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Rohit Nishant
ESC Rennes School of Business, rohit.nishant@esc-rennes.com

Thompson S.H Teo
National University of Singapore, bizteosh@nus.edu.sg

Mark Goh
National University of Singapore, bizgohkh@nus.edu.sg

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Do Shareholders Value Green Information Technology Announcements?

Rohit Nishant
Rennes School of Business, France
Rohit.nishant@esc-rennes.com

Thompson S.H. Teo
National University of Singapore, Singapore

Mark Goh
National University of Singapore, Singapore

Abstract:

Using the natural resource-based view (NRBV) and signaling theory, we conducted an event study using the Fama-French four-factor (FFM4) model to determine how shareholders react to company announcements about adopting information technology (IT) to address environmental issues. We found that green IT announcements generate positive abnormal returns and increase share trading volume. Initiatives that use IT to support decision making (ITDSS) cause positive stock market reactions. Firms with good environmental performance records enjoy positive market returns from ITDSS and direct IT assets and infrastructure (ITASSETS) announcements. In contrast, shareholders react negatively to announcements regarding sustainable products and services (SPDTSVC). Combining the NRBV with signaling theory provides deeper theoretical insights than either theory alone. The findings could serve as the basis for further research and theory development on the different types of green IT and impacts on market value. The results help explain how firm characteristics and different types of green IT announcements impact market value, and they have significant implications for how firms plan and allocate their resources to support green initiatives.

Keywords: Event Study, Green IT, Natural Resource-based View, Signaling Theory.

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1 Introduction

Scholars disagree about whether firms can use IT to counter environmental degradation. Some argue that IT artifacts replace carbon-intensive practices such as commuting and that carbon management systems can solve environmental problems (Nanath & Pillai, 2014). Others argue that IT also has a carbon footprint; for example, the Apple iPhone 5's carbon footprint equals about 70kg CO2 (Porter, 2013; Watson, Boudreau, & Chen, 2010). The debate regarding IT's environmental impact has led to a proliferation of green IT; that is, information and communication technologies that can reduce the adverse environmental impacts of business activities (Boudreau, Watson, & Chen, 2008; Lei & Ngai, 2013; Melville, 2010; Walsh, 2007).

Researchers have often focused on green IT's business value (Mithas, Khuntia, & Roy, 2010; Thambusamy & Salam 2010) but have not evaluated shareholder reactions to companies' announcing green IT adoptions. To bridge this gap, we investigate the value that shareholders place on green IT. Market value generally better indicates business value than accounting measures such as return on assets (ROA) (Chatterjee, Pacini, & Sambamurthy, 2002). Hence, similar to the market value's role in delineating change in business value (Ranganathan & Brown 2006), changes in market value following green IT announcements should also indicate the business value of IT technologies. Moreover, market-based measures tend to be leading indicators, whereas accounting measures tend to be lagging indicators. Prior research has examined the business value of environmental performance in terms of the market's response to reduced emissions, certification, and corporate initiatives such as philanthropic activities or the use of renewable energy (e.g., Jacobs, 2014; Jacobs, Singhal, & Subramanian, 2010).

Researchers have often used signaling theory to examine stock market responses to announcements such as CEO certification (Zhang & Wiersema, 2009), innovation (Sood & Tellis, 2009), environmental disclosure (Magness, 2009), and the joining of global platforms such as the United Nations Global Compact (Janney, Dess, & Forlani, 2009). We use signaling theory and the natural resource-based view (NRBV) (Hart & Dowell, 2011) to examine stock market responses to green IT announcements.

Some green IT announcements concern energy-efficiency investments, while others concern new green products or services. One can classify green IT artifacts according to the NRBV and green IT quadrant types (Corbett, 2010). We use signaling theory and the NRBV to indicate that shareholders reward or penalize green IT announcements that signal various firm characteristics or capabilities. In particular, green IT announcements can signal to shareholders that the firm intends to use green IT to reduce costs, enhance resource efficiency, and address environmental issues, which enhances brand equity. Shareholder responses indicate their views regarding green IT announcements. Not all shareholders will interpret green IT announcements the same. Share trading volume (number of shares traded during a time period) would indicate how different shareholder groups interpret green IT announcements.

We examine how different types of green IT announcements impact market value to better understand wealth effects and shareholder evaluations regarding the business potential of green IT investments. In addition, perceptions of business value depend on a firm's capabilities (Aral & Weill, 2007). Therefore, we examine whether shareholders respond differently to green IT announcements that come from firms that have different innovative capabilities to answer the following research questions:

RQ1: How much do green IT announcements affect a) market value and b) share trading volume?

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

RQ3: Do shareholders view green IT announcements by innovative and non-innovative firms differently?

To investigate the research questions, we compute abnormal return, which we define as actual stock return that deviates from expectations (Bharadwaj, Keil, & Mähring, 2009; Zhang & Wiersema, 2009). To estimate the abnormal returns associated with green IT announcements, we use the Fama-French four-factor (FFM4) model, controlling for market portfolio, market capitalization, value, and Carhart's (1997) price-momentum factor.

We make several contributions with this study. First, past studies on green IT have often invoked NRBV to conceptualize various benefits that green IT can offer (Corbett, 2013; Deng, Wang, & Ji, 2015). Undoubtedly, the NRBV focuses on firms and green IT artifacts. Although such a focus can explain the relationship between green IT and accounting measures of performance (Nishant, Teo, & Goh, 2013), it ignores how shareholders assess green IT. As such, we bridge the NRBV with signaling theory to address this gap. In doing so, we contribute to theory development by showing how the NRBV and signaling theory can complement each other and provide deeper insights on the market value effects of green IT announcements. Unlike past studies that rely either on the resource-based view (RBV) (a general variant of the NRBV) or signaling theory, we adopt an integrative approach and argue that the resource-based perspective alone cannot adequately explain the market response because it focuses on sustainable advantage, which is often difficult to realize in the short-term. We further argue that signaling theory alone cannot explain the market response because it cannot conceptualize the benefits that green IT can offer. Therefore, we invoke the NRBV to conceptualize strategies (pollution prevention, product stewardship, and sustainable development) that green IT can support and signaling theory to understand the signals that green IT announcements convey. This holistic approach expands the green IT literature by underlining the need for integrating theories in the sustainability discipline such as the NRBV with theories from economics such as signaling theory to develop a more comprehensive understanding of green IT's business value. We extend the debate on the business value of IT in general and green IT in particular by showing how stakeholders' perceptions affect the short-term market benefits that firms can realize from green IT announcements.

Second, we use an event study method, which research in the management literature has widely validated (e.g., Singhal, 2005; Singhal & Hendricks, 2002), to measure shareholders' viewpoints regarding the value of green IT announcements. Although previous researchers have examined the effect of corporate social responsibility announcements (Flammer, 2013), green business announcements (Videen, 2011), and environmental performance (Jacobs, 2014), they have not focused on green IT. Research has also examined the business value of general IT (Bharadwaj et al., 2009) but not the short-term business value of green IT. Research on the business value of sustainability suggests that shareholders penalize announcements about voluntary emission reduction (Jacob et al., 2010) but reward announcements about eco-friendly corporate initiatives (Flammer, 2013). Furthermore, research has provided support for the positive market response to IT investments (Bharadwaj et al., 2009). However, green IT is a specific type of IT investment that targets environmental objectives. Research has not established the business value of IT-enabled environmental objectives. Our study is the first to provide empirical support for the impact of green IT announcements on market value. Hence, we contribute to the literature on green IT and to the general literature on sustainability. In addition, we examine the share volume effect of green IT announcements to determine whether shareholders interpret them in diverse ways.

Third, in addition to examining the general impact of green IT, we also theorize the impact of specific types of green IT on market value. Previous IS research that has used event study methodology has tended to focus on the adoption, implementation, purchase, and use of a specific technology such as knowledge management, radio frequency identification, and enterprise resource planning (Konchitchki & O'Leary, 2011) rather than compare different types of technologies or investments. Because one can categorize green IT into different types (Corbett, 2010), our results provide insights into the relative importance of different types of green IT announcements and contribute to future theory on which types of green IT convey more effective signals to the market. We also examine how shareholders' perceptions about market value react to firm innovativeness, an unexplored topic even though researchers have viewed innovation as crucial for long-term firm survival. Consequently, we analyze market returns following green IT announcements to determine whether shareholders view such announcement by innovative and non-innovative firms differently.

Fourth, we also conducted several post hoc analyses to probe deeper into our results. We examined the importance of past environmental performance records in moderating the effect of different IT types on market returns and whether reputable firms tend to make more green IT announcements. We found that environmental performance records had varying moderating effects depending on the type of green IT. In addition, the number of announcements was positively correlated with firm reputation. Consequently, our study also contributes to theory development because we identify environmental performance record as a key moderator of market value from green IT announcements.

This paper proceeds as follows. In Section 2, we review the literature on green IT and signaling theory and present our hypotheses. In Section 3, we describe our datasets and analysis procedures. Finally, in Section 4, we provide the results and, in Section 5, discuss them. In Section 6, we discuss their implications for research and practice. Finally, in Section 7, we conclude the paper.

2 Background

2.1 Defining Green IT

Although scholars have provided various definitions for green/sustainable IT (Appendix A), they consistently agree that different IT artifacts play different roles in reducing adverse environmental impacts. IT artifacts are green if they positively impact the environment. Thus, generic knowledge management systems do not fit into the green IT category, but knowledge management systems for preventing pollution 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, Webster, & McShane, 2011).

Researchers classify IT assets according to their infrastructural, transactional, informational, and strategic objectives (Aral & Weill, 2007; Weill & Broadbent, 1998). Infrastructural IT includes hardware such as servers, networks, laptops, databases, and applications; transactional IT automates business processes; informational IT improves management through decision support systems, planning, and sales analysis; and strategic IT assets include new products and services.

Corbett (2010) categorizes green IT topics into a typology that encompasses four main types based on their underlying technological characteristics: 1) information to support decision making (ITDSS), 2) direct IT assets and infrastructure (ITASSETS), 3) collaboration, and 4) sustainable products and services (SPDTSVC) (see Appendix B). ITDSS includes business intelligence applications; enterprise asset management; manufacturing systems controls; analysis of operations, processes, and functions; and calculations of carbon-footprint or environmental impacts. ITDSS is analogous to informational IT assets: 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 that decrease an organization's carbon footprint, such as telecommuting, and is analogous to transactional IT assets: both use technology to improve work efficiency. SPDTSVC, analogous to strategic IT assets, include new green products such as online services, non-toxic products, and take-back programs for providing sustainable goods and services.

The different types of green IT address different environmental concerns. ITDSS provides information about the firm's environmental state to help executives make informed decisions to address concerns. ITASSETS addresses environmental concerns such as energy consumption and emissions associated with IT artifacts. Collaboration reduces commuting and environmental consequences. SPDTSVC address adverse environmental impacts associated with IT artifacts.

Unlike classifications solely focused on software (e.g., Forrester, 2011), Corbett's (2010) typology focuses on both IT hardware and software. Consequently, we adopt the typology to classify green IT announcements. However, Corbett's typology is rather broad because firms may deploy IT for reasons other than environmental considerations. For instance, a firm could deploy cloud computing to more effectively share resources rather than to reduce IT emissions. Hence, we treat IT artifacts as green/sustainable only when firms announce their environmental aspects.

2.2 Business Value of Green IT

The resource-based view (RBV) suggests that firms create sustained competitive advantage through resources and capabilities that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). Capabilities are ''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, p. 68). Studies on the business value of IT (e.g., Bharadwaj et al., 2009; Wade & Hulland, 2004) have envisioned IT as a valuable resource that can create sustained competitive advantage. However, we examine environmentally focused IT, and the RBV perspective overlooks the environment as a resource (Corbett, 2010). Instead, the natural resource-based view (NRBV), a variation of RBV (Hart, 1995), considers the environment as a resource.

The NRBV conceptualizes three interrelated strategies as precursors to competitive advantage: pollution prevention (e.g., eliminating emissions and waste), product stewardship (environmentally friendly products and service delivery), and sustainable development, which includes clean technology and long-term environmental and social focus (base of the pyramid (BoP)) (Corbett, 2010; Hart & Dowell, 2011). Thus, the NRBV integrates business and societal values. The four types of green IT also overlap with environmental strategies that the NRBV proposes (Corbett, 2010). Corbett maps various green IT initiatives to the different strategies in the NRBV (Table 1).

Table 1. Mapping of Green IT Types to NRBV (Corbett, 2010, p. 15)

Green IT type	Pollution prevention	Product stewardship	Sustainable development
Information to support decision making	♦	♦	♦
Direct IT assets and infrastructure	♦		
Collaboration	♦		
Sustainable products and services		♦	

A key tenet of the RBV and NRBV is that specific artifacts potentially create sustained competitive advantage. However, general IT—and, indeed, green IT—is pervasive, not rare (Vinekar & Teng, 2012). Although competitors can adopt or develop green IT artifacts, firms can use green IT to develop capabilities for using green technologies, integrate them with interfirm technologies, and develop and deploy processes to harness them. In other words, green IT is not rare, but firms can use it to develop unique capabilities. For instance, Intel developed capabilities for a data center system that reuses data center heat (Intel, 2007).

Further, competitors cannot easily observe and imitate a firm's internal operations. Thus, internal green IT can be inimitable. Also, green IT may not be easily substitutable because alternatives tend to be non-green. Taken as a whole, green IT can generate sustained competitive advantage when leveraged into business operations. Even if green IT fails to create sustained competitive advantage, it still brings other benefits. For example, green firms may attract environmentally conscious consumers for improved sales and expanded market share (Haanaes et al., 2011).

In addition to business values, green IT has societal values. It can mitigate pollution, make product- and service-delivery processes more environmentally friendly, and incorporate clean technology (Setterstrom, 2008). The announcement of societal initiatives such as corporate social responsibility (Doh, Howton, Howton, & Siegel, 2010) and reputation rank (Deephouse, 2000) are often associated with enhanced market value.

Green IT is an emerging and evolving phenomenon. Despite its benefits, it also requires capital investment. Moreover, it still has a somewhat ambiguous value: some view IT as an environmental problem rather than a solution (e.g., Boccaletti, Löffler, & Oppenheim, 2008) in that IT may be the major greenhouse gas emitter by 2020. Thus, current public discourse does not agree about whether IT is a cause or a solution (Lei & Ngai, 2013) and whether it lowers operating costs and increases revenue or has debatable environmental benefits relative to its costs. To reiterate, as per the NRBV, firms may develop unique capabilities, but, when they announce green IT initiatives, they could announce final products or investment. In addition, green IT investments may indicate intent, but sustainable competitive advantage would depend on whether the firm effectively deploys green IT. Hence, the NRBV alone cannot explain how shareholders respond because it focuses more on long-term sustainable competitive advantage rather than short-term benefits. Therefore, we invoke signaling theory, which researchers have often used to examine short-term stock market responses to announcements. We integrate the various pollution prevention, product stewardship, and sustainable-development strategies with signaling theory to hypothesize responses to green IT announcements. We use the NRBV to understand the potential benefits from different green IT artifacts and signaling theory to understand how shareholders perceive specific benefits from green IT announcements.

2.3 Signaling Theory

Signaling theory explains that one party communicates or signals information and that the other party interprets the signal. For instance, when young firms appoint renowned directors to their board of governors, they signal that they have acquired legitimacy and buy-in (Certo, 2003). Signaling theory identifies two key actors: 1) signalers (e.g., firms) who disseminate signals such as news about top management and CEO certification (Zhang & Wiersema, 2009) and 2) receivers who interpret and evaluate the signals regarding the firm's strategic direction and financial health (Connelly, Certo, Ireland, & Reutzel, 2011). Signalers have access to private information but receivers do not (Moss, Neubaum, & Meyskens, 2015), which creates information asymmetry.

Researchers have used signaling theory to examine stock market responses to announcements related to innovation (Sood & Tellis, 2009), environmental matters (Magness, 2009), and global platforms such as the United Nations Global Compact (Janney et al., 2009). Firms also send reputation and image-enhancing signals. Announcements related to environmental sustainability can signal sustainability leadership, which can improve corporate image, demonstrate good corporate citizenship, and show commitment to societal concerns (Janney et al., 2009). In the IS context, organizations often signal their current and future capabilities and performance outcomes (Zmud, Shaft, Zheng, & Croes, 2010). Shareholders will then reward or penalize announcements depending on how they view the signals.

2.4 Green IT Announcements as a Signaling Strategy

Firms that announce green IT initiatives have access to details about the required finances and associated risks. Shareholders have access to the public information the company provides, which often includes brief technical specifications and speculations about potential benefits.

Green IT aligns with the strategies in the NRBV. Green IT can reduce carbon footprints (pollution prevention), improve product and service sustainability through lifecycle management (product stewardship), and allow long-term improved environmental, social, and financial performance (sustainable development). Thus, green IT announcements can signal that firms intend to financially benefit by deploying strategies that facilitate environmental sustainability.

In terms of specific environmental benefits, firms can enhance shareholders' reactions to green IT announcements with announcement that signal potential benefits such as higher energy efficiency and lower emissions, reduced technology-related operating expenditures and higher resource efficiency (Burt, 2010; Haanaes et al., 2011), preparedness and intent to embrace emerging technologies that reduce energy costs and optimize resource usage, better resource use for reducing operational expenditures, and intentions to create or cater to the new environmentally conscious markets through new green products or services. NRBV arguments suggest that consumers value such initiatives (Wang, Brooks, & Sarker, 2015) as signaling operational and marketing benefits.

Besides operational and marketing benefits, green IT announcements can also signal reputation-enhancing commitments to environmental sustainability. Shareholders may favor green IT announcements because they suggest that firms are taking ethical initiatives that may have positive financial ramifications. Sustainability initiatives may also generate better brand reputation and market value (Berns et al., 2009; Haanaes et al., 2011). Thus, green IT signals multiple benefits to shareholders.

Shareholders evaluate future ramifications and benefits of green IT and respond accordingly. Green IT signals benefits, commitment to environmental sustainability, and acquisition and potential development of new capabilities, so shareholders would reward green IT announcements with increased share prices. As such, we hypothesize:

H1: Green IT announcements generate positive abnormal returns.

Price reactions (abnormal returns) reflect changes in market expectations (Bamber, Barron, & Stevens, 2011). Different interpretations of announcements that result in different expectations about a firm's future financials and social value tend to increase share trading volume (Bamber, Barron, & Stober, 1999).

Despite the possibilities for positive abnormal returns, a question remains: do shareholders share a consensus regarding the value of green IT announcements? We lack clarity regarding the environmental and business value of green IT announcements. That is, different shareholders could perceive green IT announcements as signaling different attributes. Some might see potentially improved performance and buy shares of firms that announce green IT initiatives; others might see such initiatives as risky with no assurance on either financial or environmental returns and sell their shares. Either way, we hypothesize that the trading volume increases:

H2: Green IT announcements increase share trading volume.

2.5 Different Types of Green IT Signals

The characteristics and costs of IT artifacts vary and could cause distinct shareholder perceptions regarding risks or benefits. ITDSS comprises business intelligence (BI) applications such as carbon calculators, carbon management systems, and enterprise asset management. ITDSS allows firms to design and execute initiatives to target their carbon footprint (pollution prevention), manage the lifecycle environmental impact of products and services (product stewardship), and devise long-term environmental sustainability (sustainable development) (Corbett, 2010). ITDSS relates to all three NRBV strategies and therefore signals a strong environmental sustainability focus. These strategies, although inter-linked, result in different sources of competitive advantage (Hart & Dowell, 2011). Pollution prevention could reduce costs, product stewardship could improve product design and development processes, and sustainable-development strategies could facilitate long-term sustainability orientation and the integration of social and economic concerns with environmental concerns. Thus, from the NRBV perspective, shareholders could reward ITDSS signals.

Past studies also provide support for effectiveness of informational IT assets and BI, which research has positively associated with even short-term financial performance (Aral & Weill, 2007). Likewise, BI enhances organizational effectiveness (Watson & Wixom, 2007) and is positively associated with firm performance across sectors (Elbashir, Collier, & Davern, 2008). Using IT to enhance organizational effectiveness aligns with the NRBV's sustainable-development strategy (Wang et al., 2015).

Specific ITDSS tools such as carbon-footprint calculators require relatively simple Web designs and moderate capital investments, so they have relatively minor risks. Carbon-footprint calculators make business processes more visible, which makes it easier to devise strategies for preventing pollution. ITDSS assets also could create positive impressions about future firm performance through better asset use that enhances environmental and operational performance. Moreover, ITDSS announcements can signal marketing benefits through deploying tools that allow firms to leverage sales of green products or services.

BI tools such as carbon management systems (CMS) help firms measure and manage their carbon footprints (Corbett, 2013) for sustainable development. CMS provide spreadsheets and webpages, are similar to carbon calculators, and vary widely in costs. Although specific information tools to gather environmental performance information are relatively new, firms have used enterprise resource planning (ERP) for more than two decades, and it yields less ambiguous benefits. Moreover, firms are more commonly reporting their environmental performance in response to increasing demands for carbon neutrality (Corbett, 2013). Thus, CMS announcements would signal that a firm intends to adopt environmental performance reporting, which can benefit a firm in allowing it to gather information about its environmental performance.

Green enterprise asset management (GEAM) is more functionally advanced and technologically complex than CMS. GEAM tools track environmental performance and analyze financial implications at different lifecycle stages and, thereby, enhance product stewardship. Despite the complexity, stakeholders can readily accept GEAM because they are familiar with conventional enterprise asset management (EAM) (ARC Advisory Group, 2008). ITDSS applications that analyze operational processes can reduce waste and wasteful expenditures. Similarly, manufacturing systems can manage assets and performance (Galloway & Hancke, 2013) for optimal energy and water use. Management studies suggest that technologies that reduce energy and material consumption are clean and reflect the NRBV's sustainable-development strategy (Hart & Dowell, 2011). Although firms have traditionally used these tools for controlling large-scale processes, they now use them (both their hardware and software components) to measure environmental performance to meet corporate reporting requirements. Like BI, these tools have less ambiguous benefits.

In sum, ITDSS announcements can signal all of the NRBV's environmental strategies (pollution prevention, product stewardship, and sustainable development) and their subsequent benefits. Specific ITDSS artifacts also signal various operational and financial benefits. Thus, shareholders may consider ITDSS announcements as signaling enhanced firm operational and financial performance. As such, we hypothesize:

H3: Green IT announcements about ITDSS are positively associated with abnormal returns.

Announcements on direct IT assets and infrastructure (ITASSETS) include IT hardware such as green data centers, virtualization software and hardware, monitoring systems (e.g., smart grids), and IT infrastructure. Since ITASSETS align with a firm's pollution prevention strategy in the sense that they can help to save energy and reduce subsequent emissions and they can reduce costs and improve efficiency (Hart & Dowell, 2011). For instance, IT hardware can reduce energy consumption for financial and environmental efficiency (Toledo & Gupta, 2010). Cloud computing/virtualization replaces dedicated data centers and shared infrastructure. Smart grids improve the environmental performance of electric grids by enhancing communication between service providers and users.

Given their strong alignment with the pollution prevention strategy in the NRBV (Corbett, 2010), ITASSETS announcements would signal that a firm more efficiently uses its resources, that it saves money from doing so, and that it is prepared to target the green market (Haanaes et al., 2011). Such announcements could help a firm to differentiate itself from its competitors and increase its competitive advantage (Chen, Ho, Ik, & Lee, 2002; Lin & Chang, 2011).

However, some direct IT assets are initially capital intensive. Smart grids require one to invest in expensive supplementary assets such as power system stabilizers (Yang, Bi, & Wu, 2007). Indeed, any capital-intensive project must deal with costly initial investments and the prospect of delayed benefits. ITASSETS also raise questions about service levels. For example, many IT experts have expressed skepticism about cloud computing's reliability and performance. Privacy advocates have expressed concern about consumer data and smart grid insecurity. Networked IT artifacts are often more vulnerable to cyberattacks. Such assets may have environmental benefits but still generate concerns that may adversely affect IT asset diffusion and disrupt growth in market share. However, privacy and cybersecurity are not issues specific to green ITASSETS—they affect all firms and IT assets (King, 2015). Firms often devise strategies to address such issues. Likewise, firms can devise strategies and solutions to improve cloud computing's reliability (Ghobadi, Karimi, Heidari, & Samadi, 2014). In doing so, they can also assuage shareholders concerns about risks. As such, we hypothesize:

> **H4:** Green IT announcements about direct IT assets and infrastructure (ITASSETS) are positively associated with abnormal returns.

Collaboration involves technology tools for telecommuting and teleconferencing, which can reduce or eliminate commuting. Thus, collaboration aligns with the NRBV's pollution-prevention strategy. However, tools such as virtual telecommuting and teleconferencing differ from ITDSS and ITASSETS in their core focus. Firms use ITDSS and ITASSETS artifacts such as carbon calculators and green data centers primarily to achieve environmental objectives such as reducing resource consumption or measuring carbon footprint. In contrast, they use collaboration tools primarily to gain productivity (e.g., a reduction in the time employees spend commuting) and psychological benefits (e.g., better work-life balance) (Gajendran & Harrison, 2007). Unlike the recent emergence of ITDSS and ITASSETS, collaboration tools have existed since the early 1990s (Nilles, 1994). Some studies have recognized other benefits of collaboration tools such as reduced emissions through reduced commuting (Corbett, 2010). Others suggest that home offices and telework electronics may reduce carbon dioxide emissions but increase nitrous oxide and methane (Kneale, 2008). Hence, telework has mixed environmental effects. Furthermore, firms often emphasize productivity benefits rather than environmental benefits from collaboration tools. For instance, CISCO (the world's largest networking firm) promotes its telepresence tools by saying: "Make it easier for teams to collaborate, innovate, and resolve issues quickly…. Video and telepresence are known to scale knowledge, unify the organization and provide better work/life balance for employees" (Cisco, 2016). Likewise, testimonials such as "online meetings make business flow faster" (Cisco, 2016) often emphasize productivity benefits rather than environmental benefits. The literature also supports our argument that firms use collaboration tools mostly to improve productivity (Al-Busaidi, 2014; Bidgoli, 2012). Hence, firms have rarely identified collaboration tools as "greening" initiatives because they are weakly associated with pollution prevention and strongly associated with productivity benefits.

Furthermore, we examined various announcements relating to collaboration and found that firms rarely publicized their adopting telecommuting or teleconferencing in conjunction with environmental benefits. Consequently, such announcements would signal productivity benefits rather than environmental benefits. Our sample comprised only a few announcements of videoconferencing/teleconferencing as green IT artifacts. However, their focus on productivity benefits justified our decision to exclude them.

Announcements about sustainable products and services (SPDTSVC) indicate that firms will introduce new IT products or services that have a minimal adverse environmental impact, such as new online services, product stewardship initiatives, and customer incentives. Product stewardship initiatives include introducing less-toxic computer components and take-back programs that allow consumers to return computers and products that have embedded computer chips for effective disposal. SPDTSVC focus on reducing the adverse environmental impact of products throughout their lifecycles; thus, it aligns with the NRBV's product stewardship strategy (Corbett, 2010), which signals ethical actions and social responsibility (Fombrun, 2005). The NRBV's product stewardship strategy extends a firm's focus on environmental sustainability to include the entire value chain (Hart & Dowell, 2011). To do so, a firm must necessarily take more control over the value chain of its products, which could result in its gaining a competitive advantage.

However, introducing new products or services and managing their lifecycles is relatively expensive. Hence, firms that make such announcements could also signal that they have sufficient cash reserves to develop, manufacture, market, and distribute new products/services and to manage their environmental impact over their lifecycle. Given increasing consumer environmental awareness, SPDTSVC may open new market segments, better differentiate products and services, and aid sustainable-development strategies.

Although SPDTSVC have unambiguous ethical aspects, one can still debate their financial implications and subsequent contributions to sustainable development. Firms must bear the complete cost of take-back programs or transfer the costs to consumers. Consumers may be averse to incurring additional expenses for product stewardship. Thus, product stewardship might be economically unviable. Likewise, customer incentives to promote environmentally friendly practices could be costly.

In sum, SPDTSVC provide uncertain financial benefits. Thus, SPDTSVC announcements signal strong ethical but risky and expensive commitment. Hence, shareholders could penalize firms for announcing such unnecessary and expensive initiatives. As such, we hypothesize:

> **H5:** Green IT announcements regarding sustainable products and services (SPDTSVC) are negatively associated with abnormal returns.

2.6 Quality of Signaler

Signalers, as the key signaling theory actors, determine signal strength (Arthurs, Busenitz, Hoskisson, & Johnson, 2009; Busenitz, Fiet, & Moesel, 2005) and interpretation (Connelly et al., 2011). Furthermore, firm innovativeness affects market returns from new product announcements (Lee & Chen, 2009).

Innovation includes applying knowledge to create new knowledge and products (Cho & Pucik, 2005). IS innovation includes new digital computer applications and communication technologies (Swanson, 1994). Green IT involves applying communication technologies to reduce adverse environmental impacts through new products and changes in extant processes. Firms that can redesign processes or develop new products are often called innovative (Katila & Shane, 2005). They create new offerings by modifying processes and product lines (Hall, 2010). They tend to have strong technological capabilities for exploring and exploiting technologies (Cho & Pucik, 2005) and have higher chances of success with new technologies (Dollinger, Golden, & Saxton, 1997). Furthermore, innovative firms reap economic benefits from new technologies. Consequently, they send credible signals, and shareholders reward their announcements with positive abnormal returns. Conversely, shareholders perceive non-innovative firms as less technologically savvy, so they may view their green IT announcements as less credible and even risky. As such, we hypothesize:

> **H6:** Green IT announcements generate higher positive abnormal returns for innovative firms but not for non-innovative firms.

3 Method

3.1 Sample Preparation

Table 2 shows our sample selection and coding methodology. Following previous research (Glascock, Davidson, & Henderson, 1987; Sood & Tellis, 2009), we searched news reports from Factiva and Lexis-Nexis. We also included websites dedicated to corporate social responsibility and sustainability, newswire sources, and press release sections on firms' websites. For multiple news reports with identical information, we used the earliest news report as the announcement. We gathered the news announcements based on the search terms related to a firm's environmental practices. We dropped green IT announcements that occurred 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 & O'Leary, 2011). Because Corbett's (2010) green IT quadrant is rather broad, we focused specifically on the IT artifacts for improving environmental performance rather than general organizational performance. If announcements involved IT artifacts but did not focus on the environment, we dropped them. We examined whether environmental objectives were salient in the announcements (e.g., energy efficiency, energy savings, low energy usage, fewer emissions, substitution of a traditional way of conducting business with an environmentally friendly approach, and a new product that replaced a conventional environmentally detrimental existing product) (see Table 3).

Thus, our final sample comprised announcements with IT artifacts that focus on the environment. The first author and a practitioner who worked in a large IT firm coded the announcements in terms of Corbett's (2010) green IT types. The values of the Perreault and Leigh (1989) reliability index for the different types were above 0.8, which indicates high inter-rater reliability. We examined the key environment-related words and the key IT artifacts in various announcements.

Table 2. Sample Selection and Coding Methodology

Step	Details
1. Identify sources and search terms	• Identified websites dedicated to environment initiatives and news databases (Factiva, Lexis-Nexis Academic) as sources. • Developed search based on initial examination of sustainability-related news.
2. Identify announcements	• Gathered news from different sources for the 2004-2011 period. • Excluded announcements from non-publicly traded firms. • Used 505 announcements as sample.
3. Identify green IT announcements	• Classified announcements into green IT announcements based on the presence of IT artifacts and emphasis on environmental objectives. • Dropped announcements made on the same day of other announcements such as dividends and earnings. • Consequently, 137 announcements remained. • First author and a practitioner coded the IT announcements into the various types. The coding showed high inter-rater reliability (Perrault and Leigh reliability index = 0.95).
4. Collect stock-price data	• Extracted from the CRSP database stock price data for a two-day event window (-1, 0) and 230-day estimation window (-260, -30) for firms with announcements. • Extracted market portfolio returns data for the CRSP index from the CRSP database.

Table 3. Classification of Announcements into Green IT

News announcement	Key words	Green IT
Apple launches free computer take-back program (31 May, 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)

3.2 Announcement Sample

Our final sample comprised 137 green IT announcements from 58 firms (2.36 announcements per firm). Our sampled firms belonged mostly to sectors such as industrial and commercial machinery, computer equipment, electronics, electrical equipment and components, business services, and communications—sectors that likely included green IT. Table 4 shows a sample classification of the green IT types.

Our sample size is comparable to the sample sizes reported in prior IS research (Konchitchki & O'Leary, 2011) and research on corporate social responsibility (e.g., Flammer, 2013). The ITDSS classification included announcements with IT artifacts that disseminate information such as carbon management tools, calculators, software to reduce environmental costs, and environmental management systems. The ITASSETS classification included announcements with IT artifacts such as data centers, smart grids, cloud computing, servers, and computers. The SPDTSVC classification included announcements with IT artifacts such as computers and with initiatives such as recycling programs, take-back programs, or online services with environmental benefits.

Table 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 (ITDSS)
Emerson builds new **energy-efficient data center** (3 September, 2008)	Direct IT assets and infrastructure (ITASSETS)
Goodwill and Dell expand **free computer recycling partnership** to Canada (6 April, 2010)	Sustainable products and services (SPDTSVC)
Note: we used the complete announcements to classify them.	

3.3 Operationalization of Firm Characteristics

We operationalized innovativeness using two measures. First, we measured how many patents firms applied for in the year before their announcement(s). We used this measure because earlier studies have found that patent count is a good proxy for innovativeness (e.g., Joshi, Chi, Datta, & Han, 2010). We used log-transformation for the patent count. Second, we classified firms as innovative and non-innovative using FastCompany's list of the 50 most innovative firms for 2008 to 2011 (www.fastcompany.com), BusinessWeek's list of innovative firms for 2005 to 2010 (www.businessweek.com), and Fortune's list of most admirable companies (www.fortune.com) that includes excellence in innovation and social responsibility. Unlike patent count, such rankings are often based on the perceptions of industry experts and senior executives who also consider firm characteristics and financial performance. We also examined initiatives listed in their annual sustainability reports to ensure that they were innovating in the ICT domain. Thus, our second measure of innovativeness also tested the robustness of our first measure.

3.4 Control Variables

We controlled for a firm's size by using the logarithm of the number of its employees and the logarithm of its revenue in the year before its green IT announcement(s). We controlled for the growth rate because a firm's historical growth rate can also influence how its shareholders evaluate its green IT announcement(s). A firm's profitability can also influence evaluation, so we controlled for profitability using the firm's return on assets (ROA) in the year before the green IT announcement. The National Bureau of Economic Research (USA) recognizes the period between December 2007 and June 2009 as recessionary years. As such, we controlled for this variation in the economic environment by creating a binary variable for economic cycle: we coded the period between December 2007 and June 2009 as "recession" and outside this period as "normal". Previous studies using event study methodology (e.g., Otim, Dow, Grover, & Wong, 2012) have also used a similar classification.

Moreover, we included the annual return from the 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): that is, 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 a firm's 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 5 summarizes the variables and their measures.

Table 5. Variables and their Measures

Variable	Data type	Measures	Source
CAR	Continuous	Difference between expected return based on prior trading window and actual return	CRSP database
ITDSS	Categorical	Absence/ presence of information to support decision making = 0/1	Factiva, Lexis-Nexis & websites
ITASSETS	Categorical	Absence/ presence of direct IT assets and infrastructure = 0/1	Factiva, Lexis-Nexis & websites
SPDTSVC	Categorical	Absence/ presence of sustainable products and services = 0/1	Factiva, Lexis-Nexis & websites
Innovativeness	1. Count 2. Categorical	1. Patents applied for in previous year of announcement 2. Non-innovative = 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 as (sale(t) – sale(t-1))/sale(t), where t is the fiscal year prior to event date	Compustat
Firm profitability	Continuous	ROA = net income / total assets	Compustat

Table 5. Variables and their Measures

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	December 2007 to 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 Index

3.5 Event Study Methodology

Event studies in IS have primarily used the efficient market model of daily stock price returns (MM model), which computes abnormal returns based on the assumption that the market portfolio is the benchmark for returns (McKinlay, 1997). However, researchers have criticized the MM model 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 & French, 1993). As such, the FFM4 model includes four factors: market portfolio, market capitalization, value, and Carhart's (1997) price-momentum factor. Market portfolio captures common variation in stock returns, market capitalization captures firm size, the value factor captures book-to-market equity, and the price-momentum factor accounts for the persistence effect in returns (which identifies the tendency of stock prices to trend in the same direction (Jegadeesh & Titman, 1993)). We used the following FMM4 model specification:

$$R_{it} – R_{ft} = \alpha_i + \beta_{1i} (R_{mt} – R_{ft}) + \beta_{2i} SMB_t + \beta_{3i} HML_t + \beta_{4i} UMD_t + \varepsilon_{it},\ E[\varepsilon_{it}] = 0,\ Var[\varepsilon_{it}] = \sigma^2_{\varepsilon it}, \quad (1)$$

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 market index

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 (1997) price-momentum factor that captures one-year momentum in returns

ε_{it}: error terms, and

α, β: parameters to be estimated.

Risk-free return captured the interest from a risk-free investment over a specific period. We used the interest rate on the three-month U.S. treasury bill as a proxy for the risk-free return because "short-term government issued securities have virtually zero risk of default" (Sood & 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 and $E(R_{it})$ 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:

$$AR_{it} = R_{it} – R_{ft} – [\hat{\alpha}_i + \hat{\beta}_{1i} (R_{mt} – R_{ft}) + \hat{\beta}_{2i} SMB_t + \hat{\beta}_{3i} HML_t + \hat{\beta}_{4i} UMD_t] \quad (2)$$

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 to 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:

$$CAR_i = \sum_{t=-1}^{t=0} ARit \quad (3)$$

$$Average\ CAR_i = \sum_{i=1}^{N} \sum_{t=-1}^{t=0} ARit / N \quad (4)$$

We used the t-test to determine whether the average CAR differed significantly from zero. In addition to the average CAR, we also computed the median CAR to examine the extent of variation in 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, and the value-weighted index has weightage based on market capitalization for each stock. Our results show 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 and Williams's (1977) estimation to compute abnormal returns. We computed abnormal volume in place of abnormal returns to test H2. For the volume study, we used the ordinary least squares market-based model and used a log-transformation of the raw volume data (similar to Barnhart & Rosenstein, 2010). The empirical specification for our remaining hypotheses (H3-H6) was:

$$CAR_{i,j} = \alpha + \beta_1(ITDSS)_{i,j} + \beta_2(ITASSETS)_{i,j} + \beta_3(Innovativeness)_{i,j} + \beta_4(Firm\ size)_{i,j} + \beta_5(Firm\ growth\ rate)_{i,j} + \beta_6(Industry\ competition)_{i,j} + \beta_7(Sector\ dummy)_{i,j} + \beta_8(Economic\ cycle)_{i,j} + \beta_9(ROA)_{i,j} + \beta_{10}(Annual\ return)_{i,j} + \varepsilon_{i,j,} \quad (5)$$

where the "i" and "j" subscripts refer to announcement i and firm j, respectively.

Our main variable of interest was a categorical variable for the different types of announcements. There were three categories; hence, our econometric specification had two classes. We had an unbalanced panel data linear model because we had a different number of observations for different firms. Serial correlation could also have been possible in a panel because 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; second, by using robust standard errors, we ensured that our estimates were robust against heteroskedasticity and 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) regression, panel regression (random effect), and OLS regression to examine the various relationships. The GLM technique allows for a non-normal distribution of the dependent variable. Research has often employed panel regression to analyze panel data, whereas OLS regression is the basic model used for such analysis. We used various control variables such as firm size, annual return from S&P 500, and macroeconomic scenario. Because our FFM4 event study method also controlled for size and volatility, we controlled for sources that might influence the relationships between the independent and dependent variables.

4 Results

4.1 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) was 0.55 percent ($p < 0.01$), and median CAR was 0.45 percent ($p < 0.01$). The average CAR based on the CRSP equal-weighted index was 0.53 percent ($p < 0.01$), and the median CAR was 0.27 percent ($p < 0.01$). The average CAR based on a two-day event window (-1, 0) was positive and significant. The average CAR based on a three-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, we found support for H1.

The average annual return from the S&P index for 2004-2010 normally was 13.10 percent (Standard & Poor, 2011), which implies that daily return was about 0.05 percent. Therefore, the magnitude of the abnormal returns from green IT announcements over a two-day period was about five times the return from the S&P

index. Because most firms that announced green IT initiatives were from the technology sector, we compared the returns from the green IT announcements with technology-specific indices. Unlike the S&P index that comprises the top-500 publicly traded U.S. firms, technology-specific indices focus on technology firms. The average daily returns from the various technology indices varied from -0.08 to 0.12 percent. Thus, the returns from the green IT announcements were higher compared with their peers' return.

If the average abnormal returns before and after the event window (-1, 0) were similar to the returns for the event window, it would indicate that a firm's characteristics rather than the green IT announcements were salient in the returns for the event window. Conversely, a reversal in returns over time pre- and post-announcement would suggest that the information related to the firm's fundamentals was not salient in the returns from such announcements. We examined the returns over a 60-day period including the event window. Table 6 shows that the average returns pre- and post-event window did not significantly differ from zero, whereas the returns for the event window were positive and significant. For the pre- and post-event windows, 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 indicates 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. Furthermore, we examined the trend for five days pre- and post-event windows (see Figure 1). The average CAR was highest for the event window, which supports our finding that shareholders favored green IT announcements.

Table 6. Average CAR for 60-day (-30, 30) Period Based on Value-weighted Index

Time window	Average CAR (%)	Median CAR (%)	Count of positive returns	Count of negative returns
(-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)				

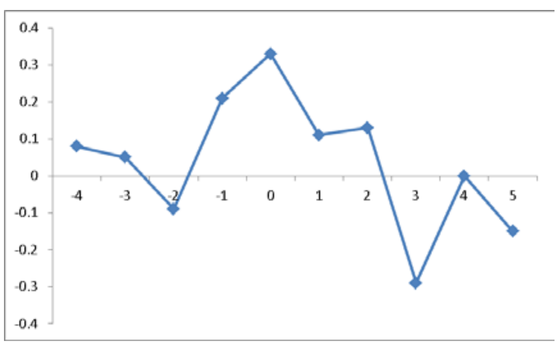

Figure 1. CAR Trend

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

4.1.1 Robustness Checks for Average CAR Computation (H1)

Given our small sample, we also conducted non-parametric tests such as the 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, which supports the robustness of our results. The estimates for average CAR based on other alternative estimation windows such as (-270, -6), (-270, -2), (-200, -6), and (-120, -2) and event windows such as (-1,1) were similar to our initial estimates. The estimates for the average CAR based on other models such as the comparison-period mean adjusted return model (1.17%, $p < 0.01$) and market-adjusted returns model (0.69 %, $p < 0.01$) (McKinlay, 1997) were also positive and consistent with our estimates. We also tested the robustness of our estimates using the conventional market model (MM model) that controlled only for market factors without additional controls. Our estimates (0.53%, $p < 0.05$) were positive and consistent with the estimates from our FFM4 model.

Errors often occur in clusters for financial data (Campbell et al., 1997): larger returns follow large returns and smaller returns follow small returns, which suggests serial correlation in returns. Therefore, we checked the robustness of our estimates (computed using OLS estimation method) with the GARCH and EGARCH estimation methods. The estimates were 0.58 percent ($p < 0.01$) and 0.59 percent ($p < 0.01$), respectively, which supports 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, the closing prices of the different stocks are not set simultaneously because their last trading occurs at different times. In other words, trading's asynchronicity introduces an econometric problem of errors in the variables (Scholes & Williams, 1977). Therefore, we tested the robustness of our estimates using the Scholes-Williams beta and obtained an average CAR of 0.55 percent ($p < 0.01$), which is consistent with our earlier results.

The FFM4 model uses a time-series approach. However, the returns from the different stocks for identical periods are possibly not independent (Ibbotson, 1975). Therefore, we applied the Ibbotson return across the trade and securities (RATS) methodology with the Fama-French factors. In this methodology, one cross-sectionally estimates the FFM4 model across a sample of firms on a daily basis. The estimate for the average CAR for event window (-1, 0) based on this method was 0.71 percent ($p < 0.01$). Hence, our estimates were positive and significant for both time-series and cross-sectional approaches. The estimates were also similar for the general method of moments (GMM) estimation and the weighted least squares (WLS) estimation. The results of the Fama-French calendar-time portfolio regression (the OLS and GMM estimation methods) were also similar, which supports the robustness of our estimates. We also dropped green IT announcements that an organization made within 10 days of an earlier one. The average CAR was positive and significant (average CAR = 0.52%, $p < 0.01$), which provides credence to our estimates. In addition, our announcements period spanned about eight years, which ensured no systematic bias in the sample. Unsystematic bias (if any) would cancel out for the overall sample.

4.2 RQ1(b): How Much do Green IT Announcements Affect Share Trading Volume?

We used stock price and share trading volume to understand the green IT announcements' market implications. A positive abnormal return indicates an upward movement in stock-price after an announcement. Such movement suggests that the market, on average, reacted positively to the announcement. In addition, we examined the change in trading volume after the green IT announcements. The mean cumulative abnormal relative volume (CARV) for the event window (-1, 0) according to the market-based model and equal-weighted index was positive and significant (98.56%, $p < 0.05$). Thus, the CARV increased an average of 49.28 percent daily. In our sample, an average of 75 percent of stocks showed a positive CARV, whereas the remaining stocks showed a 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, we found support for H2. Overall, our findings indicate that the green IT announcements were effective signals that attracted the market's overall attention.

4.2.1 Robustness Checks for Share Trading Volume (H2)

We derived the same conclusion when we used different estimation windows and other techniques. The mean abnormal trading volume for other stock market-based indices was also positive. The mean trading volume for market-based method was 235.57 percent ($p < 0.01$). The number of announcements with positive trading volume was 132. The mean abnormal trading volume based on alternate estimation window such as (-11, 210) and estimation technique that account for market-specific factors and correct for serial correlation (if any) was 157.40 percent ($p < 0.01$). Likewise, the mean abnormal trading volume, when we corrected for any potential non-synchronicity in share trading and use alternate trading window (-1, 1), was 236.20% percent ($p < 0.01$). In sum, the share trading volume was positive. Thus, our findings are robust.

4.3 RQ2: Do Shareholders React Differently to Different Types Of Green IT Announcements?

Table 7 shows the descriptive statistics and the correlation matrix. We conducted a panel data regression and the Hausman test to find the best panel regression model. The p-value was not significant, which ruled out the choice of the fixed effects model. We computed the estimates for different models using random effects regression, GLM regression, and OLS regression with clustered robust standard errors. We used stepwise regression techniques in which we included various control variables sequentially in our analyses. Our estimates were consistent across different models. Table 8 shows the estimates for the full model. 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.

The coefficient for ITDSS ($\beta = 1.52$, $p < 0.05$) was positive and significant. The other type of green IT, ITASSETS ($\beta = 0.16$, $p > 0.05$), was not significant. Compared to SPDTSVC, ITDSS announcements positively increased market value, whereas ITASSETS announcement had no significant impact on it. Thus, we found support for H3 but not H4. We also checked the relationship between the average CAR and SPDTSVC by solely including it in our regression models. The estimate was insignificant ($\beta = -0.52$, $p > 0.05$). Likewise, the insignificant relationship between SPDTSVC and the average CAR did not support H5. We further tested the validity of our interpretation by separately examining the relationships of the average CAR with ITDSS and ITASSETS. The estimates supported our interpretation.

Table 7. Correlation Matrix

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. CAR (%)	0.55	2.60	1.00										
2. ITDSS	0.25 (n = 34)	0.43	0.06	1.00									
3. ITASSETS	0.55 (n = 75)	0.50	0.02	-0.57	1.00								
4. SPDTSVC	0.20 (n = 28)	0.40	-0.09	-0.38	-0.54	1.00							
5. Invtvnss (patents)	754	1268	-0.10	-0.03	0.03	0.00	1.00						
6. Invtvnss (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. Size (log of number of employees)	4.86	0.64	0.09	-0.08	0.08	-0.02	0.46*	0.38*	-0.19*	1.00			
9. 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 green IS categorical variables are tetrachoric correlation; Bonferroni adjusted correlation are similar.

Table 8. Estimates for Returns from FFM4 Model

Hypothesis	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}

Table 8. Estimates for Returns from FFM4 Model

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	NA
* p < 0.05 (one-tailed). Standard errors are in parentheses. We included industry dummies in the regressions but did not show their estimates for sake of brevity.			

We also tested an alternate model in which we made ITDSS our reference group and used GLM regression and random effect regression. The estimates for ITASSETS and SPDTSVC were negative and significant (β = -1.24, p < 0.05; β = -1.45, p < 0.05). Our findings again indicate that, compared with ITDSS, ITASSETS and SPDTSVC decreased market value. Thus, the estimates support our interpretation.

4.4 RQ3: Do Shareholders View Green IT Announcements by Innovative and Non-innovative Firms Differently?

The coefficients for the different measures of innovativeness (Table 8) were not significant (β = -0.15, p > 0.05; β = 0.00, p > 0.05). Thus, we did not find support for H6. The insignificant estimates for patents and binary classification (innovative/non-innovative) suggest that shareholders did not treat innovative and non-innovative firms differently. 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.

4.4.1 Robustness Checks for H3-H6

The estimates from the other methods such as GLS regression also supported our findings. To ensure that our findings were robust against the potential issue of data adequacy, we included only the main variables of interest in our regression models. We controlled for heteroscedasticity and serial correlation. We computed the estimates using OLS regression, the random effects model (maximum likelihood estimation), and the generalized estimating equation (GEE) model. Moreover, we computed the estimates using the bootstrap and jack-knife procedures, which resampled the data and addressed concerns associated with small sample size. The estimates from the different models supported our finding that ITDSS was positively associated with CAR.

The awareness about sustainability in general and green IT in particular could have plausible influenced the response to green IT announcements. As such, we used the National Geographic Greendex Survey (NGGS)[1], a measure of consumer attitudes toward sustainable consumption, as a proxy for sustainability

[1] National Geographic/GlobeScan Consumer Greendex (http://environment.nationalgeographic.com/environment/greendex/). Since 2008, the NGGS has measured consumer attitudes toward sustainable consumption across 18 countries including the United States. As our study focused on the U.S. market, we used the U.S. Greendex score to measure sustainability awareness. As the awareness of sustainability and attitudes toward sustainable consumption are likely to be correlated, we use the Greendex score as a proxy for sustainability awareness. The Greendex survey data are available from 2008, but the trends in the survey indicate that U.S. score

awareness. We tested an alternate model (GLS regression model) with primary variables of interest and controls such as time dummies and awareness. We also tested for robustness by including awareness as an additional control in our full model (random effects) and operationalizing innovativeness using log-transformed count of patents application. The findings were similar.

Some firms also reported the dollar value associated with green IT. As such, we included an additional control (dollar value reported/not reported) in our full OLS model. The estimates were consistent with our findings. Capital expenditure spending could reflect that a firm acquired tangible and intangible assets, and green IT investment could be part of the capital expenditure. Hence, we included capital expenditure as an additional control (Appendix C). We also tested an alternate model (GLS regression model) with primary variables of interest and additional controls (dollar value reported/not reported) and capital expenditure. Although reporting of the dollar value was positively associated with CAR, capital expenditure was not significantly related to CAR. The estimates for main variables of interest support our findings.

Past environmental performance records might also bias shareholders' perceptions of green IT initiatives. As such, we included past environmental performance as an additional control variable. We constructed a measure of environmental performance based on data from Kinder, Lydenburg and Domini's (KLD) database in which environmental performance equals the total number of environment strengths minus the total number of environment concerns. We coded firms with negative performance as poor performers and firms with positive performance as good performers. The estimates were similar, which further supports the robustness of our results. Table 9 summarizes our results.

Table 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 firm -> returns	+	No

4.5 Post Hoc Analyses

4.5.1 Returns from Specific Green IT Assets

Our results indicate that ITDSS is positively associated with CAR. We also examined CAR for different sets of announcements. Average CAR for ITDSS announcements was 0.9 percent, and most announcements generated positive return. In contrast, ITASSETS announcements generated 0.6 percent, and SPDTSVC generated a mere 0.1 percent return. Although one can classify our sampled announcements into four green IT types, one can also classify them into specific green IT assets. However, only the sample size for ITASSETS was adequate to facilitate such a classification. Thus, we classified ITASSETS into announcements on green data centers and other announcements. The announcements on green data centers generated a high return (CAR = 0.7%), whereas other announcements generated a 0.4 percent return. Thus, specific ITASSETS generated positive returns, but the estimate for ITASSETS in the regression model (Table 8) was not significant because other firms' characteristics could be salient in return from ITASSETS announcements.

has been stable over time (between 43.7 and 45.0). Hence, we substituted the missing year values with the average Greendex score.

4.5.2 Does Past Environmental Performance Record Indirectly Influence CAR?

Our robustness check showed that past environmental performance record alone did not influence CAR. However, it could influence the returns from ITDSS and ITASSETS. Hence, we included the interaction terms of ITDSS and ITASSETS in our empirical model. The estimates for both ITDSS * environmental performance and ITASSETS * environmental performance (random effects model) were positive and significant ($\beta = 2.78$, $p < 0.05$; $\beta = 5.23$, $p < 0.05$). As Cohen and Cohen (1983) recommend, we graphed the significant interaction effects (Figures 2 and 3). Through simple slope analyses, the slopes for poor environmental performance lines were not significantly different from zero (Figure 2: $t = 0.947$, $p > 0.05$; Figure 3: $t = -0.300$, $p > 0.05$). This finding suggests that green IT announcements had no effect on the CAR for firms with poor environmental performance record. Firms with good environmental performance realized a higher CAR from ITDSS and ITASSETS (Figure 2: $t = 3.736$, $p < 0.05$; Figure 3: $t = 4.929$, $p < 0.05$).

Because of our empirical specification (SPDTSVC being a reference group), we could not examine whether past environmental performance record influenced SPDTSVC returns. Hence, we tested a separate model in which we made ITDSS our reference group. We included the interaction terms ITASSETS * environmental performance and SPDTSVC * environmental performance in this model. The estimate for SPDTSVC * environmental performance was negative and significant ($\beta = -2.79$, $p < 0.05$). The slope for the low environmental performance record line (Figure 4) was not significant ($t = -0.95$, $p > 0.05$), but the slope for the good environmental performance record line was significant ($t = -3.74$, $p < 0.05$).

Thus, for firms with poor environmental performance record, SPDTSVC announcements were inconsequential. However, for firms with good environmental performance record, shareholders penalized the SPDTSVC announcements with a lower CAR. The R^2 for our interaction models was higher than the main model (0.34 vs. 0.23 for the main model), which supports the interaction effects. We also checked the robustness of our interaction model by including additional control variables such as time dummies to control for time trends in the relationships. The findings from the extended model supported the robustness of our inferences with respect to the interaction between the past environmental performance record and the types of green IT announcements. The results suggest that only firms with good environmental performance record benefitted from ITDSS and ITASSETS. However, firms with good environmental performance record did not benefit from announcements on SPDTSVC. Instead, the market reacted negatively.

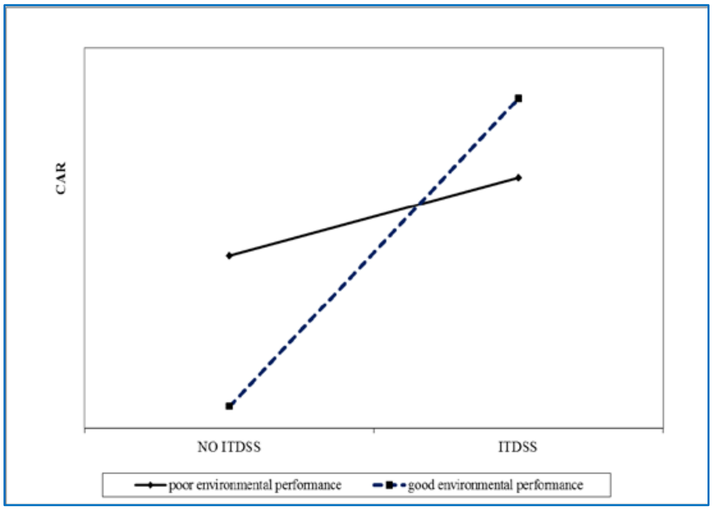

Figure 1. ITDSS * Environmental Performance Interaction Plot

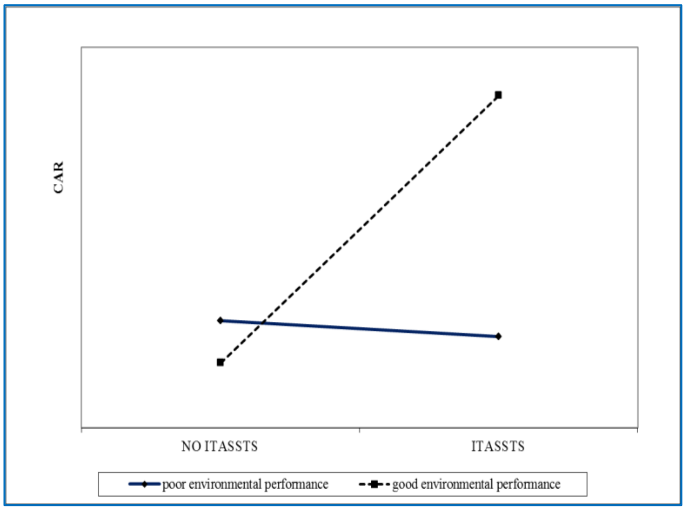

Figure 3. ITASSETS * Environmental Performance Interaction Plot

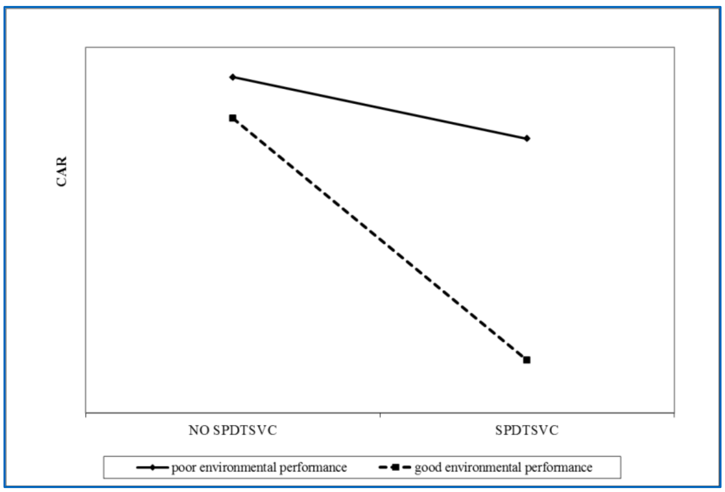

Figure 4. SPDTSVC * Environmental Performance Interaction Plot

4.5.3 Are Green IT Announcements Related to Corporate Reputation?

Like other sustainability initiatives, green IT announcements could also signal that a firm cares about broader social issues such as climate change and global warming. If so, the firm may gain a better reputation. Consequently, we examined whether firms with improved reputation scores made more green IT announcements. We analyzed reputation scores from Fortune's list of the world's most admired companies (based on categories such as social responsibility, product/service quality, and innovation) and compared these scores with number of green IT announcements that the companies made between 2006 and 2011. We computed the change in reputation score between 2006 and 2012. Firms with improved reputation scores made more announcements (4.17 announcements) in comparison with firms that had declining reputation scores or fell out of the 2012 rankings (2.19 announcements) ($t = 1.94$, $p < 0.05$). Reputation scores were positively associated with green IT announcements. We also tested alternate models to better understand the role of green IT in improving reputation. We regressed improvement in the reputation score (coded as a binary variable, yes/no) on the number of green IT announcements. The logit model showed positive and significant estimate for green IT announcements ($\beta = 0.18$, $p < 0.05$). The odds ratio was (1.19, $p < 0.05$), which suggests that firms were 19 percent more likely to improve their reputation when they made one additional green IT announcement. When we used probit model, the estimate for green IT announcement was again positive and significant ($\beta = 0.11$, $p < 0.05$), which suggests that an increase in the number of green IT announcements increased the probability a firm would gain a better reputation. In the second model, we retested our main model but included reputation as an additional control. The estimates from the GLM model suggest that ITDSS was positively associated with CAR ($\beta = 1.36$, $p < 0.05$) after controlling for reputation. This finding provides additional support for the robustness of our main finding.

5 Discussion

We found that shareholders generally favored green IT announcements. Positive abnormal returns occurred when firms made green IT announcements (with an average CAR value of 0.55%). Green IT announcements showed a slightly higher than average CAR in comparison with other event studies on IT investment announcements that have found average CAR values from 0.09 to 0.36 percent (Bharadwaj et al., 2009). Furthermore, we found that share trading volume rose, which indicates that shareholders viewed green IT favorably despite divergent views (Kalaignanam, Kushwaha, Steenkamp, & Tuli, 2013) about its benefits and risks. Our findings contrast with Videen (2011) who found that corporate environmental announcements had no effect on abnormal returns. We extend Flammer's (2013) finding that stock price increases are associated with pro-environmental firms by showing that the nature of green IT investments matters. As for why, various types of green IT can enable firms to more effectively support their sustainability initiatives. For instance, ITDSS facilitates present and future initiatives to reduce emissions by providing crucial information and visibility to firms' carbon footprints.

Green IT announcements on ITDSS elicited more positive shareholder response than the announcements on ITASSETS and SPDTSVC. Empirical support for positive returns from ITDSS suggest that shareholders reward IT assets that support the three NRBV strategies (pollution prevention, product stewardship, sustainable development) rather than a subset of NRBV strategies. This finding suggests that shareholders reward green IT announcements because IT could enable firms to support sustainability initiatives more effectively. Perhaps shareholders also perceived that ITDSS has more immediate benefits and potentially higher returns on investment. Shareholders were indifferent to the announcements of green ITASSETS possibly because such technologies are still evolving. The benefits may be elusive and may take some time to realize. Apparently, shareholders were also indifferent to SPDTSVC because they might still be wary about cost effectiveness and market acceptance. However, in contrast to our hypothesis, the relationship was insignificant rather than negative. Perhaps shareholders find it difficult to assess the impact of such investments on a firm's models of profitability (Videen, 2011). Furthermore, perhaps shareholders believed that such initiatives are good for society and therefore did not penalize them. In sum, ITDSS benefits are potentially more quickly achieved. Thereby, shareholders reward green IT announcements that signal immediate economic value. Thus, one can attribute the market response to the economic value shareholders perceive to be associated with such announcements. The inherent economic value of announcements could perhaps explain contrasting findings in past studies. Shareholders disdained voluntary emissions reduction as a wasteful expenditure (Jacobs et al., 2010) but rewarded eco-friendly corporate initiatives (Flammer, 2013). Perhaps they see the economic potential in activities that could improve a firm's reputation.

Shareholders generally did not discern between announcements made by innovative and non-innovative firms perhaps because both types of firms could face significant risks as green IT might entail commercializing products and technologies. Furthermore, shareholders might have higher expectations for innovative firms and might have become immune to their announcements, so only groundbreaking announcements would affect market returns. In contrast, shareholders might be wary of announcements by non-innovative firms because they are unsure about whether such firms could deploy green IT effectively.

Our results also indicate that industry competition measured in terms of the HHI is not significant perhaps because the associated risks and rewards are similar for both less and more competitive industries. The annual return from the S&P index was not significantly associated with the CAR, which indicates that overall market sentiments did not matter. Perhaps shareholders evaluated the green IT initiatives independently from market conditions. Few industry sectors were significant, which concurs with previous event study findings.

Firm size measured in terms of revenue was not significant. Perhaps small and large firms face similar risks in new green technologies. Furthermore, the need to be agile and responsive to environmental trends mitigated any size advantage. Although firm size is often associated with more resources, it is also often associated with greater bureaucracy. Shareholders may ignore firm size because they expect all firms to be environmentally responsible. Some industry dummies were significant, which concurs with Zmud et al.

(2010) who found that the number of IT signals varied across different industries depending on the IT's role. Consequently, we could expect varying market reactions to announcements across industries.

Green IT announcements were correlated with enhanced reputation, and past environmental performance record affected returns from green IT announcements. Specifically, environmental performance record positively moderated the relationship between ITDSS and ITASSETS with CAR. Perhaps shareholders trust such announcements only from firms with good environmental record. For firms with poor environmental performance, shareholders could have perceived such announcements as greenwashing and did not reward them. In contrast, environmental performance record negatively moderated SPDTSVC with CAR perhaps because shareholders feared that consumers would be unwilling to pay for green IT products—especially if they cost more than conventional products, which would reduce profitability. In addition, shareholders may have felt that the firm had done enough on sustainability. They could view further investments as counterproductive and less than an ideal use of resources.

6 Implications

6.1 Implications for Research

This research has several implications for future studies. First, although sustainability research continues to grow, researchers have not theoretically or empirically examined how shareholders respond to green IT announcements. We examine the effect of green IT announcements on abnormal returns and contribute to theory building by integrating NRBV with signaling theory to examine changes in market value from green IT announcements. In doing so, we explain shareholder responses to green IT announcements as a function of the NRBV's strategies that such announcements signal. Past IS event studies have used signaling theory or RBV as their theoretical foundation to explain shareholder response (Konchitchki & O'Leary, 2011). Early arguments grounded in RBV presumed that IT yields sustainable competitive advantage but failed to explain why specific characteristics in green IT announcements influence how shareholders respond. Consequently, studies invoked signaling theory and conceptualized IT announcements as signals (Roztocki & Weistroffer, 2015). Nevertheless, signaling theory itself cannot conceptualize the variety of information that announcements convey. However, by integrating both signaling theory and the NRBV, we theorized that green IT announcements could convey the NRBV's strategies. Thus, our approach extends the theoretical basis of IS event studies that often have used signaling theory alone. Future studies could adopt a similar approach to understand different facets of such announcements. They could focus on quantifying the social value rather than business value of such announcements. In examining social value, studies might bridge a theoretical lens from organizational behavior literature that could explain shareholder emotions with signaling theory. Such research could explore sentiment-based measures and use alternative techniques such as sentiment analysis to measure all stakeholder responses to such announcements. Further, future research could also explore the significance of risk effects (e.g., Dewan & Ren, 2011) in contrast to the wealth effects we examined. Understanding risk effects would require integrating risk-related concepts such as systematic and unsystematic risks with the NRBV. As more firms invest in green IT, it would be interesting to examine whether risk effects are stronger than wealth effects. Risk effects often have negative connotations. Researchers might invoke prospect theory that focuses on responses to negatives vis-à-vis positives. Given the rather limited publicly available news on the failures and risks associated with green IT, it would be interesting to compare the impact of positive and negative news on market returns as more news data become available. Bharadwaj et al. (2009), for example, has found that more severe IT failures are associated with greater decline in firm value. Another research avenue could be in exploring green IT announcement effects on systemic risks. Green IT solutions could differ in their acquisition costs and potential impact. It would be interesting to compare the negative effects associated with different types of green IT solutions.

Second, in our study, green IT announcements were associated with positive abnormal returns and significantly affected trading volume. We focused on the green IT categories ITDSS, ITASSETS, and SPDTSVC. Thus, we contribute to the debate on the business value of green IT. Past studies have argued that firms often embrace ecological efficiency approaches when they expected green IT to contribute positively to both ecological footprint and financials (Hedman & Henningsson, 2016). We found that ITDSS, which is associated with all of the NRBV's sustainability strategies and, therefore, with ecological footprint, can contribute more positively to market-based financial performance measures. ITASSETS, which focus on a subset of strategies such as pollution prevention, did not yield significant positive market return. Sustainability and green IT studies have often emphasized pollution prevention (Gholami, Sulaiman,& Ramayah, & Molla, 2013; Hart & Dowell, 2011) as salient in firms' decisions to embrace green IT, whereas our study emphasizes the salience of all three of the NRBV's strategies in realizing financial benefits such as short-term market return. Future research could more deeply investigate why certain types of green IT announcements have higher abnormal returns. As more data become available, research could focus on specific IT assets such as enterprise management systems and carbon calculators to capture business value and to examine whether market reactions change for announcements of different assets categorized under green IT types. Research has also analyzed specific green IT artifacts such as CMS based on the principle of tailoring and reducing effort (Corbett, 2013). Future research could explore whether positive abnormal returns from environmental announcements depend on whether the artifacts potentially address problems beyond improved environmental performance. Future research could also delve deeper into whether design principles derived from specific green IT artifacts increase shareholder acceptance. Green IS studies argue that IT may not directly influence corporate sustainable development, which also has a strong financial component (Elliot, 2011). Our findings on the market measure of financial performance suggest that only ITDSS announcements have a significant relationship with market returns. Studies argue that IT often would moderate the impact of other organizational initiatives. As such, future studies could explore the interplay of different categories of green IT with other sustainability initiatives in influencing corporate sustainable development.

Third, we adopted three of Corbett's (2010) four green IT quadrants. Corbett's typology is useful because it lists specific IT artifacts that facilitate an objective and distinct classification of the various IT artifacts. However, we linked the announcements relating to collaboration more often to productivity benefits than environmental benefits. Consequently, we had too few announcements that related to collaboration and emphasized the environment to analyze. Hence, we can see a disconnect between collaboration tools theoretically conceptualized as green IT and collaboration tools that predominantly focus on productivity benefits rather than environmental benefits. Consequently, we may need to refine our theoretical conceptualization of certain types of green IT. The green IT field is still in the nascent phase (Gholami, Watson, Hasan, Molla, & Bjorn-Andersen, 2016), and we need to test different aspects of it (Elliot, 2011) to help build theory. As more data become available, a larger sample could further refine Corbett's green IT quadrants, delineate the different technologies that facilitate collaboration, and examine their effects on CAR. The same IT assets could offer different benefits such as productivity improvement and emissions reduction, so different objectives might conflict with each other. One could use the paradox lens (Smith & Lewis, 2011) to explore tensions among different objectives of IT assets and rationales for preferring one over the other.

Fourth, environmental performance records could have positive or negative moderating effects on CAR depending on the type of green IT. In addition, we found no support that firm size was related to revenue and abnormal returns, although previous studies (e.g., Bharadwaj et al., 2009) have found a positive relationship between firm size and CAR. Future research could further examine when firm size might be important. We also found that firm characteristics did not always strengthen the signals; their effect could depend on the context. These results contribute to theory development because we identified a key moderator (environmental performance record) of market value from green IT announcements. Future research could examine other moderators.

6.2 Implications for Practice

This study has several implications for practice. First, in analyzing the different types of green IT, we found that ITDSS was positively associated with CAR but that other types of green IT were insignificantly related with CAR, which suggests that shareholders assessed the green IT initiatives based on their potential to create immediate benefits. ITDSS supported all three of the NRBV's strategies (pollution prevention, product stewardship, and sustainable development), while ITASSETS supported pollution prevention and SPDTSVC supported product stewardship (Corbett, 2010). Apparently, the fact that ITDSS supported the wide range of NRBV strategies made those announcements stronger signals than ITASSETS and SPDTSVC announcements. Practitioners should note that shareholders do not view all types of green IT investments equally even though such investments all relate to making firms more environmentally responsible. In addition, firms invest in green IT to satisfy both shareholders and other stakeholders who view environmental initiatives as an important part of the firm's identity. Executives and top management could use this new knowledge to justify greater investments in specific types of green IT initiatives. Thus, firms could adopt such IT artifacts to specifically improve their environmental performance and evoke positive reactions from shareholders. Better decision making in dealing with environmental issues could decrease costs, enhance revenue, increase profitability, and enhance competitive advantage.

Second, we found no empirical support for the relationship between innovativeness and abnormal returns. Green IT falls under the category of IS innovation. Thus, we might expect shareholders to reward innovative firms more than non-innovative firms. However, even innovative firms may fail to effectively deploy IT (Lindič, Baloh, Ribière, & Desouza, 2011). Hence, rather than focusing on the impact of innovativeness on abnormal returns, practitioners should be aware that the market does not differentiate between innovative and non-innovative firms when judging green IT announcements.

Third, our post hoc analyses suggest that only firms with good environmental track records benefit from ITDSS and ITASSETS announcements (though not from SPDTSVC announcements). Hence, practitioners should note that different types of green IT may bring different benefits to firms with good environmental records in terms of the CAR. Together with support for H1, our post hoc results for SPDTSVC extend previous findings regarding the existence of an attitude-behavior gap between positive attitudes toward green issues and products and inconsistent and often conflicting consumption behaviors (Moraes, Carrigan, & Szmigin, 2012). Specifically, shareholders also have a similar attitude-behavior gap when it comes to actually supporting sustainability. In fact, shareholders behave negatively when firms with good sustainability records invest in SPDTSVC because they might fear that consumers will not pay premium prices for eco-friendly products and services.

7 Conclusions

This study is the first to provide empirical evidence that green IT announcements positively affect market returns and to reassure firms that such investments are worth the effort. Among the green IT types, only ITDSS evoked a positive shareholder response. We found no difference in CAR between innovative and non-innovative firms that announced green IT initiatives.

Our post hoc analyses suggest that green IT announcements are unrelated with CAR for firms that have a poor environmental performance record. In contrast, shareholders view green announcements on ITDSS and ITASSETS positively for firms that have good environmental performance record. However, SPDTSVC announcements are negatively related with CAR. Consequently, one should consider firms' environmental performance records when assessing how different types of green IT affect CAR.

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Appendix A

Table A1. Sample of Key Research Defining Green/Sustainable IT

Study	Defining green/sustainable IT	IT artifacts
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 by producing less e-waste (through effective disposals), using less toxic materials in their production, and producing a smaller carbon-footprint (emissions).
Fuchs (2008)	Ecologically sustainable ICTs and ecologically destructive ICTs.	Recyclable and reusable IT artifacts.
Chow & Chen (2009)	Green computing refers to using computing resources to minimize environmental pollution	Disposal of IT waste and energy-efficient IT artifacts.
Melville (2010)	IS for environmental sustainability refers to "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 systems that systemize cost-benefit analyses and improve environmental risk management.
Watson et al. (2010)	Energy analytics refers to the systems that can increase efficiency of energy demand and supply system.	Information systems that can collect and analyze energy datasets such as sensors.
Bose & 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 and decision making and knowledge creation around environmental sustainability.
DesAutels & Berthon (2011)	Green IT is a component of sustainability. Sustainability refers to 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 means "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 a firm.	Energy efficient servers, IS to capture environmental data, videoconferencing, telepresence, and collaboration tools (as an alternative for travel).
Zhang, Liu, & Li (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 effectively with minimal or no impact on the environment'' (p. 83).	All IT artifacts if they are energy efficient and have minimal adverse environmental impact.
Herzog, Lefèvre, & Pierson (2012)	Energy efficient hardware/software that has a minimal adverse impact on the environment.	Server virtualization and hardware cooling.
Cai, Chen, & Bose (2013)	"Focus on the use of IT resources in an energy-efficient and cost-effective manner" (p. 493).	IT equipment (e.g., data centers).

Table A1. Sample of Key Research Defining Green/Sustainable IT

Tushi, Sedera, & Recker (2014)	Environmentally friendly IT.	All IT artifacts with minimal adverse environmental impact and IT-based initiatives.
Zhang & Xie (2014)	Environmentally friendly IT.	All IT artifacts with minimal adverse environmental impact.
Chuang & Huang (2015)	Conceptualized green IT capital comprises structural capital (green hardware and software), human capital (IT staff that understand and has expertise in greening), and relational capital (relationships with partners and users to offer green products and services).	All IT artifacts with minimal adverse environmental impact.
El Idrissi & Corbett (2016)	Green IT refers to the hardware and IT infrastructure that one can manage and design from an environmental perspective.	All IT artifacts with minimal adverse environmental impact.
Gholami et al. (2016)	IT that can address environmental problems.	All IT artifacts with minimal adverse environmental impact and IT-based initiatives.

Appendix A

Table B3. Typology of Green IT (Corbett, 2010, p. 10)

Information to support decision making	Direct IT assets and infrastructure
• Calculators for carbon footprints on 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 visualization, 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

Appendix C

Table C1. Illustration of Results of Robustness Checks

Hypothesis	I (GEE model)	II (Bootstrap)	III	IV (GLS)┼	V (GLS)	VI	VII
Information to support decision making (ITDSS)	**1.58*** **{0.8}**	**1.55*** **{0.9}**	**1.5*** **{0.9}**	**1.14*** **{0.68}**	**1.56*** **{0.72}**	**1.51*** **{0.9}**	**1.41*** **{0.59}**
Direct IT assets and infrastructure (ITASSETS)	0.27 {0.66}	0.19 {0.86}	0.1 {0.77}	0.21 {0.51}	0.22 {0.52}	0.20 {0.77}	0.13 {0.34}
Innovativeness (classification based on rankings)	0.07 {0.72}	-0.09 {1.32}	-0.13 {0.95}	0.13 {1.91}	1.01 {2.15}	0.05 {0.95}	-0.08 {0.68}
Innovativeness (number of patents)	0.00 {0.00}	0.00 {0.00}	0.00 {0.00}	0.00 {0.00}	0.00 {0.00}	0.00 {0.00}	0.00 {0.00}
Growth rate	0.64 {1.16}	0.95 {1.99}	1.06 {1.6}	-3.12* {1.51}	-1.40 {1.2}	1.03 {1.49}	0.99 {1.14}
Organization size (number of employees)	0.40 {0.63}	0.45 {0.69}	0.48 {0.62}	0.35 {0.60}	0.05 {0.63}	0.53 {0.67}	0.53 {0.42}
Organization size (revenue)	-0.55 {0.65}	-0.27 {0.85}	-0.09 {0.53}	-0.42 {0.9}	-0.36 {0.88}	-0.23 {0.57}	-0.41 {0.33}
Industry competition (HHI)	0.49 {1.50}	-0.36 {1.92}	-0.99 {1.97}	0.02 {1.9}	-1.37 {1.95}	-0.49 {1.78}	-0.13 {0.77}
Profitability (ROA)	-2.30 {2.74}	-2.35 {5.55}	-2.32 {2.34}	4.17 {6.63}	-3.62 {5.65}	-2.43 {2.40}	-0.73 {2.97}
Annual return	-1.11 {1.21}	-0.89 {2.54}	-1.14 {3.25}	-1.86 {4.71}	0.07 {2.39}	-0.76 {2.14}	-0.97 {0.88}
Economic cycle	0.22 {0.59}	0.29 {0.99}	0.20 {1.43}	0.72 {1.01}	0.95 {0.96}	0.35 {1.08}	0.19 {0.29}
Awareness (sustainability)			-0.2 {0.91}		-0.75 {1.01}		
Capital expenditure						-0.00 {0.00}	
Dollar value reported/not reported							1.82* {0.50}
R^2	NA	0.23	0.22	NA	NA	0.23	0.24

Note: * $p < 0.05$ (one-tailed). Standard errors are in parentheses.
┼: includes time dummies to control for temporal variation in awareness.

About the Authors

Rohit Nishant is an Associate Professor (SCM and IS area) at Rennes School of Business, France. He received his PhD degree in Management from National University of Singapore Business School in 2014. He is also winner of SIM Annual Paper Competition 2010 and WFF PhD Prize for dissertation in sustainability (2015). His research interests include green IS, sustainability, social implications of IS, and business value of technologies. His research has been published (or will appear) in journals such as *Journal of the Association for Information Systems*, *Journal of Strategic Information Systems*, *IEEE Transactions on Engineering Management*, *Journal of Business Research*, and *MIS Quarterly Executive*. Readers can find more information at https://www.rennes-sb.com/faculty/dr-nishant-rohit/.

Thompson S. H. Teo is an Associate Professor in the Department of Analytics and Operations at the School of Business and in the Department of Information Systems and Analytics at the School of Computing (by courtesy), National University of Singapore. His research interests include e-adoption of IT, strategic IT planning, offshoring, and sustainability. He has published more than 250 papers in international refereed journals and conferences. He has served as a senior associate editor for *European Journal of Information Systems* and is currently serving as the Regional Editor (Asia and Pacific) for the *International Journal of Information Management*. He is also on the editorial boards of *IEEE Transactions on Engineering Management*, *Information & Management*, *MIS Quarterly Executive*, and *Omega.* He has coedited four books on IT and e-commerce and is also a four-time winner of the SIM Paper Awards Competition.

Mark Goh is a Professor (Practice) in the Department of Analytics and Operations, School of Business, National University of Singapore and holds a joint appointment as Director (Industry Research) at the Logistics Institute-Asia Pacific. His current research interest is on buyer-seller relationships, performance measurement, and supply chain strategy. With over 100 internationally refereed technical publications, some of his recent papers on supply chain management have appeared in the *Journal of Purchasing and Materials Management, Industrial Marketing Management, European Journal of Purchasing and Supply Chain Management, IIE Transactions, Naval Research Logistics, Transportation Science, Production and Operations Management, EJOR, Supply Chain Management Journal, Industrial Organisations, Journal of Global Optimization, SIAM Journal of Optimization, Transportation Research Parts A & E, MIS Quarterly Executive, JOTA, International Journal of Production Research,* and *Decision Science*. He has co-authored several books.