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Profiling Green IT Leaders Quantitatively and Qualitatively

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ABSTRACT

In this study, we intend to identify key financial variables that can accurately classify Green IT leaders against Green IT followers. In particular, we build and compare single and meta-classifiers to identify the relationship between environmental performance and financial performance, while focusing on selecting and interpreting a final prediction model with a smaller set of financial performance indicators. Our experimental results demonstrate that several key variables representing the size, financial resources, operational efficiency, and risk-taking tendency of an organization can successfully identify Green IT leaders with approximately 90% of accuracy. In addition, we find that Green IT leaders show a higher utilization rate of Web pages as a green marketing channel than Green IT followers while they share common layouts of Web publication to build green IT brands with some differences.

Keywords: Green IT, Green IT Brands, Data Mining, Environmental Performance, Web Utilization Rate

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1. INTRODUCTION

Information and communication technology (ICT) has been well recognized as an important factor for firms to maintain their competitive advantage. For example, in (Dehning and Stratopoulos, 2003), managerial IT skills are positively related to firms' sustainability while competitor's knowledge of competitive advantage is negatively related to sustainability. However, the business environments of ICT industry keeps changing, and one of the main drivers of such changes comes from domestic and international regulations toward green technologies. According to a recent research by Gartner Inc., the global ICT industry accounts for approximately 2% of global CO_2 emissions through PCs, servers, fixed and mobile phones, local area network (LAN), office telecommunications, and printers. Thus, the ICT industry needs to reconsider its environmental initiatives before financial, environmental, and legislative pressures enforce IT firms to be more environmentally sustainable. In particular, due to the prevalence of PCs, servers, and all the telecommunications infrastructure worldwide, the ICT industry can play a leadership role in controlling and reducing the other 98% of CO_2 emissions caused by other industries.

According to prior studies (Murugesan, 2008; Boudreau *et al*., 2008), Green IT encompasses green use, green disposal, green design, and green manufacturing over the full life cycle of ICT-enabled products and services. Simple examples of Green IT practices include reducing energy consumption of IT equipments, properly recycling old computers and equipments, and designing energy efficient equipments. In the end, Green IT practices will have an influence on social, environment, and

financial performance either directly or indirectly. For example, it is claimed that IT investment should consider their environmental contexts and strategic directions to maximize its positive impact on financial performance because it has a greater impact when there are greater environmental changes and more proactive company strategy (Liand Richard Ye, 1999). In particular, ICT-enabled green supply chain management (GSCM) practices can affect environmental, economic, and operational performance depending on the degree of internal environmental management, green purchasing and design, and meeting environmental requirements from customers (Vachon, 2007; Zhu*et al*., 2008).

During the last decade, researchers have investigated economical and strategic motivations of firms' initiatives to responding to environmental issues (Alvarez Gil *et al*., 2001; Aragon-Correa and Sharma, 2003). Firms may start to develop Green IT strategies for their own self-interested (e.g., profit) and pragmatic drivers, ethical reasons or competitive motivations (Bansal and Roth, 2000; Montabon *et al.,* 2007). One interesting observation is that some firms become environmentally proactive, while others are still reluctant to take a more aggressive approach. For example, it is shown that B2C companies rather than B2B companies are more likely to publish environmental reporting and tend to take more proactive environmental strategies (Haddock-Fraser and Fraser, 2008). It is also claimed that internal stakeholders' and managers' awareness, behaviors, and organizational culture may determine the organizational involvement in environmental incentives, implementation, and eventually the success of firms' environmental strategy (Anderson and Bateman, 2000; Sharma, 2000).

In this study, we start from the assumption that Green IT activities lead to changes in financial performance indicators, and that Green IT leaders with higher green scores can be predicted using few financial performance indicators. This assumption is aligned with a study (Bharadwaj, 2000) that investigates the positive association between IT capability and financial performance measures of firms. Therefore, one of our main research goals is to identify these key financial variables. The usefulness of these variables is determined by their contributions to predictive accuracy in classifiers such as a decision tree, a neural network model, and meta-classifiers that combine multiple classifiers. Another goal of this study is to provide theoretical and intuitive foundations to explain when and how either a positive or negative relationship occurs between environmental and financial performance. Finally, we profile Green IT leaders and followers based on Web utilization patterns such as link structural patterns and Web utilization rates.

The remainder of this paper is organized as follows. Section 2 provides a literature review for theoretical foundation of characteristics of Green IT leaders. In Section 3, the framework of our research model and the description of the data set are provided. Section 4 shows and interprets experimental results based on data mining algorithms with accounting and financial information of IT firms, while Section 5 provides a comparative analysis of Web pages of Green IT leaders and followers focusing on the link structural patterns and Web utilization rates. Finally, Section 6 provides the conclusion of the paper and suggests several directions of future research.

2. LITERATURE REVIEW OF CHARACTERISTICS FOR GREEN IT LEADERS

We first found our theoretical foundation of which IT firms are most likely to be Green IT leaders from a stakeholder theory (Freeman, 1984). According to the stakeholder theory, the firms' responses to green IT innovation can be influenced by six external stakeholders such as customer, government, supplier, environmental parties, investor and shareholders, and media. For example, customers who are aware of Green IT issues may strongly demand that the IT firm take appropriate action in preserving the environment (Paulraj, 2009). Governmental regulations such as fuel efficiency initiatives and substances emission initiatives also encourage business entities to lower greenhouse gas emission. Other stakeholders may also influence the firm's responses to Green IT innovation by controlling financial resources (e.g., shareholders), coordinating energy efficiency and emission processes through supply chains (e.g., supplier), and bringing the transparency of environmental business activities (e.g., environmental parties and media).

It is expected that larger IT firms receive a higher level of pressures from stakeholders because green IT initiatives in larger firms have more serious impacts on green IT innovation than small- and medium-size firms. In addition, larger firms are more likely to take an explicit and strategic approach to Green IT innovation to share the same vision of green IT practices with all employees. Typically, large IT firms that take a strategic approach will review their IT infrastructures from an environmental perspective, develop comprehensive plans, and communicate and implement new initiatives to neutralize greenhouse gas emissions (Murugesan, 2008). While the size of firms can be measured in various ways, the number of employees is one of the most relevant measurements that reflect coordination costs. We posit Proposition 1 as follows:

Proposition 1: Larger IT firms in terms of the number of employees are most likely to be Green IT leaders.

Several studies (Li and Richard Ye, 1999; Russo and Fouts, 1997) investigated the applicability of a resource-based view theory to explain success or failure of similar Green IT strategies among many firms. According to the resource-based view theory, the profitability of the IT firm greatly affects the implementation of Green IT initiatives while a weak organizational culture

and inefficiencies in human resources are major barriers to the implementation of environmental action processes (Angel del Brio *et al.,* 2008; Madsen and Ulhoi, 2001). In particular, organizational capability that can develop products through environmentally friendly manufacturing processes is a must-have resource to successfully implement Green IT initiatives (Klassen and McLaughlin, 1996). In particular, financial investment is most likely to be the critical resource for IT firms to successfully implement Green IT strategies in green design (e.g., designing energy efficient and environmentally sound components, computers, servers, and cooling equipment) and green manufacturing (e.g., manufacturing IT systems, components, and associated subsystems with minimal impact on the environment) (Murugesan, 2008). Therefore, financially restricted small firms are less likely to be able to implement Green IT programs and less likely to be Green IT leaders (Henriques and Sadorsky, 1999). Several financial variables such as net income, earnings per share (EPS), and equity can be used to measure the status of financial resources. These observations are summarized as Proposition 2.

Proposition 2: IT firms with more financial resources are most likely to be Green IT leaders.

Note that the decision to carry out Green IT strategy is a strategic decision that requires the fundamental changes across organization over short and long term horizons. Therefore, when an IT firm formulates a Green IT plan, it should consider not only required financial costs to immediately implement a Green IT plan (short-term considerations) but also accrued financial benefits through avoided taxes and penalties over the coming years (long-term considerations) (Henriques and Sadorsky, 1999). In particular, designing and manufacturing energy efficient and environmentally sound IT systems will naturally lead to technological innovations, encouraging a transformation from its static organizational sys-tems into more dynamic units (Buysse and Verbeke, 2003; Lankoski, 2008).

In contrast, IT firms that already operate close to their full capacity are unlikely to find strong incentives to initiate and implement Green IT strategies because doing so will jeopardize current operational functionality and efficiency at their full capacity. Therefore, IT firms with Green IT initiatives are more likely to have lower levels of operation efficiency ratio (Henriques and Sadorsky, 1999). Several variables such as sales-to-assets ratio, return on assets (ROA), return on sales (ROS), and return on equity (ROE) can be used to measure an IT firm's operational efficiency of generating profits from every unit of asset, sales, and equity. We summarize these observations in Proposition 3 as follows:

Proposition 3: IT Firms with higher operation efficiency are less likely to be Green IT leaders.

Note that the firms' initiatives toward Green IT practices may depend on managerial perceptions of regulatory forces, public environmental concern, top management commitment and need for competitive advantage (Banerjee, 2001). In addition, competitive effects of environmental practices differ across firms, and firms should not blindly implement "best practices" of environmental management with the expectation that these practices will help them become green and competitive (Christmann, 2000). However, firms that initiated Green IT practices tend to believe that their ecological responsiveness allow them to sustain their competitiveness, thereby improving their long-term profitability (Clark, 1999). They also tend to take an aggressive risk taker's approach (e.g., pursuing new Green IT product-market expansion strategies) to realize exclusive benefits. Therefore, IT firms with higher external orientation and risk-taking tendency are more likely to initiate Green IT practices and hence to be Green IT leaders (Li and Richard Ye, 1999). The debt-to-equity ratio can be used to measure the risk-taking tendency of an organization. These observations are summarized as Proposition 4.

Proposition 4: IT Firms with higher risk-taking tendency are more likely to be Green IT leaders.

While the firms may voluntarily or involuntarily take green initiatives due to environmental regulations and public environmental concerns, they are most likely to publish their environmental management practices and outcomes to build strong green brands (Christmann, 2000; Clark, 1999). By doing so, they naturally expect ethical consumerism, a practice in which consumers who are becoming more aware of environmental conservationpurchase green brand products (Paulraj, 2009). In particular, using Web publication for green brand marketing is regarded as one of the most attractive green marketing channels because it can easily reach global customers with rich contexts of texts, images, audio and video files. While both Green IT leaders and followers are likely to utilize their Web pages to advertise their green IT initiatives, Green IT leaders are more likely to publish their green IT initiatives and efforts on their Web pages because they have invested more time and resources. These observations are summarized as Proposition 5.

Proposition 5: Green IT leaders are more likely to utilize Web pages as a green marketing channel to build green brands than Green IT followers.

While Green IT leaders may utilize Web pages as a green marketing channel more than Green IT followers, Green IT leaders and followers are likely to share common link patterns in using their Web pages for advertising Green IT initiatives on their Web pages. This is mainly because the main contents of Web pages should

reflect the same commitment of firms to environmental initiatives and their green policies and statements. In addition, it is very likely that Green IT followers (i.e., as the second movers) benchmark the structural layout of Web pages of Green IT leaders (i.e., the first movers) to maximize the effects of Web publishing for green brands (Suarez and Lanzolla, 2005). As a result, both Green IT leaders and followers are likely to publish their green initiatives and statements at the same or similar location from their home pages. We summarize our observations in Proposition 6 as follows:

Proposition 6: Green IT leaders and followers are likely to share common link structural patterns to publish their environmental initiatives and green statements.

3. RESEARCH MODEL AND DATA SET

3.1 Research Model

The first step in our study is to identify key financial variables that can accurately classify Green IT leaders against Green IT followers. For this purpose, we select multiple accounting variables that measure the firm size, financial status, risk-taking tendency, and operational efficiency based on extensive literature review. To test the usefulness of these identified variables, several data mining algorithms such as a decision tree and a neural network model are applied and their classification accuracies are computed and compared. In particular, accuracies of meta-classifiers are compared with those of various single classifiers. Once classifiers built on a complete set of accounting variables have been proved to be useful to accurately classify Green IT leaders, we try to identify a smaller set of informative and predictive variables by interpreting decision tree structures and a series of analysis of variance (ANOVA) outputs. Finally, theoretical and intuitive foundations are combined to profile Green IT leaders and Green IT followers.

3.2 Data

One of the main data sets for this study is green rankings list compiled by Newsweek Inc. with three research partners that assess the green scores of 500 largest U.S. firms based on revenue, market capitalization and number of employees. This is the first green score report created by Newsweek (http://www.thedailybeast.com/topics/green-rankings.html) and the final green score is an aggregated score of three scores: the environmental impact score based on actual resource consumption and emissions (45%), the green policies score (45%), and the reputation score (10%). The environmental impact score measures the total cost of all environmental impacts of an organization's operations through over 700 variables. The green policies score reflects an assessment of a company's environmental policies, program initiatives, lawsuits, and regulatory infractions, while the reputation score reflects the outcomes of an opinion survey to 13,000 international and national environmental professionals of academics, corporate social responsibility, and key green areas (Newsweek, 2009).

For our analysis, we first select all firms in IT industry (Green IT leaders) with their three green scores from the green ranking list. Initial Green IT leaders are 53. Then, we start to build a new set of financial variables for each company based on extensive literature review and authors' intuition. A total of 15 variables includes total asset, total liability, equity, sales, cost of goods sold (COGS), net income (NI measured as operating income before depreciation [OIBDP]), net profit after tax, EPS, number of employee, ROA, ROS, ROE, COGS/sales (COGS/S), debt to equity ratio, and sales to asset ratio. We collected values of these variables in 1998, 2003, and 2008 to possibly measure the relationship between "lagged" financial performance and environmental performance (Orlitzky *et al.,* 2003). Note that our data collection dated back to 1998, considering the fact that the first ISO standard (ISO 140001) to implement a systematic approach to improve environmental performance was released in the fall of 1996. A few IT firms are removed from further analysis due to missing

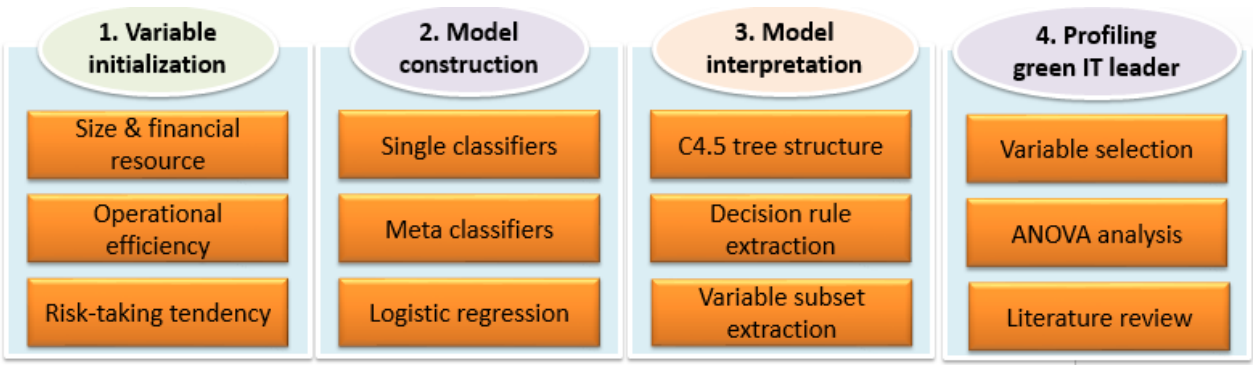

Figure 1. Research model.

values, resulting in 44 Green IT leader firms. We also computed the ratio of all these variables between 1998 and 2003, and 2003 and 2008. Finally, we selected 89 other IT firms (Green IT followers) matched by size, and collected the same set of financial variables information. In the end, we have a total of 133 IT firms (Refer to Appendix 1 for the complete list of these firms), 44 Green IT leaders and 89 Green IT followers with 75 variables.

Another data sets used for this study was obtained after visiting the Web sites of each one of the 133 IT firms and taking the snapshots of their home pages and contents of Web pages designed for building green brands (green Web pages). In particular, we recorded the navigational distance of such green Web pages from home pages and unique characteristics such as green images and texts in green fonts embedded in green Web pages. In this due process, we took the snapshots of merger's Web pages for merged firms since 2008 (i.e., 3Com and Palm Inc. merged by HP; Sun Microsystems by Oracle; Voyager Learning Co. by Cambium Learning Group) and the snapshots of new Web sites for the firms that recently changed their names (i.e., from Technitrol Inc. to Pulse Electronics; from Convera Corp. to Vertical Search Works). Note that we do not focus on analyzing the contents of Green IT announcements, and readers who are interested in this direction of research is recommended to refer to (Jain *et al.,* 2011).

4. EXPERIMENTAL RESULTS

4.1 Model Construction and Performance Analysis

In our first experiment, we tested whether or not many well known data mining algorithms can successfully distinguish Green IT leaders from Green IT followers based on financial performance indicators. For this classification task, we created a new class variable with two possible values ("yes" for a Green IT leader and "no" for a Green IT follower). We used Weka tool that can be downloaded from http://www.cs.waikato.ac.nz/ml/weka/. We selected four well known classifiers-a Zero R, a logistic regression, an artificial neural network (ANN), and a decision tree algorithm (C4.5). The Zero R classifier predicts all observations as points in the mode class (majority class) and hence is included only to serve as a basis algorithm. In our implementations of these algorithms, we used all the default settings in Weka for easy replications of our results except the number of hidden layers in an ANN which is set to 3 to avoid computational burden. We also compared the performance of meta-classifiers, bagging (Breiman, 1996) and boosting (Freund and Schapire, 1996) that combine 25 C4.5 tree classifiers to improve the performance of a single classifier.

To fairly evaluate these algorithms, we decided to take a *k*-fold cross validation evaluation in which the original data set is partitioned into *k* equal-sized sets, each maintaining the original class distribution, and each set is in turn used as a test set while the classification system is trained on the other sets. The final estimate from this *k*-fold cross validation is the average of estimates from each set and hence provide a more reliable estimate. Considering the fact that there are only 133 records, we set *k* to 133 so that each record is in turn used as a test set while the classification system is trained on the remaining records. We presented the performance of four prediction algorithms in Figures 2, 3.

Considering the fact that the proportion of the Green IT followers is 66.92% (89 firms out of a total of 133 firms), the predictive accuracy of Zero R (66.92%) was

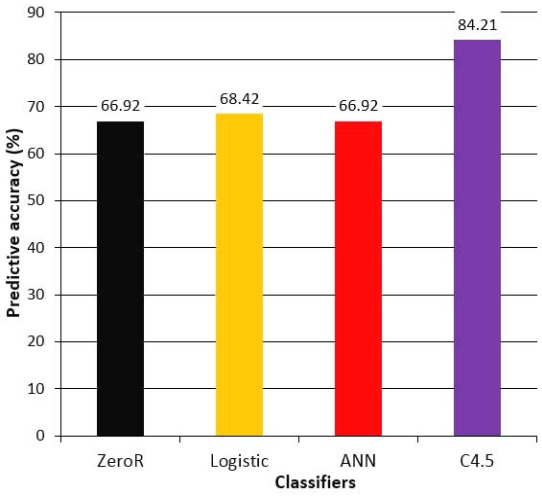

Figure 2. Accuracy of four single classifiers.

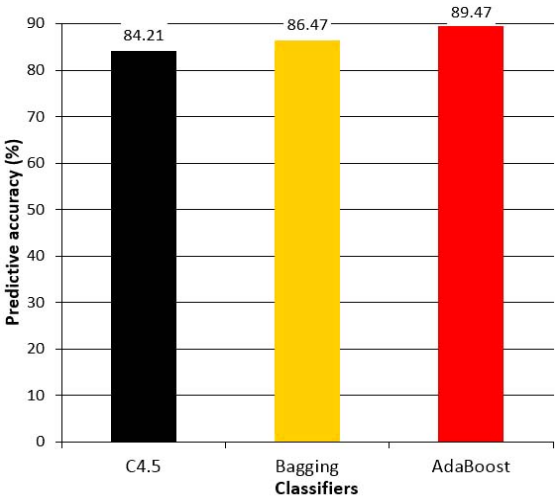

Figure 3. Accuracy of meta-classifiers vs. C4.5.

expected. The accuracy of a logistic regression model (68.42%) was slightly better than Zero R, but was not very promising. The accuracy of ANN model (66.92%) was somewhat unexpected, and we partially attributed this finding to the fact that we did not try to tune parameter values. The best performance was recorded by C4.5 with an 84.21% of accuracy. We also observed that the Zero R was the fastest, followed by C4.5 which took a few minutes to complete, Logistic regression, and ANN that took over several hours to calibrate and evaluate a model. Based on the predictive accuracy, speed, and easy interpretation, we concluded that C4.5 is the best (we will discuss in detail about the interpretation of C4.5 tree model in the following sections) and hence use it to form various meta-classifiers. In Figure 3, the Ada Boost meta-classifier showed the best performance with an 89.47% of accuracy, which is an improvement of 33.70% point and 6.24% point of Zero R and C4.5, respectively. Since meta-classifiers are more difficult to interpret and are computationally more complex, C4.5 will be used to select the key variables.

4.2 Interpretation of C4.5 Tree Structure and Identification of Informative Variables

Since we showed that 75financial indicators could be used to accurately distinguish Green IT leaders from Green IT followers, we narrow down a set of key variables further by drawing out *if-then* rules from a final C4.5 tree structure. Note that a rule-based classifier (e.g., C4.5) that consists of *if-then* rules improves the comprehensibility and boost the managers' trust in the classifier itself. We presented a C4.5 tree obtained from aforementioned classification tasks in Figure 4 and corresponding *if-then* rules in Table 1.

According to the tree structure in Figure 4, the most important variable for identifying Green IT leaders is the number of employees in 2008, which is located at the root node. Other important variables include the ratio of COGS/S between 2003 and 2008, the ratio of NI between 2003 and 2008, and EPS and ROS in 2008. Considering the cut-off values of these variables, we constructed the results of Figure 4 with five *if-then* rules that distinguish Green IT leaders from Green IT followers in Table 1.

Let's consider Rules 1 and 2.In both rules, "the ratio of COGS/S between 2003 and 2008 $\leq$ 0.537314" implies that the proportion that COGS occupies in Sales is dramatically reduced (cost reduction) by about 47% between 2003 and 2008. Then, Rule 1 reads as follows: If the number of employees in 2008 is less than or equal to 750 (0.75 thousands) and the cost index is reduced by 47%, then the firm is a Green IT follower. Similarly, Rule 2 specifies that if the number of employees in 2008 is between 750 and 5,300 and the cost indicator is improved by 47%, then the firm is a Green IT leader. That is, when the cost indicator is improved in a small size company ($\leq$ 750 employees), it is more likely to be Green IT followers, but when the cost indicator is improved in a medium size company with employees between 750 and 5,300, it is more likely to be a Green IT leader. Interestingly, Rule 3 indicates that as long as it is a small size or medium size company with up to 5,300 employees, if its cost indicator is worsened by 47%, then the firm is a Green IT follower. Other rules can be interpreted in a similar manner and hence will not be discussed further due to the limited space.

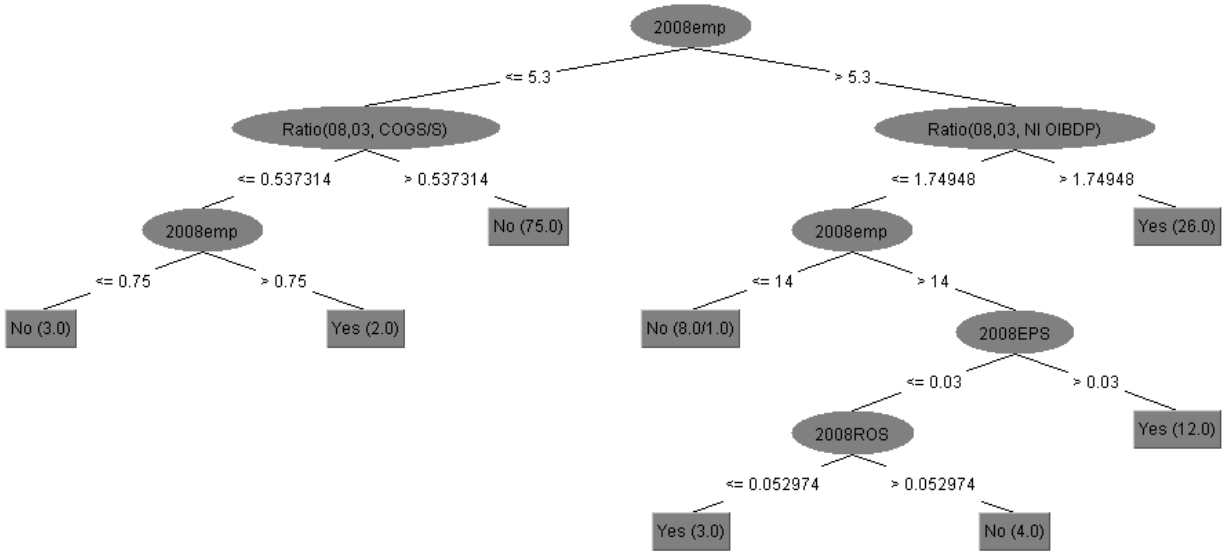

Figure 4. Tree structure of a C4.5 decision tree classifier. emp: employee, COGS/S: cost of goods sold/sales, NI: net income measured as OIBDP: operating income before depreciation, EPS: earnings per share, ROS: return on sales.

Table 1. Rule statements of a C4.5 decision tree classifier

Rule	Rule statement
Rule 1	if the number of employee in 2008 ≤ 0.75, and the ratio of COGS/S between 2003 and 2008 ≤ 0.537314, then the firm is a Green IT follower.
Rule 2	if 0.75 < the number of employee in 2008 ≤ 5.3, and the ratio of COGS/S between 2003 and 2008 ≤ 0.537314, then the firm is a Green IT leader.
Rule 3	if the number of employee in 2008 ≤ 5.3, and the ratio of COGS/S between 2003 and 2008 > 0.537314, then the firm is a Green IT follower.
Rule 4	if the ratio of NI between 2003 and 2008 ≤ 1.74948, the number of employees in 2008 > 14, EPS of 2008 ≤ 0.03, and ROS of 2008 ≤ 0.052974, then the firm is a Green IT leader.
Rule 5	if the ratio of NI between 2003 and 2008 ≤ 1.74948, the number of employees in 2008 > 14, EPS of 2008 > 0.03, then the firm is a Green IT leader.

Employee is shown in thousand.
COGS/S: cost of goods sold/sales, NI: net income, EPS: earnings per share, ROS: return on sales.

In pursuit of another way to identify predictive variables, we implemented a forward variable selection algorithm in Weka and obtained six variables, including the number of employees and EPS in 2008, and ratios of four variables (Asset, NI OIDBP, Employees, and Equity) between 2008 and 2003. Note that these variables are very similar to those found from C4.5 classifier. When the C4.5 classifier was built only on these six informative variables, the classification accuracy was the highest (89.47%) which is identical with the performance of Ada Boost metal-classifier. Further more, the final model was accurate for prediction of both Green IT leaders (84.21%) and Green IT followers (92.1%).

4.3 Validating Propositions with Financial Variables

We found that most propositions are at least partially validated, but none of them is completely validated mainly because all decision rules incorporate more than one financial variable while the propositions are stated in terms of only one variable. For example, the number of employees was chosen at the root node on a C4.5 decision tree, indicating that it is the most important indicator and is included in all decision rules. Therefore, it is clear that the size of a company is critical to identify Green IT leaders, which partially validate Proposition 1. However, the size of a company by itself should be used in conjunction with other types of variables such as sales growth, operation efficiency measures (EPS or ROS), and/or profitability (NI or COGS/S) to correctly identify Green IT leaders (refer to the interpretation of Rules 1, 2, and 3).

Rules 1 through 8 partially validate Proposition 2 in which profitability indicators (NI, COGS/S, and EPS) play an important role with other variables in a classification task. As a simple example, Rule 8 specifies that if the profitability is increased by more than 74.95% between 2003 and 2008 in a large size firm (≥ 5,300 employees), it is a Green IT leader. Rule 8 is a good example of establishing both Propositions 1 and 3 simultaneously, meaning that a larger firm with healthier financial resources is more likely to be a Green IT leader. Both Rules5 and 6 present a good example that illustrates the importance of a firm's operation efficiency combined with the size of a firm and a profitability indicator, partially validating Proposition 3.In Rules 5 and 6, a firm's operation efficiency is expressed as ROS (the higher ROS value, the higher efficiency a firm's operation is), and they can be restated as follows: assuming that profitability indicators meet certain criteria (i.e., net income in 2008 is increased by 75% from 2003, EPS of 2008 ≤ 0.03) in a company (≥ 1,400 employees), if operation efficiency is less efficient than 0.052974, then it is a Green IT leader, otherwise, it is a Green IT follower.

We noted that no decision rules include risk-taking tendency variables such as debt-to-equity ratio and hence Proposition 4 is not explicitly validated by any one of decision rules. A series of ANOVA also revealed that there is no significant difference between the mean values of debt-to-equity ratio of Green IT leaders and that of Green IT followers except in 1998 at $\alpha = 0.05$. However, another series of ANOVA showed that the mean values of both liability and equity of Green IT leaders and Green IT followers are significantly different at $\alpha = 0.05$. Therefore, we conclude that risk-taking tendency is still an important factor in accurately identifying Green IT leaders, validating Proposition 4. However, it is recommended that the risk-taking tendency be separately measured by measuring both Liability and Equity indicators, not by measuring one combined measure such as liability/equity.

5. WEB UTILIZATION FOR BUILDING STRONG BRAND TOWARD GREEN IT-LEADER

5.1 Web Utilization Rates of IT Firms

We also investigated the Web pages of 133firms

(44 Green IT leaders and 89 Green IT followers) during the period of September 16–20, 2011 to qualitatively and quantitatively measure their continuing efforts for establishing strong brand through Web site as Green IT leaders. In particular, we focused on images (e.g., image location, size, and color), structural designs (e.g., navigation depth and difficulty of locating information related to environmental initiatives), and common layouts of their green policies and statements (e.g., Home page → About Us → Corporate Responsibility). We explored all the links from home pages to search for the same items for the maximum of five minutes because typical Web navigators do not spend more than five minutes to find such information. Once such information were found, we subjectively analyzed the details and completeness of the informative contents and recorded quantitative (e.g., page length and navigation depth to the desired information) and qualitative information (e.g., rigor and completeness of environmental policy) along with information of how difficult it is for typical users to find such information. If no such information were found, we concluded that the company fails in utilizing the Web to promote its Green IT initiatives.

We first estimated the Web utilization rates of 44 Green IT leaders and 89 Green IT leaders separately. To our surprise, we found that only 26 out of 44 Green IT leaders maintain Green IT mission statements on their home pages or pages linked from home page. Note that the firms that provide green IT solutions (i.e., cloud computing and virtualized computing solutions) for other firms but do not maintain explicit green Web pages of their own are regarded as one of the firms that fail to utilize the Web pages to advertise green initiatives. Therefore, we estimated the overall Web utilization rate of Green IT leaders for building brand toward Green IT leader was about 59.1% (≈ 26/44 of Green IT leaders). Then, we also decided to estimate the Web utilization rates for two subgroups of Green IT leaders, "High" Green IT leaders (21 Green IT leaders firms) with green scores of 75 or higher and "Middle" Green IT leaders (23 Green IT leaders with green scores of 74 or lower). We found that the Web utilization rate of "High" Green IT leaders is significantly higher (17/21 ≈ 80.95%) than that of "Middle" Green IT leaders (9/23 ≈ 39.1%). The Web utilization rate for Green IT followers is even lower than that of "Middle" Green IT leaders, estimated to be about 30.3% (≈ 39/89). We concluded that the Web utilization rate of IT firms was relatively low except "High" Green IT leaders. However, Web utilization rates among Green IT leaders and followers validate Proposition 5.

In addition, we noted that, among those 26 Green IT leaders, only two firms (Dell and Cognizant Technology) make their environmental responsibilities visible using images on their home pages as shown in Figures 5, 6. For example, on Dell's home page shown in Figure 5, users can immediately notice an image of a green leaf under Headlines section and learn about Dell's environmental policies by clicking the image or the link of "Dell Announces Corporate Responsibility Report." This report contains valuable information of Dell's various sustainability efforts such as "developing innovative energy efficient products and solutions for customers, shipping products with sustainable packaging materials, and providing world class recycling options that makes it easy for its customers to be green." In addition, users may select "Corporate Responsibility" → "Environment" option to read more articles related to

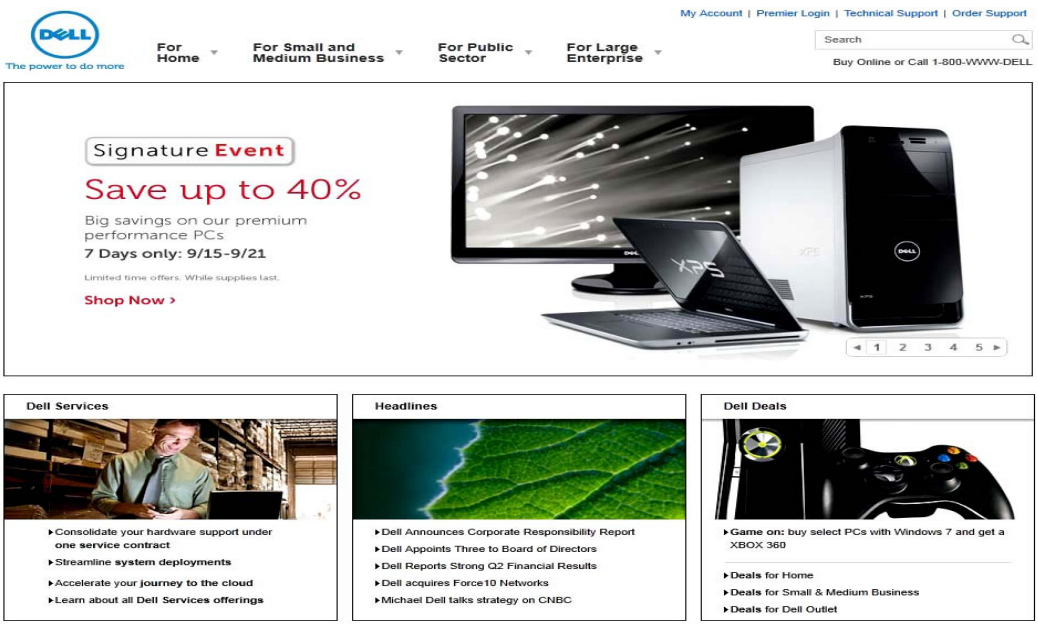

Figure 5. Snapshot of Dell's home page.

Dell's Green IT activities.

The Cognizant Technology's home page shown in Figure 6 is the aesthetically best for the purpose of delivering its strong commitment to Green IT through a visible and large image at the lower central location of the home page with texts written in green colors. By clicking on "The Greening of IT" link or image, users can access two reports: one business case report for reducing technology's green footprint and the other report on interviewing chief information officer (CIO) as chief sustainability officer about Greening IT practices at their workplace. The home page of Apple does not contain any image but contains a link, Environment, but it is not easy to immediately notice because it is written in a very small font size and users need to scroll down to locate it at the bottom of the home page.

The home pages of four Green IT followers (Hitachi,http://hitachi.com; Datagram, http://datagram.com/; USA Mobility, http://usamobility.com/; and Fujitsu, http://www.fujitsu.com/) also include a direct link or an image that promotes their strong efforts for implementing Green IT initiatives. For example, visitors of Fujitsu's home page can easily check out by clicking on "Environment" option on the home page various activities ranging from its fundamental philosophy, principle, and environmental vision to environmental protection and communication activity including the environmental management system, environmental education, and green policy innovation.

5.2 Link Pattern Analysis for Web Utilization

We visited and investigated the link structure of 65 IT firms (26 Green IT leaders and 39 Green IT followers) that use Web to advertise their efforts to implement green initiatives to validate Proposition 6. To categorize the structural patterns of Web pages, we use "[A: B]" and "{ }" to indicate alternative and optional Web pages, respectively, while using "→" to represent a link between pages. For example, the link structure component of "[Corporate: Social] Responsibility" implies that some firms use "Corporate Responsibility" and others use "Social Responsibility", while "{Corporate} Responsibility" implies that firms use either "Corporate Responsibility" or "Responsibility" to indicate the linked Web pages of environmental initiatives. We discovered a total of seven link structural patterns of green Web pages and summarized them in Table 2.

Note that the first link pattern, L1, is the most desired pattern among all the link patterns because it places images or links on the home page to directly deliver its environmental initiatives so that users immediately recognize their efforts. Although this is the most effective way of building a brand toward Green IT leaders, only three firms in Green IT leaders and four firms in Green IT followers used this pattern. The most popular link pattern adopted by Green IT leaders was the variations of "Home → About Us (or Company Name)." All the three patterns (L2, L3, and L4) include "Home → About Us (or Company Name)" as a root structure and then contain a few additional links such as "Corporate Citizenship", "Corporate Responsibility" or "Environmental Compliance." Seventeen Green IT leaders and 16 Green IT followers use one of L2, L3, or L4 patterns, resulting in 65.3% (≈ 17/26) and 41.0% (≈ 16/39) of adoption rate of these link patterns, respectively. This implies that firms with an intention to host their environmental initiatives on their Web pages consider using one of these patterns to maximize the usability and impacts of their brand marketing messages.

One of the most important differences of link patterns between Green IT leaders and followers was the fact that Green IT followers used two new link patterns, L7 and L8, that none of Green IT leaders adopted. We noted that these two new link patterns were related to "{Product} Support" and "{Product} Quality" and adop-

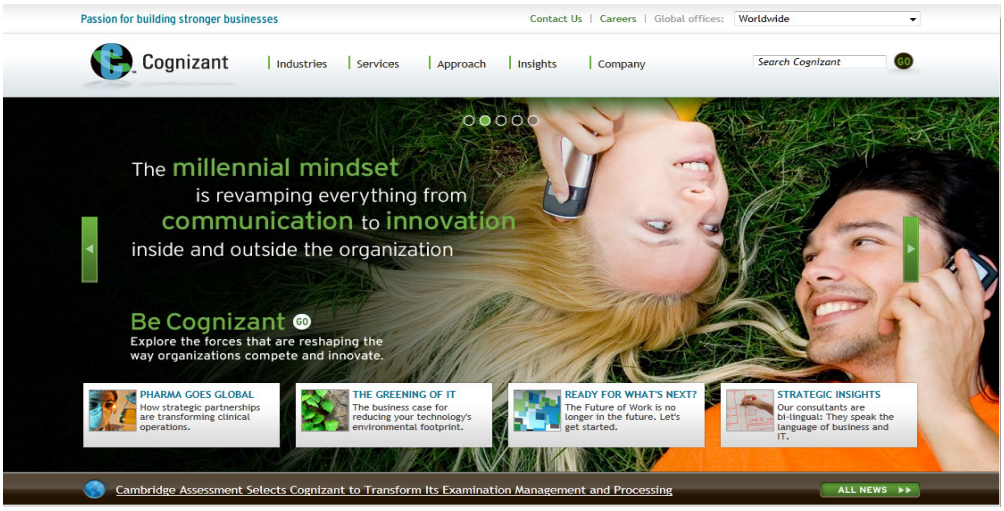

Figure 6. Snapshot of Cognizant Technology's home page.

Table 2. Link structures from home pages to Web pages of environmental initiatives

No.	Location of Green IT Information	Green IT Leaders	Green IT Followers
L1	**Home**	3 (Dell, Cognizant, Apple)	4 (Hitachi, Datagram, USA mobility, Fujitsu)
L2	**Home → About Us (or Company Name)** → [Corporate: Social] Responsibility → Environmental Sustainability	7 (HP, IBM, Applied Materials, Cisco, Adobe System, Advanced Micro Devices, Symantec)	11 (LAM Research Co., etc)
L3	**Home → About Us (or Company Name)** → Corporate Citizenship → Environmental Sustainability	5 (Intel, Sun Microsystem, Oracle, Nvidia, CA)	
L4	**Home → About Us (or Company Name)** → [{Environmental} Compliance: Environment]	5 (Xerox, EMC, Micron Technology, Analog Devices, KLA-Tencor)	5 (LexMark, Microchip Tech, Hutchinson, Hickory, Manitoba Telecom)
L5	**Home → [Corporate Citizenship: GlobalResponsibility]**	4 (Motorola, Verizon, Texas Instrument, Qualcomm)	1 (BT Group PLC)
L6	**Home → News and Information** → {⋯} → Responsibility → Sustainability	2 (Harris, Corning)	
L7	**Home → Support** → [RoHS Compliance: Quality and Reliability]		9 (Radysis, Tekelec, etc)
L8	**Home** → {[About: Company]} → **Quality**		9 (Quantum, Innovex, etc)
	Total number of firms	26	39

ted by many semiconductor manufacturing B2B firms that use hazardous raw materials regulated by Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) directive or other quality management certificate. In fact, the combination of these two link patterns was the most frequently adopted by Green IT followers (i.e., 46.2% of adoption rate). However, the length of all the link patterns adopted by either Green IT leaders or followers is shorter than five hops from the home page, allowing visitors to find such information easily. Overall, the Proposition 6 is partially validated.

6. CONCLUSION AND FUTURE RESEARCH

In this paper, we developed several classifiers and meta-classifiers to identify key financial variables to distinguish Green IT leaders from Green IT followers. In general, meta-classifiers returned higher accuracy although their final prediction models were difficult to understand, significantly discouraging decision markers to adopt them for exploratory studies. A finally chosen simple decision tree model with a set of six variables was able to accurately classify Green IT leaders and Green IT followers with an accuracy rate of 89%. Decision rules from a decision tree and a series of ANOVA validate (at least partially) all propositions based on theories and literature review.

Among the most predictive six variables, the number of employees is chosen at the root node of decision trees and hence regarded as the most important indicator to distinguish Green IT leaders from Green IT followers and is included in all decision rules. However, our experimental results indicate that the size of a company by itself should not be used alone but should be used in conjunction with other variables such as sales growth, operation efficiency measures (EPS or ROS), and/or profitability (NI or COGS/S). We also noted that a larger firm with healthier financial resources is more likely to be a Green IT leader. While no decision rules include risk-taking tendency variables, ANOVA analysis indicates that both liability and equity information are still important in accurately identifying Green IT leaders. In addition, Green IT leaders show a higher utilization rate of Web pages as a green marketing tool than Green IT followers while most of them share common layouts of Web publication-e.g., taking similar link structural patterns of "Home → About Us (or Company Name)"-to build green brands while Green IT followers use two new link patterns that none of Green IT leaders adopted.

One possible direction for future study is to study the dynamics of Green IT practices in IT organizations over years. Note that while our decision rules include changes of a few variables over past 5 years to capture dynamic financial performance, we were not able to fully consider the dynamic environmental performance mainly because green score data sets were not available for the past years. Therefore, it will be an interesting research question to collect qualitative and quantitative data sets over years and to profile specific organizational and managerial behaviors and cultures of successful champions in Green IT leaders and unsuccessful champions in Green IT followers. Another possible direction for future study starts with the understanding that firms in different industries or even in different sectors responses of firms may respond differently to environmental concerns because of the uniquely perceived com-

petition structure, societal responsibility, and environmental impact. However, many studies in regard to environmental concerns have overwhelmingly focused on the manufacturing industry. Therefore, it will be interesting to compare organizations in different industries (e.g., IT and manufacturing) to study whether or not different levels of perceived competitiveness and societal responsibility requirement can affect the environmental proactive initiatives in organizations.

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REFERENCES

Alvarez Gil, M. J., Burgos Jimenez, J., and Cespedes Lorente, J. J. (2001), An analysis of environmental management, organizational context and performance of Spanish hotels, *Omega*, **29**(6), 457-471.

Anderson, L. M. and Bateman, T. S. (2000), Individual environmental initiative: championing natural environmental issues in U.S. business organizations, *Academy of Management Journal*, **43**(4), 548-570.

Angel del Brio, J., Junquera, B., and Ordiz, M. (2008), Human resources in advanced environmental approaches: a case analysis, *International Journal of Production Research*, **46**(21), 6029-6053.

Aragon-Correa, J. A. and Sharma, S. (2003), A contingent resource-based view of proactive corporate environmental strategy, *Academy of Management Review*, **28**(1), 71-88.

Banerjee, S. B. (2001), Managerial perceptions of corporate environmentalism: interpretations from industry and strategic implications for organizations, *Journal of Management Studies*, **38**(4), 489-513.

Bansal, P. and Roth, K. (2000), Why companies go green: a model of ecological responsiveness, *Academy of Management Journal*, **43**(4), 717-736.

Bharadwaj, A. S. (2000), A resource-based perspective on information technology capability and firm performance: an empirical investigation, *Management Information Systems Quarterly*, **24**(1), 169-196.

Boudreau, M. C., Chen, A., and Huber, M. (2008), Green is: building sustainable business practices, In: Watson, R. T. (ed.), *Information Systems*, CEPORT LLC, Oak Brook, IL.

Breiman, L. (1996), Bagging predictors, *Machine Learning*, **24**(2), 123-140.

Buysse, K. and Verbeke, A. (2003), Proactive environmental strategies: a stakeholder management perspective, *Strategic Management Journal*, **24**(5), 453-470.

Christmann, P. (2000), Effects of best practices of environmental management on cost advantage: the role of complementary assets, *Academy of Management Journal*, **43**(4), 663-680.

Clark, D. (1999), What drives companies to seek ISO 14000 certification?, *Pollution Engineering*, **31**(7), 14-18.

Dehning, B. and Stratopoulos, T. (2003), Determinants of a sustainable competitive advantage due to an IT-enabled strategy, *Journal of Strategic Information Systems*, **12**(1), 7-28.

Freeman, R. E. (1984), *Strategic Management: A Stakeholder Approach*, Pitman, Boston, MA.

Freund, Y. and Schapire, R. (1996), Experiments with a new boosting algorithm, *Proceedings of the Thirteenth International Conference on Machine Learning*, Bari, Italy, 148-156.

Haddock-Fraser, J. and Fraser, I. (2008), Assessing corporate environmental reporting motivations: differences between 'close-to-market' and 'business-to-business companies, *Corporate Social Responsibility and Environmental Management*, **15**(3), 140-155.

Henriques, I. and Sadorsky, P. (1999), The relationship between environmental commitment and managerial perceptions of stakeholder importance, *Academy of Management Journal*, **42**(1), 87-99.

Jain, R. P., Benbunan-Fich, R., and Mohan, K. (2011), Assessing green IT initiatives using the balance scorecard, *IT Professional*, **13**(1), 26-32.

Klassen, R. D. and McLaughlin, C. P. (1996), The impact of environmental management on firm performance, *Management Science*, **42**(8), 1199-1214.

Lankoski, L. (2008), Corporate responsibility activities and economic performance: a theory of why and how they are connected, *Business Strategy and the Environment*, **17**(8), 536-547.

Li, M. and Richard Ye, L. (1999), Information technology and firm performance: linking with environmental, strategic and managerial contexts, *Information and Management*, **35**(1), 43-51.

Madsen, H. and Ulhoi, J. P. (2001), Greening of human resources: environmental awareness and training interests within the workforce, *Industrial Management and Data Systems*, **101**(2), 57-65.

Montabon, F., Sroufe, R., and Narasimhan, R. (2007), An examination of corporate reporting, environmental management practices and firm performance, *Journal of Operations Management*, **25**(5), 998-1014.

Murugesan, S. (2008), Harnessing green IT: principles and practices, *IT Professional*, **10**(1), 24-33.

Newsweek (2009, September 16), Green rankings 2009: methodology, cited 2013 May 15, Available from: http://www.thedailybeast.com/newsweek/2009/09/16/green-rankings-2009-methodology.html.

Orlitzky, M., Schmidt, F. L., and Rynes, S. L. (2003), Corporate social and financial performance: a meta-analysis, *Organization Studies*, **24**(3), 403-441.

Paulraj, A. (2009), Environmental motivations: a classi-

fication scheme and its impact on environmental strategies and practices, *Business Strategy and the Environment*, **18**(7), 453-468.

Russo, M. V. and Fouts, P. A. (1997), A resource-based perspective on corporate environmental performance and profitability, *Academy of Management Jo-urnal*, **40**(3), 534-559.

Sharma, S. (2000), Managerial interpretations and organizational context as predictors of corporate choice of environmental strategy, *Academy of Management Journal*, **43**(4), 681-697.

Suarez, F. and Lanzolla, G. (2005), The half-truth of first-mover advantage, *Harvard Business Review*, **83**(4), 121-127.

Vachon, S. (2007), Green supply chain practices and the selection of environmental technologies, *International Journal of Production Research*, **45**(18-19), 4357-4379.

Zhu, Q., Sarkis, J., and Lai, K. H. (2008), Confirmation of a measurement model for green supply chain management practices implementation, *International Journal of Production Economics*, **111**(2), 261-273.

Appendix 1. The list of firms used in Green IT analysis

No	Class	Name	No	Class	Name	No	Class	Name
1	High	Hewlett-Packard	*45*	Low	LAM RESEARCH CORP	*90*	Low	TECHNITROL INC
2	High	Dell	*46*	Low	NOVELLUS SYSTEMS INC	*91*	Low	ZYGO CORP
3	High	Intel	*47*	Low	SCIENTIFIC GAMES CORP	*92*	Low	II-VI INC
4	High	IBM	*48*	Low	HITACHI LTD	*93*	Low	SHENANDOAH TELECOMMUNCO
5	High	Applied Materials	*49*	Low	LASERCARD CORP	*94*	Low	TELEPHONE & DATA SYSTEMS INC
6	High	Cisco Systems	*50*	Low	XATA CORP	*95*	Low	USA MOBILITY INC
7	High	Sun Microsystems	*51*	Low	STEELCLOUD INC	*96*	Low	VIMPEL COMMUNICATIONS
8	High	Adobe Systems	*52*	Low	CONCURRENT COMPUTER CP	*97*	Low	BT GROUP PLC
9	High	Advanced Micro Devices	*53*	Low	CRAY INC	*98*	Low	CINCINNATI BELL INC
10	High	Motorola	*54*	Low	PALM INC	*99*	Low	HICKORY TECH CORP
11	High	Texas Instruments	*55*	Low	DATARAM CORP	*100*	Low	GENERAL COMMUNICATION CL A
12	High	Xerox	*56*	Low	QUALSTAR CORP	*101*	Low	LEVEL 3 COMMUNICATIONS INC
13	High	Microsoft	*57*	Low	QUANTUM CORP	*102*	Low	TELEFONICA DE ARGENTI
14	High	Autodesk	*58*	Low	OVERLAND STORAGE INC	*103*	Low	MANITOBA TELECOM SVCS
15	High	Yahoo	*59*	Low	DOT HILL SYSTEMS CORP	*104*	Low	MERISEL INC
16	High	EMC	*60*	Low	BLUE COAT SYSTEMS INC	*105*	Low	INSIGHT ENTERPRISES INC
17	High	Verizon Comm.	*61*	Low	BROCADE COMM.	*106*	Low	NOVELL INC
18	High	Symantec	*62*	Low	3COM CORP	*107*	Low	SILICON GRAPHICS INC
19	High	AT&T	*63*	Low	EMULEX CORP	*108*	Low	ZIX CORP
20	High	Micron Technology	*64*	Low	ELECTRONICS FOR IMAGI	*109*	Low	BLACK BOX CORP
21	High	Apple	*65*	Low	RADISYS CORP	*110*	Low	VOYAGER LEARNING CO
22	Middle	Qualcomm	*66*	Low	LOGITECH INTERNATIONALS A	*111*	Low	IAC/INTERACTIVECORP
23	Middle	Oracle	*67*	Low	INTELLI-CHECK - MOBIL	*112*	Low	EASYLINK SERVICES INT
24	Middle	Analog Devices	*68*	Low	LEXMARK INTL INC -CL A	*113*	Low	COVER-ALL TECHNOLOGIES INC
25	Middle	Pitney Bowes	*69*	Low	EMS TECHNOLOGIES INC	*114*	Low	PHOENIX TECHNOLOGIES LTD
26	Middle	Harris	*70*	Low	TEKELEC	*115*	Low	INTRUSION INC
27	Middle	Western Digital	*71*	Low	WEGENER CORP	*116*	Low	DATAWATCH CORP
28	Middle	Intuit	*72*	Low	ESCO TECHNOLOGIES INC	*117*	Low	CONVERA CORP
29	Middle	Qwest Communications	*73*	Low	WHITE ELECTRONIC DESIGNS CP	*118*	Low	MAGIC SOFTWARE ENTERPRISES
30	Middle	Nvidia	*74*	Low	DIODES INC	*119*	Low	AMERICAN SOFTWARE -C
31	Middle	Juniper Networks	*75*	Low	DIONICS INC	*120*	Low	EPICOR SOFTWARE CORP
32	Middle	NetApp	*76*	Low	ENERGY CONVERSION DEV	*121*	Low	VERAMARK TECHNOLOGIES
33	Middle	Corning	*77*	Low	EXAR CORP	*122*	Low	MANDALAY MEDIA INC
34	Middle	KLA-Tencor	*78*	Low	INNOVEX INC	*123*	Low	AUTHENTIDATE HOLDING CORP
35	Middle	Computer Sciences	*79*	Low	INTL RECTIFIER CORP	*124*	Low	BRANDPARTNERS GROUP I
36	Middle	CA	*80*	Low	MICROSEMI CORP	*125*	Low	CADENCE DESIGN SYSTEM
37	Middle	NII Holdings	*81*	Low	ZARLINK SEMICONDUCTOR	*126*	Low	EBIX INC
38	Middle	Citrix Systems	*82*	Low	NATIONAL SEMICONDUCTO	*127*	Low	SEDONA CORP
39	Middle	Ingram Micro	*83*	Low	SEMTECH CORP	*128*	Low	SYBASE INC
40	Middle	Cognizant Technology	*84*	Low	SPIRE CORP	*129*	Low	BORLAND SOFTWARE CORP
41	Middle	BMC Software	*85*	Low	LOGIC DEVICES INC	*130*	Low	PROGRESS SOFTWARE CORP
42	Middle	American Tower	*86*	Low	LATTICE SEMICONDUCTOR CO	*131*	Low	PARAMETRIC TECHNOLOGY CORP
43	Middle	Cerner	*87*	Low	CREE INC	*132*	Low	FUJITSU LTD
44	Middle	McAfee	*88*	Low	MICROCHIP TECHNOLOGY INC	*133*	Low	INTEGRAL SYSTEMS INC
			89	Low	HUTCHINSON TECHNOLOGY			

The sequential number (i.e., No column) reflects the Green IT rankings based on green rankings from the Newsweek study.
High: IT firms with green scores of 75 or higher, Middle: IT firms with green scores of 74 or lower, Low: IT firms without green scores.