissions. Finally, we show that the environmental performance–operational performance relationship may be more complex than previously envisioned, and that organization-specific factors may moderate the relationship.

Chapter 4

The Nexus between Social Sustainability and Environmental Sustainability with Economic Sustainability

Summary

Drawing from stakeholder theory and the paradox lens, we seek to understand social and environmental sustainabilities as they relate to economic sustainability. Archival data reveal that social sustainability is positively associated with profitability, but environmental sustainability is negatively associated with profitability. Social and environmental sustainabilities together interact to positively affect profitability. Therefore, social sustainability may mitigate environmental sustainability's negative impact. However, our post-hoc analysis suggests that both social sustainability and environmental sustainability are negatively associated with operational costs, but their interaction effect is not related with operational costs. Thus, both social and environmental sustainabilities reduce operational costs, but they do not influence each other. The results suggest that different theoretical lenses may be more suitable for different performance measures. Implications for research and practice are discussed.

4.1. INTRODUCTION

"We need to integrate sustainability, not as a layer, but in the fabric of the business" (Harper 2011).

"The only way to continue growing and continue being a successful business [is] to treat sustainability as a key business lever in the same way that you treat marketing, finance, culture, HR or supply chain" (Gowland 2011).

With the growing recognition that natural resources are finite and that companies must utilize resources judiciously, firms are increasingly emphasizing sustainability. Broadly speaking, "sustainability" is defined as "*the way of utilizing resources, which meets the need of the present generation without compromising the ability of future generations to meet their own needs*" (WCED 1987:41). Previously, the concept of sustainability was primarily used with reference to society and its emphasis was on the excessive consumption by society. Nevertheless, realizing that firms are major consumers of natural resources has led to the emphasis on firms as drivers of a sustainable society (Ekins 1993). This realization led to an increased focus on Corporate Social Responsibility (CSR) (Norman and McDonald 2004), which is defined as a firm's obligations to make decisions and to follow actions that are compatible with the aims and values of society (McWilliams and Siegels 2001). Firms started contributing to society by engaging in community development, but soon realized that this approach emphasizes CSR as a voluntary engagement with weak linkages to organizational performance (Burke and Logsdon 1996).

Compared to CSR, which is narrower in focus, sustainability in an enterprise context is defined as achieving sustainable development by delivering economic, environmental and social benefits (Hart 1995). This three-pronged benefits approach, known as "triple bottom line" (TBL), extends the metrics of firm performance beyond economic benefits to social and environmental benefits. In other words, the focus is not merely confined to economic value addition but also encompasses the creation or destruction of social and environmental value (Elkington 1998).

TBL has emerged as a new paradigm in the domain of firm performance metrics comprising the three dimensions of environmental, social and economic sustainability (Hubbard 2009). While economic sustainability comprises measures that reflect the financial health of a firm such as profitability, environmental sustainability focuses on the resources utilized by a firm in its operation and its subsequent impact on the environment, and social sustainability refers to a firm's impact on the communities in which it operates.

Recent surveys suggest that senior executives often consider environmental sustainability and social sustainability as precursors to economic sustainability (Berns et al. 2009). Factors such as increasing consumer awareness about sustainability and the rapid depletion of natural resources motivate firms to adopt different sustainability practices. Thus, firms are increasingly adopting various social sustainability and environmental sustainability practices to improve their economic sustainability. Nevertheless, firms incur expenditure when imbibing various practices of social and environmental sustainability. This raises the question of whether the implementation of the various practices of social and environmental sustainability is good for the economic sustainability of firms.

Despite the growing interest in the field of sustainability, empirical research in this area is scant (Seuring and Muller 2008). Moreover, research often construes profitability as a measure of economic sustainability (Endrikat et al. 2014). However, profitability is also vulnerable to the costs and resources that firms might incur when they imbibe the various dimensions of sustainability. It is also possible that the different dimensions offset the benefits from each other as they compete in the same resource pool. Recent empirical evidence compound this issue. Specifically, environmental performance that reflects environmental sustainability often fails to directly affect profitability (Lioui and Sharma 2012). However, the main objective behind the various sustainability practices is to achieve cost efficiency (Berns et al. 2009, Haanaes et al. 2011) which could translate into firms' financial performance (Corsten et al. 2011). Economic sustainability at the operational level is reflected in production or manufacturing cost (Cruz and Wakolbinger 2008). Firms have limited resources and need to be mindful of the possible ramifications of social sustainability on the finance available for environmental sustainability (Gimenez et al. 2012). The interaction effect of social sustainability and environmental sustainability on profitability could be either positive or negative, and therefore social sustainability and environmental sustainability together could relate either positively or negatively to economic sustainability. Against this background, we examine the following two research questions:

RQ 4.1*: Does economic sustainability increase when social sustainability and environmental sustainability increase?*

RQ 4.2*: What is the nature of interaction between social sustainability and environmental sustainability with economic sustainability?*

In this study, we make several important contributions. First, although the literature has theoretically recognized that sustainability has economic value (Pezzey and Toman 2005), studies have rarely examined whether social sustainability and environmental sustainability interact to affect economic sustainability (Cavaco and Crifo 2014). We address the gap by examining social and environmental sustainability relationships with economic sustainability in terms of profitability. We provide empirical evidence regarding whether social and environmental sustainabilities strengthen or attenuate each other's relationship with economic sustainability in terms of profitability. We also conduct post-hoc analysis to understand social and environmental sustainability interaction effects on operational costs as a proxy for operational performance. Our findings suggest that environmental sustainability may fail to affect profitability, but it may reduce operational costs. Social and environmental sustainabilities neither strengthen nor diminish each other's relationship with operational costs. Thus, we highlight the dichotomy between profitability and operational costs. Moreover, we suggest that environmental sustainability may reduce operational costs, but adversely impact profitability. Perhaps environmental sustainability increases assets that offset its benefits.

Second, we compare two perspectives – stakeholder theory and paradox lens – and examine their applicability in the context of sustainability. Our findings suggest that for profitability, the applicability of the stakeholder theory appears to be stronger than paradox lens. Moreover, the support for the stakeholder theory strengthens with time; thus it is likely that the stakeholder theory dominates in the long run. However, for operational performance, our findings suggest that the needs of different stakeholders are distinct without any synergies or discord. Our findings also suggest that social sustainability could improve profitability through reduction in operational costs. But, no such relationship is evident in the context of environmental sustainability.

Third, following recent research such as Jayachandran et al. (2013), we disaggregate social sustainability and environmental sustainability to understand how they relate to profitability and operational costs. We further examine whether the negativity bias (namely, weaknesses have stronger effects than strengths) is also applicable in the context of sustainability. Our findings again point to the dichotomy of impact for various dimensions of social sustainability on profitability and operational costs. While employee relations and diversity dimensions are positively associated with profitability, employee relations and community dimensions are negatively associated with operational costs. There is limited support for the negativity bias, as firms benefit by avoiding the negative consequences of weaknesses associated with different dimensions of social sustainability.

The rest of the paper is structured as follows. We review the relevant literature and propose our research framework and hypotheses. Next, we describe our dataset and analysis procedures. This is followed by the results, discussion, implications for research and practice, limitations, and concluding remarks.

4.2. THEORETICAL ORIENTATION

Stakeholder Theory

The imbuement of sustainability practices involves economic, social and ecological stakes, thus forcing a firm to take cognizance of the concerns of a wide range of stakeholders (Sharma and Henriques 2005 Westley and Vredenbung 2005). In fact, past research suggests that stakeholder influence is salient in a firm's adoption of sustainability as a corporate strategy and the types of sustainability practices that firms adopt. Further, empirical research has often found support for the influence of resource-based and institutional pressures on the evolution of corporate sustainable development (Bansal 2005). These pressures reflect the demands of the stakeholders. The underlying theory behind the triple bottom line (TBL) that emphasizes a firm's financial, social, and environmental performance is the "stakeholder theory" (Hubbard 2009).

Stakeholder theory is considered to be an ethical theory as it is based on the necessity to achieve broad societal needs rather than a narrow focus on profit maximization (Garriga and Mele 2004). Although suppliers, customers, employees, shareholders, and the local community are included as stakeholders in a firm's operations, stakeholder theory suggests that each group of stakeholders is concerned about its own interest. Therefore, it is the firm's responsibility to simultaneously attend to the concerns and interests of the different groups of stakeholders (Garriga and Mele 2004). Firms, by focusing on TBL, could deliver value to the different stakeholder groups. Note that TBL and sustainable development are values-based concepts (Garriga and Mele 2004). Environmental sustainability focuses on reducing the ecological footprint of a firm's operations (Bansal 2005) and involves practices such as pollution prevention (reduction or elimination of waste) (Klassen and McLaughlin 1996) and product stewardship (life cycle approach toward products) (Hart 1995). Social sustainability focuses on social issues such as employing child labor, and the use of unethical practices. Economic sustainability focuses on value creation and enhancing firm performance (Bansal 2005). Note that firm performance is improved by its capability to generate value (Bowman and Ambrosini 2000), but is also vulnerable to externalities such as market conditions (Makadok 2001).

Akin to the stakeholder theory, the common good approach argues that the key responsibility of firms is to ensure the common good of society as firms themselves are an inseparable part of society (Alford and Naughton 2002). These approaches consider economic, social and environmental as integral and intertwined components of firm performance metrics (Hubbard 2009). Other theoretical lenses such as the integrative social contract theory also provides support for the social responsibility of firms by arguing that a social contract exists between business and society. Concepts such as "corporate citizenship" and "business citizen" also reflect the existence of a relationship between business and society (Matten et al. 2003).

Different theories and the conceptualization on the responsibility of the firms towards society agree that firms have a responsibility to society beyond profit maximization, and they need to be considerate towards environmental issues and work toward improvement of the local community. In contrast, various instrumental theories such as the Natural Resource-Based View (NRBV) proposed by Hart (1995) and the Competitive Advantage of Corporate Philanthropy proposed by Porter and Kraemer (2002) suggest that every actions including corporate social responsibility (CSR) are strategic instruments to achieve economic objectives such as maximizing profit and maximizing shareholder value (Windsor 2001). Despite the divergence in their focus, these instrumental theories do not exclude taking into account the interest of different stakeholders. They support the view that satisfying different stakeholders' interest could often yield positive economic consequences (Mitchell et al. 1997, Odgen and Watson 1999), e.g., investing in philanthropy and social activities could improve profitability (McWilliams and Siegel 2001). Together, various theories suggest positive relationships of social sustainability and environmental sustainability with economic sustainability. However, several factors are salient in a firm's response to stakeholder concerns (Brower and Mahajan 2013). Moreover, the simultaneous focus on different stakeholder demands could drain a firm's limited resources and could have negative economic implications.

Paradox Lens

While different theories suggest that firms could benefit economically by paying attention to different stakeholders, thereby implying the positive interaction effect of social sustainability and environmental sustainability on economic sustainability, there are also dissenting opinions based on the "paradox lens" (Smith and Lewis 2011) (see Table 4.1). There are four categories of paradox that represents the different elements of firms, namely: learning (knowledge), belonging (identity), organizing (processes), and performance (goals) (Smith and Lewis 2011). The learning paradox arises when a firm's system changes, and involves destroying the past to survive in the future. In the context of sustainability, such a paradox may arise, when firms have to move beyond the extant product lines and develop products based on a new technology, or a new product line that contributes to sustainability. The belonging paradox arises when opposing, but coexisting roles emerge in firms. With the increased focus on sustainability, new roles such as Chief Sustainability Officers (CSOs) are created in the firm. The value system associated with such roles may be different from that of the Chief Financial Officers (CFOs) or Chief Marketing Officers (CMOs), thus resulting in a belonging paradox. Organizing paradox arises due to competing designs and processes. For example, firms often choose between processes with or without product stewardship. The choice of product stewardship involves balancing manufacturing cost with the total life-cycle cost. A performance paradox stems from the conflicting demands of the various stakeholders, who have competing views of success (Donaldson and Preston 1995).

In the present context, the focus on TBL or addressing the concerns of the different stakeholder groups could involve a tension among social, environmental, and economic sustainability. Due to budgetary constraints, firms have to select between choices that may adversely impact the environment, but improve their financial performance, or choose between social initiative such as community development and environmental initiative such as financing a green product development. There is also a prevalent view that there is a tension between a firm's profit-seeking objectives and social responsibility (Margolis and Walsh 2003). While it is the firm's responsibility to simultaneously attend to the concerns of different stakeholder groups (Garriga and Mele 2004), firms have to prioritize the interests of the stakeholders (Freeman 2010). Thus, firms could adopt the dimensions of sustainability to different extent. Hence, the performance paradox is at the core of the interaction effect of social sustainability and environmental sustainability.

Table 4.1:Stakeholder Theory and Paradox lens

Key Aspects	Stakeholder Approach	Paradox Lens
Focus on stakeholders	Firms need to pay attention to the interest of all stakeholders.	Potential of conflicting demands from various stakeholders.
Relationships between different dimensions of sustainability	Economic, social and environmental sustainability are integral and intertwined components of a firm's performance metrics.	Firms are expected to address economic, social and environmental concerns. Individually, these concerns are desirable, but taken together they may contradict each other.
Impact on economic sustainability	Positive relationships of social and environmental sustainability with economic sustainability.	Emphasizes embracing tensions and managing them to benefit from different dimensions of sustainability.

4.3. RESEARCH MODEL AND HYPOTHESES

In this study, we focus on the individual effects as well as the interaction effect of social sustainability and environmental sustainability on economic sustainability. We examine if social sustainability interacts positively or negatively with environmental sustainability in their effect on economic sustainability. Figure 4.1 shows the relationships and hypotheses relating to social sustainability and environmental sustainability with economic sustainability.

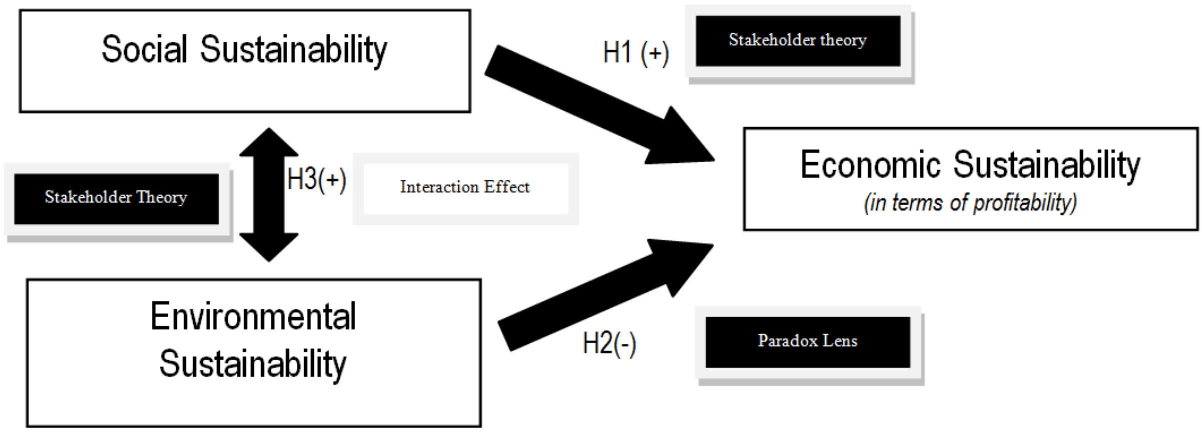


Figure 4.1 Research model

Social Sustainability and Economic Sustainability

Social sustainability is a broad construct comprising aspects such as community, employee, diversity, and rights (Hollos et al. 2012). Social sustainability focuses on addressing social issues such as the use of child labor, products with socially undesirable consequences, and relationships with unethical partners (Bansal 2005). It comprises practices ranging from employee satisfaction to community relationships (Hubbard 2009). By focusing on social sustainability, firms could build rent-earning resources as well as capabilities

(Bansal 2005). Social sustainability could positively influence employee morale and bolster community support for the firm through fair employment practices that encompass gender and racial equity (Labuschagne et al. 2004). A firm's focus on employee health, safety and well-being could also facilitate improvement in employee productivity (Porter and Kramer 2011). Community support may help firms to better access human resources relative to its competitors. Such practices improve overall sustainability outcomes (Pullman et al. 2009), which in turn result in better firm performance. Better focus on employee health and safety could reduce the number of days lost due to work-related injury and the healthcare cost per employee in the firm. While addressing issues such as child labor and ensuring wage equity could increase the average hourly labor cost, it could indirectly reduce expenses by reducing turnover and training cost (Davidson et al. 2010).

A key component of social sustainability is the focus on ethical issues in the supply chain, e.g., firms that engage inexpensive suppliers with substandard working conditions could benefit in the short term, though it is unethical to engage such suppliers (Hart 2007). However, it could result in higher operational cost over the long-term and firms might receive negative publicity from their association with such suppliers (Mefford 2010). This could reduce the demand for their products. Firms would therefore lose the benefits of scale and their operational cost per unit of output could increase. Focusing on social sustainability across the supply chain requires firms to adopt a "responsible procurement policy" that emphasizes on social concerns and human rights issues (Hollos et al. 2012). It also requires working closely with suppliers in regions (such as emerging economies) where institutional emphasis on sustainability is weak. In such context, suppliers could create greater idiosyncratic sustainability risks (Reuter et al. 2010). Social sustainability could also reduce the operational risks that arise from poor working conditions across the supply chain (Klassen and Vereecke 2012). Close relationships with suppliers could help firms to reduce their expenses on raw materials and products' components. Empirical evidence suggests that sustainable procurement and supplier cooperation could reduce operational costs (Watt et al. 1992) and enhance firm performance. These observations suggest that:

H1: Social sustainability is positively associated with economic sustainability.

Environmental Sustainability and Economic Sustainability

When a firm adopts environmental sustainability, it adopts the practices aimed at reducing or controlling pollution from a firm's operations (Chen et al. 2009), thereby mitigating the cost of pollution treatment. Such practices could also improve the energy efficiency of technological infrastructure as energy efficiency is interlinked to pollution emissions (Worrell et al. 2009). Consequently, energy expenditure would reduce, thereby reducing operating costs. Moreover, firms might also benefit from institutional incentives for pollution reduction. Increasingly, countries are imposing taxes on firms' practices that are detrimental to the environment (Molla and Cooper 2009). By adopting environmental sustainability, firms could avoid taxes and penalties associated with harmful environmental practices. Environmental sustainability also comprises recycling, reuse, and waste disposal, which improve the environmental friendliness of both upstream and downstream aspects of supply chain. Recycling and reuse promote efficient utilization of resources as recycled materials could be used as substitutes for new raw materials. Consequently, production costs could decrease. In addition, it facilitates better utilization of resources due to the management of the entire life cycle of products. Use of life cycle assessment in a firm could result in cost reduction in the long-term (Pullman et al. 2009). Products that are produced under strict environmental standards suffer less process disruption (Burnett et al. 2007). Thus, throughput increases and unit cost of production could decrease. Environmental sustainability initiatives such as recycling improve firms' eco-efficiency and resource productivity (Lye et al. 2001). Better resource productivity could result in better cost efficiency. When firms work in partnership with their suppliers and enforce environmental sustainability across the supply chain, their operational costs could decrease (Hollos et al. 2012). The close relationships among various firms in a supply chain could create synergy among the processes of different firms and enhance recycling and reuse, thereby improving firm performance.

Despite the potential benefits of environmental sustainability, firms could incur additional expenses that might reduce their profitability in the short term. Firms might witness specific paradoxes such as the organizing paradox and performing paradox. The organizing paradox could arise due to competing designs and processes such as the choice between processes with or without product stewardship to balance manufacturing cost with the total life-cycle cost. If firms invest in environmental sustainability to reduce total life-cycle cost by substituting more polluting inputs with environment-friendly inputs, it would reduce a product's total life-cycle cost by reducing its end of lifecycle cost (reducing waste treatment cost). However, firms would benefit in future but would incur additional expenses immediately. This dichotomy between long term benefits and short term costs might also result in a performance paradox. Performance paradox might stem from the contradictory demands of the short-term focused and long-term focused stakeholders. Such tensions could adversely impact the firms' ability to engage in environmental sustainability. This in turn could adversely impact a firm's ability to benefit from environmental sustainability due to the lack of comprehensive support for a firm's environmental sustainability initiatives. We therefore hypothesize that:

H2: Environmental sustainability is negatively associated with economic sustainability.

Interaction Effect of Social Sustainability and Environmental Sustainability

While stakeholder theory suggests that it is better for firms to address the concerns of stakeholders, possible tensions among the concerns of different stakeholders could occur. Hence, addressing the needs of stakeholders often entails paradoxes and contradictions (Berger et al. 2007). Empirically, past research has found support for various tensions between different objectives (Jarzabkowski and Sillince 2007). Lately, the paradox lens has emerged to provide a better understanding of the various tensions facing a firm (Smith and Lewis 2011). A paradox refers to a situation where contradictory yet interconnected elements not merely co-exist but persist over time (Smith and Lewis 2011). As such, these elements individually seem logical and rational, but together seem inconsistent. Lately, research in the broader realm of sustainability has also argued that there are tensions between various processes and at different levels (Hahn et al. 2014). Such tensions result in business managers being hesitant to push for radical changes when confronted with complex issues such as sustainability (Hahn et al. 2014).

Nevertheless, managers with paradoxical thinking embrace these tensions instead of trying to eliminate them. An integrative approach to sustainability based on paradox lens recognizes that the economic, social, and environmental sustainability are interconnected but conflicting dimensions (Hahn et al. 2014). Individually, social sustainability and environmental sustainability seems to influence operational performance positively. There are empirical evidences to support the interdependencies among the economic, social, and environmental performance of firms (Gao and Bansal 2013). However, resource constraint could result in performance paradox, when firms focus on social and environmental sustainability simultaneously.

Prior research suggests that effective deployment of resources form the basis for rent generation (Huesch 2013). When firms adopt social sustainability and environmental sustainability simultaneously, they have to utilize their limited resources to initiate a wide gamut of activities ranging from recycling to social initiative such as community development. Thus, different dimensions of sustainability compete for the limited resources (both financial and nonfinancial) of the firm. If a firm adopts both social sustainability and environmental sustainability simultaneously, it might not be in a position to allocate the required resources to both dimensions. Consequently, firms would not be able to realize maximum potential benefits from social sustainability and environmental sustainability. In addition to the competition for limited resources, different dimensions of sustainability could negate the potential benefits from each other. For example, when a firm is focused on providing livelihood to the community in the vicinity of its operations, it might have to commence operations in forested areas. This would affect the environment adversely. If firms resist such environmentally detrimental activities, it might not be able to provide livelihood to the native community as well as benefit from access to cheap labor. Likewise, if firms attempt to enforce strict ecological standards across their supply chain, it could increase initial investments for suppliers. Suppliers face trade-off decisions between spending on environmental sustainability and other initiatives that may relate to employee welfare. This in turn could adversely affect employee productivity. These arguments favor the paradox lens over stakeholder theory in explaining the tensions between social sustainability and environmental sustainability.

However, there are contrasting views that favor the stakeholder theory over the paradox lens. Firms might benefit more from both environmental and social sustainability, if the firms adopt them simultaneously. There are possible synergies between social and environmental sustainability, which could strengthen the benefits from each other. Environmental sustainability could be initially expensive due to the investment in less polluting technologies and less harmful raw materials. Nonetheless, social sustainability could offset some initial expenses by making cheap labor from the community accessible to firms. Social sustainability also leads to improved productivity and better employee morale, which could help firms to benefit from new technologies. Social sustainability also results in close firm-supplier ties. Close relationships with suppliers could help firms to reduce their expenses on raw materials and products' components. Firms also have better reputations when they engage in social sustainability, which could help them to improve demand for their products. Increased demand could help firms to benefit from economies of scale and thus recover costs incurred on new technologies quickly. We have hypothesized negative relationship between environmental sustainability and economic sustainability because of potential for several paradoxes. However, based on arguments grounded in stakeholder theory, social sustainability could attenuate the potential negative relationship between environmental sustainability and economic sustainability. Consequently, firms with both social sustainability and environmental sustainability would have higher economic sustainability relative to firms with environmental sustainability alone. Thus, the interaction between social sustainability and environmental sustainability would be positive implying increase in economic sustainability, when social and environmental sustainability simultaneously increase. Therefore, we hypothesize:

H3: The interaction between social sustainability and environmental sustainability is positive such that social sustainability attenuates the negative effect of environmental sustainability on economic sustainability.

4.4. METHOD

We obtain sustainability data from the Kinder, Lydenburg, and Domini (KLD) database, which rates firms on areas such as community, corporate governance, diversity, employee relations, environment, human rights, and product. KLD uses a proprietary framework of indicators for strengths and weaknesses in these areas. We used data from Compustat to measure firm performance and for control variables.

Measures

Social Sustainability and Environmental Sustainability

We used a summated score of the environmental dimension from the KLD database to operationalize environmental sustainability. We obtained the summated score by differencing the scores on the strengths and weaknesses of the environmental dimension. The specific items for strength were environmental opportunities, waste management, packaging materials and waste, climate change, property, plant, equipment, environmental management systems, water stress, biodiversity and land use, raw material sourcing, and other strengths. The specific items for weaknesses were hazardous waste, regulatory compliance, ozone depleting chemicals, toxic spills and releases, agriculture chemicals, climate change, impact of products and services, biodiversity and land use, operational waste, supply chain management, water management, and other concerns (Hillman and Keim 2001). The strength ratings covered the actions that firms took to prevent pollution and reduce wastes, whereas the weakness ratings reflected disconfirmation (if any) with expected environmental norms. These ratings had often been used in past research such as Jayachandran et al. (2013) and Guo and Bansal (2013)[5] to operationalize environmental-related aspects of sustainability.

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[5] Jayachandran et al. (2013) operationalized product environmental performance using KLD's environmental ratings, whereas Guo and Bansal (2013) operationalized environmental commitment using KLD's environmental ratings

Similarly for social sustainability, we used aggregated score of community, employee relations, human rights, as well as the diversity dimension from the KLD database. Social sustainability included both employee-related as well as community-related aspects (Klassen and Vereecke 2012, Hollos et al. 2012). Therefore, we included employee, community, human rights, and diversity dimension (community-related aspects). Recent studies such as Gao and Bansal (2013) has utilized these dimensions to create measures of aspects of social sustainability such as corporate social commitment. The items for social sustainability included strength items such as charitable giving, innovative giving, support for housing, support for education, community engagement, volunteer programs, board of directors - gender, work-life benefits, women and minority contracting, employment of the disabled, gay and lesbian policies, employment of underrepresented groups, union relations, no-layoff policy, cash profit sharing, employee involvement, retirement benefits strength, employee health and safety, supply chain labor standards, compensation and benefits, employee relations, professional development, human capital management, labor rights strength, and human rights policies and initiatives. The weakness items included human rights violations, concerns on employee health and safety, child labor, non-representation of various social groups, and negative community impact[6]. Consistent with past research using aggregated sustainability measures such as Barnett and Solomon (2012), we also used ratings for these areas to create a net social sustainability performance score.

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[6] See Hillman and Kleim (2001) and the KLD social rating databases for details for specific items.

Economic Sustainability

We operationalized economic sustainability in terms of profitability measured by the ratio of revenue to total assets, also known as the Return on Assets (ROA) (Bharadwaj 2000, Barnett and Solomon 2012)[7]. ROA reflects how much revenue a firm is able to generate from its assets.

Control Variables

We operationalized size as the logarithm of the number of employees as well as the logarithm of total assets.[8] Consistent with past research, we control for industry type (Takeuchi et al. 2009). By controlling for industry, we controlled for industry specific characteristics such as industry concentrations, regulations and industry specific variations in a firm's performance. By controlling for time, we controlled for the impact of time-related factors such as impact of macroeconomic variables on firm performance. We also controlled for a firm's annual growth in revenue and leverage in terms of ratio of total debt to total assets (as proxy for a firm's specific risks). Consistent with Barnett and Solomon (2012) and Jayachandran et al. (2013), we controlled for corporate governance and product-related aspects of sustainability. Following Aiken and West (1991), we centered continuous variables

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[7] While computing ROA, we do not include income from extraordinary items as they are consequences of unforeseen events such as hurricanes and storms, and therefore do not constitute regular income. We checked the correlation between the ROA computed using different approaches. The correlation ranges from 0.98 to 0.99. Thus, our results are robust against different approaches to compute the ROA.

[8] Although different measures of size are correlated (0.55), their VIF are less than 4. Hence, multicollinearity is not an issue

before computing their interaction terms to address potential issue of multicollinearity. We summarize the constructs and their measures in Table 4.2.

Table 4.2: Constructs and their measures

Construct	Data Type	Measure	Data Source
Profitability (ROA)	Continuous	Revenue/total assets	Compustat
Environmental Sustainability	Continuous	Difference of strengths and weaknesses on environment	KLD database
Social Sustainability	Continuous	Difference of strengths and weaknesses on community, employee relations, human rights, and diversity dimensions	KLD database
Size	Continuous	Logarithm of number of employee strength and logarithm of total assets	Compustat
Industry	Categorical	2 digit industry code	Compustat
Growth	Continuous	Revenue(t) - Revenue (t-1)/ Revenue (t-1)	Compustat
Leverage	Continuous	Total debt/Total assets	Compustat
Corporate governance	Continuous	Difference of strengths and weaknesses on corporate governance dimension	KLD database
Product social performance	Continuous	Difference of strengths and weaknesses on product social performance dimension	KLD database

Empirical Specification

We lagged ROA by two years as the effect of social sustainability and environmental sustainability might not be immediately visible. KLD provided social ratings from 1991. However, KLD changed its reporting of different areas from 1998. Earlier, KLD reported on eight dimensions. Post-1998, it reported on thirteen dimensions (Barnett and Solomon 2012). Therefore, we used KLD data from 1998 to 2010. We combined the firm's KLD data with corresponding performance data from Compustat. Our final sample comprised 6884 firm-year observations for 1080 firms (average of 6.4 observations per firm).

We used ordinary least squares (OLS) with clustered robust standard errors to control for heteroskedasticity and serial correlation. We also tested our model using mixed-effect model with clustered robust standard errors. Random-effect linear models with an AR (1) disturbance controls for potential auto-regression or specifies that ROA depend linearly on its prior value. Similar estimation techniques had been used in recent research such as Barnett and Solomon (2012), and Jayachandran et al. (2013).

4.5. RESULTS

Table 4.3 showed the descriptive statistics and correlations while Table 4.4 showed the results of regression analyses. Different models provided similar estimates for our variables of interest. As the mixed-effect model contained both fixed and random effects, we interpreted the findings from it. The results showed that social sustainability was positively associated with profitability (β=.0036, $p<.05$). Hence, H1 was supported. However, estimates for environmental sustainability was negative ($\beta = -.0027$, $p < .05$). Thus, H2 was supported. Nonetheless, support for H2 was not observed for the other models. In addition, the estimate for the interaction term was positive and significant ($\beta = .0009$, $p < .05$), thereby supporting H3.

Among control variables, size in terms of the number of employees was positively associated with profitability, but size in terms of total assets was negatively associated with profitability. Growth, corporate governance and product social performance were not significantly associated with profitability. Leverage was negatively associated with ROA. Many time dummies and industry dummies were significant.

Table 4.3: Descriptive Statistics and Correlation

Variable	Mean	Std Dev.	1	2	3	4	5	6	7	8
1. ROA	0.0400	0.0854	1.00							
2. Environmental Sustainability	-0.1311	0.9220	0.01	1.00						
3. Social Sustainability	0.1854	2.0413	0.06*	0.15*	1.00					
4. Size (log(employee in thousands))	1.8365	1.8861	0.12*	0.00	0.29*	1.00				
5. Size (log(total assets))	8.2780	1.6092	-0.07*	-0.09*	0.39*	0.55*	1.00			
6. Growth	0.1119	1.1243	-0.03*	-0.01	0.00	-0.04*	0.00	1.00		
7. Leverage	0.2598	0.2183	-0.11*	0.01	-0.09*	-0.16*	0.02	-0.01	1.00	
8. Corporate governance	-0.3464	0.7134	0.02	0.08*	-0.06*	-0.25*	-0.27*	0.00	0.03*	1.00
9. Product social performance	-0.3037	0.7417	0.00	0.13*	-0.14*	-0.30*	-0.41*	0.01	0.05*	0.21*

Notes: ∗ $p<0.05$. Correlation computed using Bonferroni and Sidak adjustments gives the same value as normal pairwise correlation.

Table 4.4: Results

Variable	OLS regression (clustered robust)	Mixed-Effect Model (REML[9])	Linear Regression with AR1 (RE)
Environmental Sustainability	-0.0026 (0.002)	-0.0027* (0.0013)	-0.0028 (0.002)
Social Sustainability	0.0036** (0.000)	0.0036** (0.000)	0.0028** (0.000)
Environmental Sustainability* Social Sustainability	0.0009* (0.000)	0.0009* (0.000)	0.0010* (0.000)
Size (log(employee))	0.0109** (0.0016)	0.0109** (0.0011)	0.0122** (0.0016)
Size (log(total assets))	-0.0123** (0.0018)	-0.0123** (0.0012)	-0.0149** (0.0018)
Growth	-0.0017 (0.0007)	-0.0017 (0.0009)	-0.0022** (0.0007)
Leverage	-0.0292* (0.0146)	-0.0292* (0.0057)	-0.0067 (0.0007)
Corporate governance	0.0012 (0.0021)	0.0012 (0.0015)	0.0020 (0.0017)

[9] REML estimates are based on the likelihood function calculated from a transformed data set to reduce the effect of nuisance parameter.

*Notes. ** p<0.01; * p<0.05. Standard errors are in parentheses. Year dummies and industry control were included in the regressions wherever applicable, but their estimates are not shown for the sake of brevity.*

Variable	OLS regression (clustered robust)	Mixed-Effect Model (REML[9])	Linear Regression with AR1 (RE)
Product social performance	-0.0018 (0.0019)	-0.0018 (0.0015)	-0.0017 (0.0019)

Robustness Checks

We further checked the robustness of our estimates using several different methods. Different approaches provide support for our findings. First, we recomputed estimates for our mixed-effect model using maximum likelihood and using different residual structure. We also included industry as an additional level. The findings were similar. We computed estimates using robust regression that controlled for any potential outliers. Further, we also included ROA_t (ROA in year t to control for ROA initial value) as additional control variable. The estimates provided support for our findings. We also tested whether our findings were consistent for different time lags. Our estimates provided support for H1 for 1, 2, 3, 4, 5, 6 and 7 years of time lags. We also found that the negative impact of environmental sustainability and the interaction effect of social sustainability and environmental sustainability diminished with higher time lags.

Graphical Representation of Interaction Effect

The estimate for the interaction term was positive and significant (β=.0009, $p<.05$), thereby supporting H3 that social sustainability and environmental sustainability have positive interaction effect. However, as recommended by Cohen and Cohen (1983), we graphed the significant interaction effect (Figure 4.2) to develop a better understanding of the observed result. We also conducted simple slope analysis. Figure 4.2 showed that ROA was maximum when firms had high social sustainability but low environmental sustainability. Low values of social sustainability was associated with low ROA. When social sustainability increased, ROA also improved. However, firms with low environmental sustainability achieved higher ROA.

While the positive estimate for social sustainability and the interaction plot clearly suggest that social sustainability relates positively to ROA, the interaction plot suggests an interesting relationship with respect to environmental sustainability. As the estimate for environmental sustainability was negative and significant, which suggests negative individual impact of environmental sustainability, firms with high environmental sustainability achieved a low ROA. However, the interaction term had a positive and significant estimate, which suggested that when social and environmental sustainability increased simultaneously, firms achieved a higher ROA.

The slope for low social sustainability line was significantly different ($t = -2.493$, $p<.05$), and firms achieved higher ROA when environmental sustainability was low. In contrast, the slope for high social sustainability line was insignificant ($t = -0.389$, $p> .05$). Thus, environmental sustainability was inconsequential. These findings indicate that social sustainability mitigates the negative consequences of environmental sustainability. Therefore, our findings supported the stakeholder theory and H3 was supported. Our research suggests that social sustainability weakens the negative relationship between environmental sustainability and profitability. However, research such as Mohnen and Röller (2005) and Cavaco and Crifo (2014) suggest that sign of interaction effect itself do not reveal the complete relationship between two variables. In this study, we are examining the relationship between social and environmental sustainability. In order to develop our understanding of the nexus between social sustainability and environmental sustainability, in addition to interaction plot, we use alternative empirical testing approach such as "productivity approach", which has been often used in innovation literature.

The underlying theoretical lens for this approach is the theory of supermodularity (Cavaco and Crifo 2014). Basically, the notion of complementarities (substitutions) is the idea that doing more of one thing increases (decreases) the returns of doing more of another (Milgrom and Roberts, 1995). Complements (substitutes) are indicated by a positive (negative) interaction effect (Poppo and Zenger 2002, Siggelkow 2002). Similar to the notion of complementarity proposed in past research such as Tiwana (2007), this theory also considers two variables as complements when increase in one variable increase the benefits from other. However, the empirical approach diverges from sole reliance on the interaction term because there is no test of linear restrictions (Mohnen and Röller 2005).

We follow Mohnen and Röller (2005) and use the method developed by Kodde and Palm (1986). We have three terms (two independent term and one interaction term). We write inequality constraints to test the relationship between social sustainability and environmental sustainability. We denote the estimates for social sustainability, environmental sustainability and social sustainability*environmental sustainability by β_1, β_2, and β_3 respectively. The equations for supermodularity or complementarity are as under:

$$\text{Null hypothesis: } \beta_3 - (\beta_1 + \beta_2) \geqslant 0$$

$$\text{Alternate hypothesis: } \beta_3 - (\beta_1 + \beta_2) \ngeqslant 0$$

We conducted Wald test of the constraints. The estimate value was -.000032 ($p = 0.984$), thus our null hypothesis was not rejected, thereby suggesting that the joint impact of social sustainability and environmental sustainability is positive and greater than individual impact of social sustainability and environmental sustainability. But, since individual impact of environmental sustainability is negative, therefore the joint positive impact is visible in terms of negating the negative impact of environmental sustainability.

Environmental sustainability could initially result in increase in expenses. Perhaps, this could explain the negative relationship between environmental sustainability and profitability. Since the negative impact of environmental sustainability diminished with higher time lags, we conjecture that environmental sustainability is profitable in the long run.

We also conducted an additional analysis to empirically test our assertion. We divided our dataset into two parts (pre-2006 and post-2006). For the former data, environmental sustainability was negatively associated with profitability. However, for the post-2006 data, environmental sustainability was insignificantly associated with profitability. Nonetheless, social sustainability was always positively associated with profitability. We summarize the results of hypotheses testing in Table 4.5.

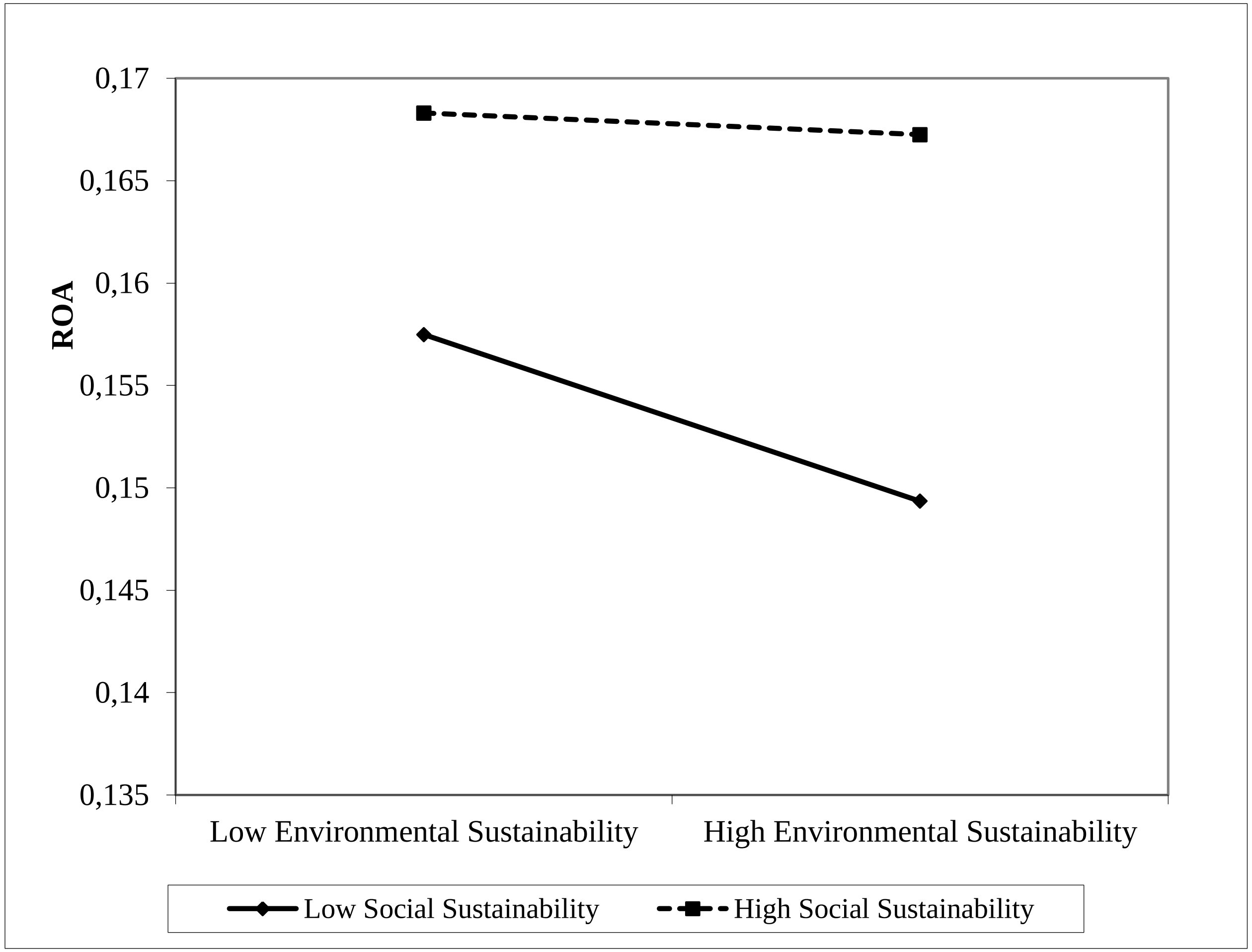

Figure 4.2 Visual depiction of interaction effect

Table 4.5: Summary of Results

Hypothesis	Proposed relationship	Hypothesized effect	Supported
H1	**Social Sustainability →Economic Sustainability**	+	**Yes**
H2	**Environmental Sustainability → Economic Sustainability**	**-**	**Yes**
H3	**Social Sustainability* Environmental Sustainability → Economic Sustainability**	+	**Yes**

**Supported hypotheses are in bold.*

Post-hoc Analyses

Our results suggested that social sustainability was positively associated with profitability. However, like prior research such as Hollos et al. (2011), our conceptualization of social sustainability was rather broad. As such, we further examined whether different dimensions of social sustainability had similar relationships with profitability by decomposing social sustainability into community, diversity, employee relations and the human rights dimensions (see Table 4.6). Our finding suggested that while employee relations and diversity dimensions were positively associated with profitability, the human rights dimension was negatively associated with profitability.

Table 4.6: Relationships of Components of Social Sustainability with Profitability (ROA) and Operational Costs (COGS/Revenue)

Variable	Estimates (ROA)	Estimates (COGS/Revenue)
Environmental Sustainability	-0.0017 (0.0014)	**-0.0340*** **(0.0184)**
Social Sustainability (Employee relations area)	**0.0040**** **(0.0011)**	**-0.0375**** **(0.0147)**
Social Sustainability (Community area)	0.0028 (0.0019)	**-0.0411*** **(0.0246)**
Social Sustainability (Diversity area)	**0.0042**** **(0.0009)**	0.0038 (0.0121)
Social Sustainability (Human rights area)	**-0.0078*** **(0.0034)**	0.0203 (0.0444)
Social Sustainability Environmental Sustainability*	**0.0008*** **(0.0004)**	0.0004 (0.0059)
Size (log(employee))	0.011** (0.0011)	0. 026* (0.0143)
Size (log(total assets))	-0.013** (0.0012)	-0. 009 (0.0162)
Growth	-0.0017* (0.0009)	-0.0373** (0.0117)
Leverage	-0.028** (0.0057)	-0.040 (0.0755)
Corporate governance	0.0012 (0.0016)	-0.0096 (0.0203)
Product social performance	-0.0016 (0.0015)	0.0209 (0.0202)

To further develop our understanding of the interaction effect of social sustainability and environmental sustainability, we investigated their relationship with operational costs which included material, labor, and allocated overhead cost. We operationalized operational costs as the ratio of costs of goods sold (COGS) to revenue. We note that COGS/revenue reflects expenses relative to revenue. Hence, its decline implies improvement in operational performance.

The results showed that both environmental sustainability and social sustainability were negatively associated with operational costs [(β= -.032, $p<.05$, β= -.016, $p<.05$)]. However, the estimate for the interaction term was insignificant (β=.0012, $p>.05$). Thus, unlike profitability, social sustainability does not strengthen or diminishes the relationship between environmental sustainability and economic sustainability. Moreover, both environmental sustainability and social sustainability exhibit similar relationships. Both reduce operational costs.

Operational costs were negatively associated with profitability (β= -.0072, $p<.05$). Thus, it is plausible that social sustainability improve profitability through reduction in operational costs. However, despite the negative relationship with operational costs, environmental sustainability does not improve profitability.

We also decomposed social sustainability into community, diversity, employee relations, and the human rights dimensions. Our findings showed that while employee relations and community dimensions were negatively associated with operational costs, diversity and human rights dimensions were insignificant (see Table 4.6).

Lately, research had found that weaknesses on different dimensions of sustainability had stronger effect on firm performance compared to strengths (Jayachandran et al. 2013), thereby suggesting negativity bias. However, such research often involved market-based measures that reflected investors' evaluation of firms' strengths and concerns. Negative information could outweigh positive information in such cases and strengths and weaknesses could influence operational performance differently. Thus, we disaggregated different dimensions of sustainability into strength and weaknesses or concerns[10].

We observed that the strengths and weaknesses on the different dimensions are associated with operational costs differently. Our results indicated that while strengths on community were negatively associated with operational costs, the strengths in the other areas were not. However, the weaknesses on environmental and employee relations dimensions were positively associated with cost.

4.6. DISCUSSION

The results showed support for our hypothesis that social sustainability improved economic sustainability. Together with our post-hoc analysis, our results suggested that social sustainability could reduce the cost of operations and consequently improve cost efficiency, which could translate into better profitability. Improved cost efficiency could help to free up a firm's resources for new initiatives that might create new capabilities. Interestingly, social sustainability and profitability showed a positive, more consistent, and longer-lived relationship. Evidently, social sustainability has short-term and long-term orientations.

[10] We use weakness and concern interchangeably.

In contrast, environmental sustainability was negatively associated with operational costs, but was negatively associated with profitability. Thus, environmental sustainability improved cost efficiency, but did not improve profitability. However, the negative relationship between environmental sustainability and profitability diminished with longer time lags. Evidently, environmental sustainability had a long-term orientation. Perhaps, this explains why there are conflicting views on the business value of sustainability (Albertini 2013) as a long-term orientation makes empirical validation of the immediate impact of environmental sustainability difficult. While, firms could reduce their costs relative to revenue, revenue itself depends on various firm-specific as well as external factors. Profitability measures such as ROA and net margin reflect an increase in revenue. Thus, the impact of sustainability on profitability is not immediately visible. Also, when firms engage in environmental sustainability, they often invest in new technological assets, which could reduce the revenue to asset ratio in the short-term. In contrast, social sustainability could reduce operational costs by reducing labor costs and could create new market for firms' products by improving the purchasing power and economic conditions of the local community. Our findings are similar to the finding reported in recent research such as Gao and Bansal (2013).

Recent research such as Barnett and Solomon (2012) has found support for U-shaped relationship between corporate social performance (CSP) and corporate financial performance (CFP). Barnett and Solomon operationalized CSP using aggregate KLD score. Our results suggest that disaggregated dimensions have different relationships with CSP and together they have increasing returns. Perhaps, these relationships are salient in U-shaped relationships. Initially, the negative relationship of a particular dimension results in decline in CFP, which is later compensated by another dimension and together results in increasing returns.

Although the *independent* impact of social sustainability and environmental sustainability is an unambiguous corner stone of the sustainability field, it is often assumed that their interaction effect would either be positive or negative depending on the theoretical orientation which one espouses. Empirically, this study suggests that nature of interaction effect also depends on the choice of measures. Our study indicates that the interaction effect of social sustainability and environmental sustainability is positive, as far as profitability is concerned. Their interaction effect is synergistic, where social sustainability even negates some of the negative consequences of environmental sustainability. When firms engage in environmental sustainability, they need to invest their resources in social sustainability, which offset immediate negative cost consequences of environmental sustainability. When firms engage in environmental sustainability, they often invest in new technological assets which could generate positive returns after few years. Firms could compensate for the expenses on such assets by engaging in social sustainability, which could improve productivity and lower the labor costs.

However, there is neither synergy nor discord between them for their relationships with operational costs. In terms of operational costs, the focus of environmental sustainability and social sustainability are on different areas, and this is reflected in the absence of any synergy between them. When firms focus on suppliers, they could focus on their environmental as well as social sustainability. However, from the perspective of the suppliers, these two areas are separate. This distinction is also apparent in the sustainability reporting by firms. Firms report different sustainability indicators in their annual sustainability reports. They often report social sustainability and environmental sustainability indicators and initiatives in separate sections. Our results support the findings reported in meta-analysis such as Albertini (2013) and Endrikat et al. (2014) that attribute the different findings in different research to choice of measures.

Our results suggest that a performance paradox is not always present in the context of sustainability. It also depends on the specific financial performance measure. Specifically, environmental and social concerns are unrelated as far as operational costs is concerned. While this is likely, it is also possible that some environmental concerns complement social concerns, whereas others conflict. Consequently, we do not observe any significant relationship.

The empirical evidence in post-hoc analysis showed more nuanced findings. Among the different dimensions of social sustainability, only community and employee relations dimensions were consequential in terms of their relationships with operational costs. These two dimensions could affect employee productivity and a firm's access to cheap labor, and therefore have significant relationships with operational costs. However, employee relations and diversity dimensions were positively associated with ROA, whereas human rights were negatively associated with ROA. Diversity might help firms to improve their reputation, but could not influence operational costs. The costs incurred by firms when they improve their human rights could negate any economic benefits from them. While aggregated environmental sustainability reduces operational costs, the negative impact of environmental concerns on operational costs seems to be the underlying cause. When strengths exceed weaknesses, firms mitigate the negative consequences of environmental sustainability weaknesses and thus reduce their operational costs. The potential negative implications from environmental sustainability weaknesses could include increased resource use, decline in resource efficiency, and penalties for environmental degradation.

Among the control variables, the corporate governance dimension as well as the product dimension of social sustainability had no significant relationship with ROA. Efficient corporate governance results in a firm's adherence to institutional norms with regard to financial reporting, and board compositions. While such initiatives could improve a firm's reputation, they had no significant relationship with ROA. The product dimension of social sustainability strengths includes product quality and safety. Focusing on quality could result in the adoption of quality management programs such as TQM at the firm's facilities, which in turn could improve profitability. But, firms could also benefit from weaknesses such as the anticompetitive practice and unethical advertising practices. Such practices could increase revenue in the short-term. Hence, product social performance has insignificant results with both profitability and operational costs.

Size (in terms of employees) was positively associated with profitability. However, size (in terms of assets) was negatively associated with profitability. The acquisition of new technological assets could increase the value of assets and consequently reduce revenue relative to assets. Many industry dummies were significant, thus providing support for the salience of sectoral variation in operational performance. Time dummies were also significant, thereby providing support for the salience of macroeconomic scenario in firms' profitability. Growth was not significantly associated with profitability. Our findings suggest that increase in sales does not always translate into better profitability.

As expected, leverage (proxy for firm's specific risks) was negatively associated with profitability.

Our robustness checks also suggested that support for significant estimates of interaction effect of social sustainability and environmental sustainability diminished with higher time lags. Therefore, it is likely that stakeholder theory becomes more valid in the long-term.

4.7. IMPLICATIONS FOR RESEARCH AND PRACTICE

There are several implications for research that this study facilitates. First, this study builds on stakeholder theory and the triple bottom line approach to examine the business value of social and environmental dimensions of sustainability. We show that while social sustainability reduces costs as well as improves profitability, environmental sustainability only reduces costs and does not improve profitability. Future research could examine the mechanisms by which social sustainability and environmental sustainability affect economic sustainability.

Second, we find evidence for the positive interaction effect of social sustainability and environmental sustainability on profitability. However, we did not find evidence for the interaction effect of social sustainability and environmental sustainability on operational costs. Past research suggests that there exist boundary conditions on the interactions between various firm activities (Newbert 2008, Heusch 2013). Our findings also indicate that there is indeed a boundary condition – interaction effect of social sustainability and environmental sustainability with profitability is significant, but interaction effect with operational cost is insignificant. Future research could further develop these boundary conditions by focusing on market-based measures such as Tobin's Q. Moreover, research could explore the salience of sectoral characteristics and temporal factors in determining these boundary conditions.

Third, we have examined the direct relationship of social sustainability and environmental sustainability with profitability and operational costs. Future research could examine if there is empirical evidence for more complex model such as the moderator-mediator model, where we examine the role of various firm's characteristics on possible intermediate variables such as operational costs in the relationship of social sustainability and environmental sustainability with profitability. Our study also suggests that the time dimension is salient in the relationship between environmental sustainability and profitability. Future research could explore the time dimension using other method such as longitudinal growth curve modeling.

While our findings suggest that environmental sustainability does not improve profitability, recent research grounded in the European context such as Cavaco and Crifo (2014) suggests that environmental sustainability improve profitability. Perhaps, differences in institutional norms and government policies could be salient in the different findings. Future research could explore the underlying rationale behind such conflicting findings.

This research also has several implications for practice. First, our research suggests to managers that they should pursue action such that social sustainability strengths exceed weaknesses. In other words, managers need to view the different dimensions of sustainability with some granularity. Specifically, they need to focus on employee relations and community dimensions of social sustainability.

Second, social sustainability seems to offset the negative impact of environmental sustainability and consequently results in better profitability. While it is possible that like other initiatives, they are competing with each other for limited resources (underlying rationale for paradox lens), they also complement each other on other aspects such as intangible resources, which perhaps result in an insignificant interaction effect in terms of operational cost and positive interaction effect in terms of profitability. This study provides empirical evidence to the business community that sustainability has its business benefits and firms need to adopt it to improve performance rather than being motivated by institutional factors (Watson et al. 2010).

Third, our findings indicate that social sustainability and environmental sustainability reduce operational costs. However, environmental sustainability is negatively associated with profitability. Taken together with the other studies that examine the relationships between sustainability and profitability that found conflicting evidence (Albertini 2013), our findings suggest to managers that they should not judge the value of the sustainability initiatives only through its impact on profitability. This is crucial as improving top-line (such as sales) is dependent upon factors such as global economic scenario and inflationary pressures. However, firms could improve their financial performance in the long run only if they improve their bottom-line. Reducing operational costs could be the key to improving their bottomline as it helps firms withstand the spiraling input costs through better resource utilization.

4.8. LIMITATIONS

There are several limitations in this study. First, we operationalize sustainability by differencing the strengths and weaknesses. While this approach has often been used in studies such as Barnett and Solomon (2012) and Jayachandran et al. (2013), it assumes that the items for the strengths and weaknesses as equally important. Second, our sample is limited to firms that are covered under the KLD social ratings. As such, some caution is required when generalizing the findings to a larger sample. Third, we have considered broad categories such as the presence or absence of employee health and safety practices, rather than actual amount spend by firms on different practices or other objective measures such as actual man-hours lost. This limitation will be reduced as more granular sustainability data become available in future.

4.10. CONCLUDING REMARKS

From a theoretical standpoint, this study contributes to the broader sustainability literature by empirically establishing the dominance of stakeholder theory over paradox lens in the context of profitability. Our empirical findings suggest that there is no empirical support for the existence of paradox, specifically, performing paradox in the context of profitability and operational costs; while the interaction between social sustainability and environmental sustainability is positively associated with profitability, there is no significant interaction effect in terms of operational costs. This study suggests that the tension between social sustainability and environmental sustainability may be restricted to specific practices of social sustainability and environmental sustainability, as at the higher level, the interaction term has a positive and significant relationship with profitability. However, the significant relationship of the interaction term with profitability diminishes with time. This study also contributes empirically to the burgeoning theoretical literature on the paradox lens and the stakeholder theory by showing that the relationship between social sustainability and environmental sustainability with firm performance is more complex than envisaged in previous research. Nevertheless, this study also indicates that in the long-term, firms that have adopted sustainability comprehensively may be more profitable relative to firms which have adopted it less comprehensively as they reduce their operational costs. As such work progresses, we can develop a clearer understanding of the implications of sustainability at different levels and how the effects of disaggregated measures translate into relationships at the aggregated level.

Chapter 5

Conclusion

The central theme underlying the three essays in this dissertation is in exploring the various payoffs from various sustainability initiatives. Specifically, the essays attempt to study the short-term payoffs (in terms of market reaction), long-term payoffs (in terms of operational performance and profitability), and the nexus between different dimensions of sustainability.

The first essay investigates the short-term payoffs (market abnormal returns) from green IT (a subset of sustainability) announcements. The findings show that green IT announcements evoke positive sentiments from a sub-set of shareholders. This positive sentiment results in marginally better return relative to other IT artifacts studied in past research. Since, green IT artifacts are of different types, I classified green IT announcements into three distinct types based on Corbett's green IT quadrant (2010) and examined the shareholders' response to them. The results show that shareholders' respond positively to announcements on "information to support decision-making". The results further suggest that shareholders assign value to "greening through IT" or "IT as a solution".

With regards to organizations that make announcements, organizations with better past environmental record reap benefits from announcements on "information to support decision-making" and "IT assets and infrastructure". Organizations also improve their reputations by green IT announcements.

The second essay is about the relationships between specific types of emissions (classified according to their source and ownership) and different dimensions of operational performance that reflect cost efficiency and productivity. The findings suggest that reducing direct emissions or emissions that emanate from sources owned by organizations is salient in improving operational performance in terms of cost-efficiency. Further, results also show divergent relationship of quality management and environmental management systems on cost efficiency and productivity. While quality management improves productivity, environmental management improves cost-efficiency. Thus, our findings suggest different levers for different relationships between specific operational decisions and different dimensions of operational performance.

With regards to the moderating role of quality management and environmental management system, the findings suggest that reducing direct emissions through quality management diminishes productivity. In contrast, reducing indirect emissions in the presence of quality management improves productivity. The findings suggest that past studies have found conflicting results on the relationship between environmental performance and organizational performance because they considered aggregated emissions rather than direct and indirect emissions. The findings for direct relationship and moderating role of specific initiatives such as QM and EMS suggest that environmental performance–operational performance relationship may be more complex than previously envisioned, and that organization-specific factors may moderate the relationship.

The third essay is about the inter-relationship between different dimensions of sustainability, specifically the relationship of social sustainability and environmental sustainability with economic sustainability. The findings suggest that while social sustainability is positively associated with profitability, environmental sustainability is negatively associated with profitability. Together, their interaction is positively associated with profitability. Social sustainability mitigates the negative impact from environmental sustainability, and organizations therefore benefit from environmental sustainability, when they engage in social sustainability.

Further, the results show that both social sustainability and environmental sustainability are negatively associated with operational costs, but their interaction effect has no relationship with operational costs. Thus, both social sustainability and environmental sustainability reduce operational costs, but they do not influence each other. Hence, there is no synergy as well as discord, as far as operational costs is concerned.

The results also show that different components of social sustainability influence profitability and operational costs differently. There is limited support for the negativity bias, as organizations benefit by avoiding the negative consequences of weaknesses associated with different dimensions of social sustainability.

This essay suggests that the proposed tension between social sustainability and environmental sustainability may be restricted to specific practices of social and environmental sustainability, as at the higher level, the interaction term has a positive and significant relationship with profitability. However, the relationship is different from pure synergistic relationships observed in past research such as Tiwana(2007) and Heusch (2013), where independent relationship was often positive. Here, one independent relationship (social sustainability with profitability) is positive, whereas other (environmental sustainability with profitability) is negative. Thus, in terms of joint impact, social sustainability offsets the negative impact from environmental sustainability. Therefore, organizations with merely social sustainability alone could achieve higher profitability, relative to organizations with both social sustainability and environmental sustainability.

Contributions

This dissertation contributes to research and practice in several ways. First, the dissertation contributes to research on green IT. This dissertation establish the short-term business value of green IT and augment the existing studies that emphasize the long-term business value of green IT primarily by focusing on accounting measures such as ROA. Prior studies have suggested that specific aspects of sustainability such as voluntary reduction in emissions could result in negative shareholders' reaction (Jacob and Singhal 2010, Jacob 2014). However, announcements on new technologies often generate positive shareholders' reaction (Sood and Tellis 2009, Lin and Chang 2011). Nevertheless, green IT announcements which are at the confluence of sustainability and technologies generate positive reaction. This dissertation also indicates that there is lack of consensus on the effectiveness of green IT. Primarily, shareholders view green IT announcements that include IT artifacts that provide information and thus potentially relatively inexpensive and similar to IT artifacts such as ERP and CRM positively .Such insights may help practitioners better select suitable green IT for investment.

Second, this dissertation contributes to the research on sustainability by focusing on operational performance. Despite extensive focus on the financial implications of environmental performance, prior research has rarely focused on the link with operational performance (Albertini 2013, Endrikat et al. 2014). This dissertation asks whether improved environmental performance in terms of direct and indirect emissions improves operational performance in terms of cost efficiency and productivity. Unlike past studies, this dissertation disaggregate emissions into direct and indirect emissions to show that different types of emissions may have different effects on operational performance, and consequently may require different strategies. I show that direct and indirect emissions affect cost efficiency and productivity differently. Specifically, I show that indirect emissions are insignificantly related to operational performance, a noteworthy finding because indirect emissions, often account for most of organizations' carbon-footprints, must be curtailed to combat global warming. It is possible that the insignificant findings for indirect emissions could be attributed to captive power generation. Consequently, I add to the stream of research by demonstrating the salience of ownership of emissions in the environmental performance-organizational performance linkage. Business executives and top management could use these findings to focus on technologies that reduce direct emissions in seeking enhancements for operational performance. They should compare the reduction of direct emissions in terms of cost of ownership and then choose whether the means are appropriate based on constraints such as costs. The dissertation also cautions practitioners that environmental performance and operational performance may have more complex relationships than previously envisioned, and operational decisions such as environmental management system and quality management could influence them differently.

Third, this dissertation provides empirical evidence of the nature of interaction effect (i.e., whether social sustainability and environmental sustainability strengthen or attenuate each other's relationship with economic sustainability in terms of profitability and operational costs). The findings suggest that while social sustainability improves positive payoffs from environmental sustainability in terms of profitability, social sustainability and environmental sustainability neither strengthens nor diminishes each other's relationship with operational costs. Thus, findings from the third essay contribute to the stream of research by highlighting the dichotomy between profitability and operational costs in the context of payoffs from sustainability. This dissertation points to the ineffectiveness of environmental sustainability in improving profitability despite the reduction in operational costs. The findings from the third essay add to the stream of research on the business value of sustainability in suggesting that there are different mechanisms by which different dimensions of sustainability influence profitability. While social sustainability could improve profitability through the reduction in operational costs, environmental sustainability does not exhibit the same result. I also show that specific components of social sustainability relates differently with profitability and operational costs.

These findings suggest to managers that they should not judge the value of the sustainability initiatives only through its impact on profitability. Improving top-line (such as sales) is dependent upon factors such as global economic scenario and inflationary pressures. However, firms could improve their financial performance in the long run only if they improve their bottom-line in terms of operational costs. I summarize the findings and contributions in Table 5.

To conclude, the findings from this dissertation could help research and practice to develop a better understanding of payoffs from sustainability. Scholars and practitioners should focus on granular aspects such as type of announcements, type of emissions, and components of social sustainability to understand the benefits derived from sustainability. In sum, this dissertation is a small step in developing a clearer understanding of the implications of sustainability at different levels.

Table 5: Findings and Contributions

Findings	Contributions
Essay 1: Do Shareholders Value Green Information Technology Announcements?	
• *Green IT announcements result in positive abnormal returns for firms. The abnormal return is slightly higher compared to abnormal return observed in other studies on IT artifacts* • *There is a lack of consensus on the business value of green IT* • *Specifically, green IT announcements on information to support decision-making (ITDSS) are positively associated with cumulative abnormal return.* • *Shareholders do not differentiate between innovative and non-innovative organizations while evaluating green IT announcements.* • *Organizations' past environmental record is salient in realizing benefits from announcements on information to support decision-making (ITDSS) and direct IT assets and infrastructure (ITASSETS)*	• *This study addresses an important research gap. While technology is often associated with positive abnormal return, environmental performance is associated with negative abnormal return. Green IT are at the confluence of technology as well as environmental initiative, its short-term market value is not established.* • *This study also demonstrates that shareholders assign more value to green IT artifacts that are relatively inexpensive and are similar to other IT artifacts such as analytics.* • *As green IT is an emerging phenomenon, shareholders do not differentiate between innovative and non-innovative firms, despite green IT being a technological artifact.*
Essay 2: Toward a Better Understanding of Environmental–Operational Performance Nexus	
• *Direct emissions are negatively associated with cost efficiency. Thus reducing direct emissions improve cost efficiency in terms of COGS/revenue and operating expenses/revenue* • *Direct emissions improves productivity* • *Indirect emissions alone are not associated with cost efficiency as well as productivity*	• *This study addresses an important research gap. While prior research have often examined the relationship between environmental performance and financial performance, they have rarely focused on operational performance and disaggregated environmental performance into components based on their source.*

Findings	Contributions
• *EMS improves cost efficiency* • *QM improves productivity.* • *QM and high direct emissions together improve productivity.* • *But, QM and high indirect emissions diminishes productivity.*	• *Past research have rarely focused on the salience of initiatives such as EMS and QM in the relationship between environmental performance and operational performance. This study provides important insights with regards to the role of EMS and QM.* • *This study also focus on distinct measures of operational measures that reflect cost efficiency and productivity.*
Essay 3: The Nexus between Social Sustainability and Environmental Sustainability with Economic Sustainability	
• *Social sustainability is positively associated with economic sustainability in terms of profitability* • *Environmental sustainability is negatively associated with economic sustainability in terms of profitability* • *Social sustainability attenuate the negative effect of environmental sustainability on profitability* • *Social sustainability and environmental sustainability are negatively associated with economic sustainability in terms of operational costs* • *Social sustainability and environmental sustainability neither strengthen nor diminishes each other's relationship with operational costs.* • *Social sustainability could improve profitability through reduction in operational costs* • *Environmental sustainability could not improve profitability despite reduction in operational costs*	• *Unlike prior research that often focuses on the relationship of social sustainability, environmental sustainability, or sustainability in general with profitability, this study focus on the interaction between social sustainability and environmental sustainability, and its implications for profitability as well as operational costs. The results demonstrate that the relationship is more complex than those envisioned in past research.* • *Prior research often suggests that social sustainability or environmental sustainability could improve profitability through reduction in operational costs. This study shows that environmental sustainability could not improve profitability despite reducing operational costs, thereby showing that different levers exist for different dimensions of sustainability as well as different measures of organizational performance.* • *Prior research often focuses on aggregate measures. However, this study shows that even different components of social*

Findings	Contributions
• *Different components of social sustainability relate differently to profitability and operational costs.*	*sustainability could relate differently to profitability and operational costs, thereby delineating the need for more nuanced analysis of relationship of sustainability with profitability and operational costs.*

APPENDIX A

Information to Support Decision-Making	**Direct IT Assets and Infrastructure**
• Calculators for carbon footprints or environmental impacts • Business intelligence applications • Analysis of operations, processes, functions • Enterprise asset management • Manufacturing systems controls	• Data centers • Energy efficient hardware, such as computers and servers • Server virtualization, decommissioning • Monitoring systems (sensors, smart meters) • Cloud computing
Collaboration	**Sustainable Products and Services**
• Telecommuting, telepresence, video-conferencing • Document sharing • Collaboration technologies	• Customer incentives • New, online services • Removal of toxins from products and take-back programs to reduce waste

(Source: Corbett (2010), p. 10)

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