Do green supply chain management initiatives impact stock prices of firms?

Indranil Bose a,⁎, Raktim Pal b,1
a School of Business, The University of Hong Kong, Pokfulam Road, Hong Kong
b College of Business, James Madison University, Showker Hall, MSC 0202, 800 South Main Street, Harrisonburg, VA 22807, USA

1 Tel.: +1 540 568 7094.
⁎ Corresponding author. Tel.: +1 852 2241 5845; fax: +1 852 2858 5614.
E-mail addresses: indranil_bose@yahoo.com (I. Bose), palrx@jmu.edu (R. Pal).

A R T I C L E  I N F O

Article history:
Received 4 February 2011
Received in revised form 29 September 2011
Accepted 23 October 2011
Available online 28 October 2011

Keywords:
Event study
Green operations
Green supply chain
Stock prices
Sustainability
Recycling
Remanufacturing

A B S T R A C T

Although firms have been taking green supply chain management (GSCM) initiatives, it is not known whether they create value for firms. We analyze 104 announcements related to GSCM using an event study, and determine what causes statistically significant gain in stock prices for these firms. Manufacturing firms, firms with high R&D expenses, and early adopters show a strong increase in stock prices on the day of the announcement. At the same time, small firms, firms not well-known for taking green initiatives, as well as firms that are low in growth potential considerably surprise the market when they make such announcements.

In addition, while some initiatives may yield significant benefits in the long run their short-term outcomes may not be very attractive. Also, there is the risk of adopting a relatively unproven technology. Some of the GSCM projects may have involved multiple organizations and all key supply chain partners should be on board through proper incentive alignment and there should be a consensus on measures to be used for assessing project success. While a number of previous research studies have looked into various dimensions of benefits of GSCM, we take a different approach. We use the event study method to analyze the change in stock price of firms due to implementation of GSCM practices. We hope our study will be able to clear up some of the dilemmas about the value of green supply chain.

The rest of the paper is organized as follows. In the next section we discuss the motivation and scope of the study. The next section details the development of the research hypotheses. Then we present the research method, and explain the process of data collection and filtering. Next, the results obtained from this research are described. Finally, we discuss the managerial implications and conclusions derived from the study.

2. Motivation and scope

2.1. Green supply chain fundamentals

First, let us discuss what green supply chain means. Broadly speaking, any sustainability issues encountered in managing supply chain is part of GSCM. According to the Environmental Protection Agency (EPA), “the traditional definition of sustainability calls for policies and strategies that meet society's present needs without compromising...
the ability of future generations to meet their own needs.” We use the same connotation of long-term maintenance of the well-being of the natural world with responsible use of resources in the context of supply chain management. While regular forward supply chain usually deals with flow of products starting from initial processing of raw materials at suppliers to delivery of finished items to customers, the scope of green supply chain goes beyond this usual definition. It also includes environmentally friendly product and process design, extension of product life cycle, and recovery of end-of-use and end-of-life returns. Thus, green supply chain encompasses components of environmental management as well as closed-loop supply chain, which integrates design, operations, and control of a system for maximizing value over life cycle of a product including value recovery from return/disposal at the end of its use. For example, by employing efficient closed-loop supply chain Xerox Corporation not only makes and sells new printer cartridges but also the organization generates substantial revenue by remanufacturing used cartridges collected from the users. Interested readers may refer to Linton et al. [57] and Guide and Van Wassenhove [36] for detailed information on the topic of closed-loop supply chain.

In green product design, analysis is made to assess the environmental impact during the useable life cycle and afterwards, and attempts are made to minimize adverse effects [47]. Modular design and easy disassembly options help in repair and remanufacturing of the end-of-use returns, and recycling of end-of-life returns [36,52]. Green process design includes elimination and/or reduction of waste and by-product during manufacturing [48], reuse of wasted energy [32], adherence to quality standards such as ISO 14000 and related eco-management and audit schemes to reduce defects [17], and adoption of lean principles to avoid excess usage [50,107]. Extension of product life cycle helps in reducing resource consumption [56]. Reverse supply chain deals with acquisition of used products, reverse logistics for bringing collected products to reprocessing facilities, inspection (for deciding subsequent actions such as repair, remanufacturing, recycling, or disposal), recovery (remanufacturing, recycling, etc.), and remarketing [34]. This reverse chain is coordinated well with the regular forward chain to form the closed-loop supply chain. Thus the scope of green supply chain includes environmental management, closed-loop supply chain, and a broad perspective of generating value for the organization and society.

2.2. Supply chain and sustainability issues

A number of studies have discussed various sustainability issues, made arguments in favor of GSCM, and estimated its benefits. Here, we briefly mention some of those studies.

Laws and regulations have been passed in the last few years to promote environmental sustainability. One such notable regulation is the European Directives on Waste and Electronic Equipment [25,26]. Many states in the US also have passed environmental laws [58,89]. Obviously, organizations need to adopt green practices to comply with the laws and regulations. However, these initiatives may take the organizations above and beyond compliance, and help them develop competitive advantages and bring tremendous profit potential. For example, considering toxicity of lead used in shoulder- ing, Hewlett-Packard anticipated that this would be banned some day and invested money in finding alternatives. When the European Union’s Restriction of Hazardous Substances Directive took effect in 2006 they were ready with an amalgamation of tin, silver, and copper, and this provided a competitive edge [67]. Volvo planned proactively in anticipation of a Swedish law that made automakers responsible for disposal of used vehicles, and eventually set up sophisticated operations for salvaging and dismantling vehicles that generated significant revenue stream [90].

Sustainable product and process design can contribute to the bottom line of a firm. The number of environmentally conscious customers is growing and has passed a threshold size to justify introducing green offerings in certain industry sectors. For example, in 2005 P&G launched Tide Coldwater in the US and Ariel Cool Clean in Europe. As these cold water detergents can reduce electricity consumption appreciably, they captured significant market shares. In order to reduce fuel consumption in shipping and delivery processes, FedEx uses innovative flight schedules, routing, and load planning, fuel-efficient delivery trucks, and intelligent vehicle routing. In 2008, Clorox introduced the Green Works line to address significant environmental concerns associated with the household cleaning products and by the end of the year the line had grown the US natural cleaners market by 100% [67]. In addition to independent green projects implemented by individual firms, joint product sector approaches and cross sector approaches involving multiple organizations to undertake sustainability initiatives have emerged as more recent trends [100].

Life cycle of products can be extended by adopting appropriate product recovery strategies. Many organizations such as Xerox [94], Caterpillar [4], and Hewlett-Packard [106] have successfully implemented remanufacturing and recycling operations to increase profitability. Also, the span of the life cycle may become a key consideration. For example, when the product life cycle is short, such as we see in personal computers that may lose 1% of their value per week [35], fast recovery through the reverse supply chain is important.

Green thinking may also influence sourcing decision, which is a critical activity in supply chain management. Pagell and Wu discuss in details how most of the sustainable companies they examined in their case studies incorporate social dimensions in their supplier management practices [70]. Many large organizations encourage suppliers to become environmentally conscious and even provide incentives sometimes. Cargill and Unilever have invested in greener technology and worked with farmers to adopt sustainable practices in producing agricultural commodities. In 2008, Wal-Mart issued a directive to its China based suppliers to cut packaging cost by 5% and increase energy efficiency of products by 25% [67]. Staples has more than 2800 SKU’s which contain recycled materials and is actively working with its suppliers to develop additional environmentally friendly products [105]. Wipro has agreed to only work with suppliers that have adopted green practices [8].

Return collection and recovery are an integral part of green supply chain. Appropriate recovery of returns can be value-added. For example, earlier Cisco used to consider used equipment as scrap but later improved the recycling operations to reduce cost significantly and increase reuse of equipment from 5% in 2004 to 40% in 2008 [67]. While efficient return collection system saves logistics costs, easy and environmentally conscious return policy improves customer relationships that in turn may generate more sales [87,90].

2.3. Scope of the study

Since one of the important goals of supply chain management is improving supply chain performance [12], a number of arguments can be made in favor of adopting sustainability practices in supply chain management. In general, by focusing on business fundamentals researchers have argued that environmental sustainability can contribute to profitability and competitive advantages [55,75]. The resource based view has been used to justify competitive advantage of sustainable practices because of better access and utilization of resources [44]. Markley and Davis also use the resource based view to argue that firms can increase competitive advantage as a result of a stronger triple bottom line consisting of financial, social, and environmental outcomes [62]. The impacts of sustainable operations on the triple bottom line involving profit, people, and planet have also been discussed [52]. Defee et al. develop a conceptual framework to establish competitive advantages of closed-loop supply chain [20]. Using structural equation modeling supported by conceptual framework, Rao and Holt show greening of different phases of supply chain in an integrated fashion leads to competitiveness and economic gains [78].
Among the practitioners, green supply chain management has gained significant importance. According to a number of Gartner reports, green supply chain is an emerging area and is being considered actively in many firms’ business strategy [71,104]. Some of the McKinsey reports also have reiterated the significance of environmental sustainability issues [7,79]. Using content analysis of corporate communications to stakeholders through corporate social responsibility (CSR) report, Tate et al. show how many top organizations incorporate their triple bottom line goals through operations and supply chain strategies [92]. Researchers have studied the design of supply chain with environmental considerations [102], and the decision making behavior of multiple stakeholders in a supply chain with optimization of CSR [18].

We have not come across any studies that have assessed the impact of GSCM on market value of firms. While other studies have looked into the merits of green initiatives from various perspectives, the direct measure of change in valuation of shares due to such initiatives definitely provides another set of insights in justifying its adoption. We specifically address two research questions:

- Do the announcements of GSCM initiatives lead to a significantly positive increase in stock prices of firms taking the initiatives?
- Which type of firms benefit considerably from the announcements related to GSCM?

We use the event study method that has been used widely in accounting and finance literature to analyze the effect of the announcements on the short-term change in stock prices of the announcing firms.

3. Research hypotheses

To address the above research questions we systematically develop a series of hypotheses that are grounded on extant literature and current practice. These hypotheses relate the impact of GSCM announcements on the short-term change in stock prices of the announcing firms, and argue which type of firms are likely to benefit from these announcements.

3.1. Impact on firms taking green supply chain initiatives

Firms are increasingly taking up the mandate of adopting sustainable business practices. GSCM is an example of such a business practice. There are several advantages to adoption of GSCM. It has the potential to advance firms in an environmentally friendly direction much before regulations force them to adopt such practices. GSCM initiatives can enhance the brand value of the firm and can create a positive impression about the firm in the minds of the various stakeholders that are associated with the firm. GSCM can also be looked upon as an opportunity to develop new lines of business that can become profitable in the future. This leads us to hypothesize:

H1. Firms that announce GSCM initiatives are likely to show significant positive impact in their stock prices.

3.2. Impact on manufacturing oriented firms

Production is an integral part of the value-chain concept advocated in the strategic management literature [74], and internal supply chain’s performance can be managed well within this function [82]. Recoverable manufacturing operations contribute significantly to the economy. According to Guide et al., it accounts for sales in excess of US$53 billion [33].

The importance of manufacturing in the context of environmental sustainability may be established using management and organization theories [83]. It is argued that natural resource view [37] and eco-centric management idea [86] help to guide organization’s practices in relation to the natural environment. These theories delineate the differences between traditional and environmentally friendly strategic management processes including product design and production systems. Both of these are core manufacturing issues.

We also like to argue that typical manufacturing firms usually deal with a number of major functional processes including purchasing and inbound logistics, production, distribution, and reverse logistics that have a huge potential to implement environmentally friendly projects successfully. Because of the capital intensive nature of operations, even a small percentage of savings attained by the successful implementation of such projects may also result in a substantial amount in monetary terms. Hence, manufacturing firms may have higher likelihood to be successful with green supply chain initiatives.

Also, typically many manufacturing operations cause pollutions. Hence, green practices adopted by the manufacturing firms may be viewed more positively by investors. Previous research studies have observed other positive impacts of green initiatives for manufacturing organizations. Vachon and Klassen [98] have found collaborative environmental activities among the North American manufacturing firms to enhance several production related performance measures including reduction of scrap rate, cycle time, and setup time, and improvement in on-time delivery, flexibility, and quality. Zhu and Sarkis have found Chinese manufacturers to gain significant economic benefits by adopting green supply chain practices [107]. In addition to direct financial benefits such as cost savings and profit increases, manufacturers may obtain other benefits from green initiatives. Some of these include preparedness to launch new products and to adhere to new compliances [67], better relationship with customers [87], and image of corporate social responsibility [85]. It appears that manufacturing firms have a lot to gain from green initiatives. Hence, we hypothesize:

H2. Compared to other firms, manufacturing firms will show stronger positive impact in their stock prices when they make GSCM related announcements.

3.3. Impact of research and development (R&D) expenditure

In a number of event studies on firm performance R&D has been used as a control variable [6,43]. The existing literature suggests that well-orchestrated R&D activities are important to implementation of successful GSCM practices. Bowen et al. argue that implementation of green supply chain is better explained by the development and deployment of an organization’s internal resources rather than usual external pressures [10]. A recent study reports that green companies usually have higher R&D expenditures [9].

The importance of a well-coordinated R&D policy for developing sustainable technology is emphasized by O’Brien [68]. The R&D strategies of firms are important in extending the product life cycle and enhancing recycling activities [11]. Christensen et al. mention the critical role of the R&D team as one of the internal stakeholders in implementing green sourcing [16]. Ettlie and Sethuraman also report that higher R&D intensity in firms lead to enhanced level of global sourcing [24]. Hence, it may be conjectured that among the firms implementing GSCM initiatives, the ones with greater focus on R&D are more likely to succeed. We formalize the hypothesis as follows:

H3. Firms with high R&D expenses will show stronger positive impact in their stock prices when they make GSCM related announcements compared to firms with low R&D expenses.

3.4. Effect of early adoption of green initiatives

It may be argued that firms that adopt green practices earlier may have some advantages and hence they may have better performance...
of their stocks. Zhu et al. argue that early adopter of GSCM or closed-loop supply chain may enjoy greater benefit because they are aware of more opportunities for economic gains that can be achieved by adopting these green practices [108]. They further mention that these firms are more likely to adopt green practices based on their unique environmental concerns, and hence may attain a more sophisticated level of adoption. On the other hand late adopters are likely to seek benefits of legitimacy by conformance [103], and hence their adoption practices may be compromised [22]. Zhu and Sarkis found that early adopters of GSCM among Chinese manufacturers achieved both environmental and economic goals [107]. Early adoption of green practices may improve some of the business processes in an organization. Kingston, a renowned manufacturer of memory products, passed substantial savings to their customers by helping them shorten the qualification process of suppliers because of lead-free operations mandated by green initiatives [76]. Also, green initiatives may boost economic development by creating new jobs. A recent report mentioned about green job growth in Colorado based on early adoption of renewable energy and energy efficiency standards [45].

Usually time delays have negative impacts on business. An early article in Harvard Business Review track the impact of decision making delays in a business system consisting of a factory, a warehouse, and multiple retailers, and develop a model for showing the adverse effects of such delays on organization’s performance [31]. Thirty years later Stalk emphasizes similar views on importance of rapid response to changing business environment [88]. There are many other studies that have shown that firms with late entry into the market tend to have higher development and manufacturing cost [19,66], and lesser market share [80,97]. Delays in introducing new products have significant negative impact on stock prices of firms [41], and also on profitability [42]. We are aware that a counter argument may be made that late adopters may learn from the mistakes of early adopters and may see greater positive impact. However, a previous study did not find any such positive impact in the case of IT-based supply chain implementation [21]. Also, considering the likelihood of green supply chain initiatives being unique and more subject to firm-specific customization, we think that the early adopters will be in a more advantageous position by traversing the learning curve before the others. Based on the existing literature, we argue that the firms that introduce the green supply chain initiatives early may gain early-mover’s advantage and the market is likely to react positively to their potential to develop expertise from sustained experience that may eventually enhance their profitability. Hence, we hypothesize:

**H4.** Firms that are early adopters of GSCM initiatives will show more positive impact in their stock prices than firms that are late adopters.

### 3.5. Impact of initiatives related to remanufacturing and/or recycling

A significant amount of green supply chain initiatives are related to remanufacturing or recycling. While a number of issues can be claimed to be associated with green supply chain, remanufacturing and recycling are arguably the most prominent ones. Many of the research studies in operations and supply chain management, which deal with environment concerns, address issues related to recycling and remanufacturing [29,33,34,49,60,61,94-96,99]. Also, recycling and remanufacturing are important considerations in the marketing literature. For example, Sharma et al. use recycling and remanufacturing as two of the three major components in their framework for understanding the role of business-to-business marketing in the supply chain for attaining environmental sustainability objectives [84]. A recent green supply chain study finds that concerns about waste and recycling are more critical than greenhouse gas emissions and resource consumptions [93]. Hence, it may be argued that firms that implement green initiatives related to remanufacturing and/or recycling may be seen favorably by the market. Formally, we test the hypothesis:

**H5.** Firms that make announcements related to remanufacturing and/or recycling show more positive impact on their stock prices than firms making announcements on other aspects of green supply chain.

### 3.6. Effect of firm size

The operating performance of organizations may vary by its size [28]. The critical role of the size of an organization on its performance has been studied extensively in the strategic management literature. A number of empirical research papers focusing on impact of diverse issues of firm value/performance have also considered firm size as an important factor. Some of them are on ERP implementation [39], IT investment [46], outsourcing [38], product introduction delays [43], and supply chain glitches [42]. Thus, it is logical to check if firm size has any impact in our analysis.

The size of the firm may play a role in adoption of green supply chain practices. An earlier survey reported that smaller organizations give less importance to environmental issues compared to their larger counterparts [64]. This may be due to the fact that the smaller organizations are usually resource strapped. Another study also finds that larger companies tend to be more environmentally conscious [3]. In a study of manufacturers, Walton et al. find that encouraging small companies to participate in green purchasing is more challenging [101]. Now, the question is how the market will react if a small firm announces its plans for getting involved in green supply chain initiatives. Capital valuation theory suggests that announcements of new capital expenditures made by the smaller firms usually draw larger market reactions than those made by the larger firms [5]. In the context of IT investment, Im et al. provide empirical evidence of significant returns by the smaller firms [46]. We argue that one will not expect smaller firms to undertake major environmentally focused projects, and it will be a pleasant surprise if a small firm makes announcements to such effect. Hence, we hypothesize:

**H6.** Smaller firms making GSCM announcements will show more positive impact on their stock prices than larger firms.

### 3.7. Impact of corporate sustainability stewardship

Many organizations take up sustainability issues strategically for creating shareholder values by harnessing revenue potentials and managing risks from sustainable products and services. Organizations can gain substantial competitive advantages from sustainable strategies [2,62]. Since 1999, the Dow Jones Sustainability Index is tracking the financial performance of the leading sustainability-driven companies across the world [53]. The index captures the top 10% of the biggest 2500 companies worldwide based on long-term economic, environmental, and social criteria. According to a systematic corporate sustainability assessment the leaders in each of the 57 industry groups are identified. The companies that are in the index may be considered adept in managing sustainability issues, and hence may be more likely to implement green initiative successfully any way. On the other hand, the companies that are not in the index may not be that prominent, and hence the investors may not expect them to take up green supply chain projects. Thus, if the firms that are not listed in the Dow Jones Sustainability Index make any green supply chain related announcements there is a possibility of them getting more favorable response from the investors compared to the firms that are listed in the index. We test the hypothesis:

**H7.** Firms not listed in the Dow Jones Sustainability Index will show more positive impact in their stock prices than firms that are not listed in the Dow Jones Sustainability Index.
3.8. Effect of firm’s growth potential

The growth potential of firms has significant impact on its performance [27]. The growth potential of a firm is widely accepted in accounting and finance as one of the key characteristics that influence the market reaction. Typically, accounting measures such as market-to-book ratio and Tobin’s Q are used as proxies for firm’s growth potential [6,14]. Higher value of the market-to-book ratio suggests that investors may expect high growth from the firm. Chatterjee et al. use market-to-book ratio as a control variable in assessment of value creation by IT infrastructure investments [14]. Oh et al. (2006) also use the ratio to find the impact of growth prospect on cumulative abnormal returns (CAR) of firms making IT investments [69]. The growth potential of firms has been used in event studies within other contexts such as equity financing [73], capital investment [13], and asset sales [54].

It may be argued that the firms with higher growth potential are more likely to implement newer projects and investors have high expectations from these companies. On the other hand, investors may not have much expectation from the firms with low growth potential, and hence their green supply chain initiatives may be viewed more positively than their counterparts with higher growth potential. We formalize the hypothesis as follows:

H8. Firms with low growth potential will show stronger positive impact on their stock prices compared to firms with higher growth potential.

4. Research method

The event study technique analyzes the immediate impact of announcements of events on firm value. This is widely used in the field of accounting and finance. The event study is an appropriate method for examining the financial impact of GSCM initiatives because such announcements are of great interest to investors of the firms. Using an event study allows the investors to estimate the immediate impact of the action undertaken by the firm rather than waiting to check the impact on accounting measures that are not immediately available. At the same time it is known that “event study has become a classic because it works”. It can be used under less than perfect conditions and still produce reliable results [40]. This leads us to use the event study method for this research.

In this method, the relevant announcements are retrieved from one or more news databases using a suitable list of keywords. The databases commonly used include Factiva, PR Newswire, and Business Newswire. After downloading all announcements that match the keywords, those related to private companies, and non-listed companies are removed. Then duplicate announcements are filtered, and only the earliest occurrences of such announcements are retained. Next, announcements that are released around the date of some other confounding events are eliminated. The confounding events can include announcements of earnings, mergers, acquisitions, declaration of dividends, change of senior management, and declaration of analyst ratings, among others. In this research, we adopted a three-day confounding window, starting from 1 day prior to the date of the announcement, and lasting up to 1 day after the date of the announcement. Then firms that had average stock price less than US$1 or average daily trading volume less than 50,000 shares in the estimation period, are removed from further consideration, as thinly traded markets have limited predictability [91].

4.1. Computation of abnormal stock return

For the computation of abnormal stock market returns we used the capital asset pricing model (Fama and French, 1992) that is shown in Eq. (1):

$$R_{it} = \alpha_i + \beta_i R_{mt} + \epsilon_{it}$$  

where $R_{it}$ is the rate of return for announcement $i$ on day $t$, $R_{mt}$ is the rate of return of market index $m$ on day $t$, $\alpha$ is the y-intercept, $\beta$ is the slope that measures the sensitivity of $R_{it}$ to $R_{mt}$, and $\epsilon$ is the disturbance term. We primarily used the NYSE index for US listed companies, and other country specific indexes for firms listed in other countries.

The rate of return of stock price of the adopting firm on the announcement day and 1 day after the announcement is computed with respect to the benchmark market index. Although the windows used for estimation of the event varied from one study to another, we used 200 trading days’ data prior to the announcement of the event for obtaining the regression model [14,46,77]. We also left a gap of 30 days between the estimation window and event window to reduce the impact of the event on the estimation model [81]. To compute the abnormal return (AR) of announcement $i$ on day $t$, the formula used is shown in Eq. (2):

$$AR_{it} = R_{it} - (a_i + b_i R_{mt})$$  

where $R$ is the rate of return, $m$ is the market index, $a_i$ is the intercept, and $b_i$ is slope of the regression model for announcement $i$. The cumulative abnormal return (CAR) is then computed using Eq. (3):

$$CAR = \frac{1}{N} \sum_{i=1}^{N} \frac{\sum_{t=1}^{T} AR_{it}}{N}$$  

where $N$ is the number of announcements, and the event window is from $S_1$ to $S_2$ days around the event day. To facilitate the computation of the subsequent statistical significance test, AR is usually transformed to the standardized abnormal return (SAR), as shown in Eq. (4):

$$SAR_{it} = \frac{AR_{it}}{\sqrt{Var(AR_{it})}}$$  

where $Var(AR_{it}) = s_t^2 \left[ 1 + \frac{1}{N} + \frac{(R_{it}-R_{mt})^2}{\sum_{i=1}^{N} (R_{it}-R_{mt})^2} \right]$. $s_t^2$ is the residual return variance obtained from the regression model for announcement $i$, $D_i$ is the number of trading days used in the regression model for announcement $i$ and ranges from $T_1$ days to $T_2$ days before the date of the announcement, and $R_{mt}$ is the mean return on market index over the estimation period of $D_i$. The cumulative standardized abnormal return (CSAR), is computed using Eq. (5):

$$CSAR = \frac{1}{N} \sum_{i=1}^{N} \frac{SAR_{it}}{\sqrt{S_2-S_1+1}}.$$  

Assuming that CSAR follows a normal distribution, a one tail Z test is used to test its statistical significance. The test statistic is given by Eq. (6):

$$Z = \sqrt{N}CSAR$$  

For a more detailed description of the above parametric statistical procedure, the interested reader may refer to past research in the area [23,46].

In addition to the parametric test, some researchers have used non-parametric tests, such as the sign test [15], to improve the robustness of the obtained results [77]. In order to test the generated hypotheses, appropriate subsamples based on the criteria determined in the hypotheses are created, and the abnormal returns are computed for each subsample. Again, both parametric and nonparametric tests are used and conclusions are drawn about whether the results obtained for the entire sample hold for the selected subsamples or not.
Table 1
Filtering of announcements using different criteria.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of announcements matching keywords</td>
<td>14,871</td>
</tr>
<tr>
<td>Number of relevant announcements</td>
<td>228</td>
</tr>
<tr>
<td>Number of announcements confounded by other news</td>
<td>41</td>
</tr>
<tr>
<td>Number of announcements related to private firms</td>
<td>49</td>
</tr>
<tr>
<td>Number of announcements related to thinly traded firms</td>
<td>34</td>
</tr>
<tr>
<td>Number of announcements selected for analysis</td>
<td>104</td>
</tr>
</tbody>
</table>

4.2. Data collection and filtering

For obtaining the announcements data we searched the Factiva database. The keywords used for this purpose included green supply chain, closed-loop supply chain, sustainable operation, green operations, remanufacturing, green refurbishment, green disassembly, green returns management, and product recovery. Although some of the past studies have found synergy between green supply chain and quality and lean principles [30,63,72,78], we did not include quality and lean as keywords in our search as these concepts have been studied for a long time in a variety of contexts other than green. Although they may be involved in successful green supply chain operations in certain situations, it becomes difficult to establish conclusive evidence from the announcements on whether they indeed supported green supply chain initiatives in an organization. The earliest announcement date in our sample data is found to be May 27, 1997, and the latest announcement date is December 14, 2009. After all the filtering activities, our final data set consisted of 104 announcements involving 48 companies. Out of these 48 firms, 34 were listed in the US, and the remaining 14 firms were listed in Canada, China, Germany, Japan, Taiwan, and the UK. Table 1 provides a step-by-step breakdown of how the announcements are collected and cleaned for analysis. A sample announcement is shown in the Appendix A.

Table 2 shows the distribution of green supply chain related announcements used in our study by year. It is evident that increasing numbers of firms are taking green supply chain initiatives in recent years. This is quite expected because of the growing attention the topic is gaining lately. Table 3 presents distribution of the firms selected in our study by two-digit SIC codes.

Table 2
Distribution of green supply chain related announcements by year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of announcements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>3</td>
</tr>
<tr>
<td>1998</td>
<td>1</td>
</tr>
<tr>
<td>1999</td>
<td>1</td>
</tr>
<tr>
<td>2000</td>
<td>2</td>
</tr>
<tr>
<td>2001</td>
<td>2</td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
</tr>
<tr>
<td>2003</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>1</td>
</tr>
<tr>
<td>2005</td>
<td>13</td>
</tr>
<tr>
<td>2006</td>
<td>22</td>
</tr>
<tr>
<td>2007</td>
<td>22</td>
</tr>
<tr>
<td>2008</td>
<td>22</td>
</tr>
<tr>
<td>2009</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>104</td>
</tr>
</tbody>
</table>

Table 3
Distribution of sample firms making the green supply chain related announcements by 2-digit SIC.

<table>
<thead>
<tr>
<th>2-Digit SIC</th>
<th>Industry</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Paper and allied products</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>28</td>
<td>Chemical and applied products</td>
<td>2</td>
<td>4.8</td>
</tr>
<tr>
<td>34</td>
<td>Fabricated metal products</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>35</td>
<td>Industrial machinery and equipment</td>
<td>11</td>
<td>26.2</td>
</tr>
<tr>
<td>36</td>
<td>Electronic and other electric equipment</td>
<td>3</td>
<td>7.1</td>
</tr>
<tr>
<td>37</td>
<td>Transportation equipment</td>
<td>4</td>
<td>9.5</td>
</tr>
<tr>
<td>38</td>
<td>Instruments and related products</td>
<td>2</td>
<td>4.8</td>
</tr>
<tr>
<td>40</td>
<td>Railroad transportation</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>42</td>
<td>Motor freight transportation/warehouse</td>
<td>3</td>
<td>7.1</td>
</tr>
<tr>
<td>49</td>
<td>Electric gas and sanitary services</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>50</td>
<td>Wholesale trade-durable goods</td>
<td>6</td>
<td>14.3</td>
</tr>
<tr>
<td>53</td>
<td>General merchandise stores</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>67</td>
<td>Holding and other investment offices</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>73</td>
<td>Business services</td>
<td>3</td>
<td>7.1</td>
</tr>
<tr>
<td>75</td>
<td>Auto repair and parking</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>87</td>
<td>Engineering and accounting and management services</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>42</td>
<td>100.0</td>
</tr>
</tbody>
</table>

hypothesized that these types of businesses may gain greater positive results by adopting green initiatives and higher percentage of announcements in these categories provides an early indication of the validity of the assumptions. Table 4 provides descriptive statistics of the financial data of the firms included in the study. Specifically, it lists the mean, median, standard deviation, maximum, and minimum values of different accounting measures of the firms (such as total assets, EBIT, total liabilities, working capital, and sales) as well as their R&D expenses, and market value. It shows that there is a wide variation between the firms that are included in this research.

4.3. Determination of subsamples

In order to conduct the subsampling analysis, we characterized the firms according to a number of factors based on hypotheses H2–H8. To determine whether the firms belonged to the manufacturing sector we examined their SIC codes. If the firms had SIC codes between and including 20 and 39, they are considered to be manufacturing firms [14]. Otherwise, they belonged to the ‘Others’ subsample. The next subsample is related to R&D expenses of the firm. For this we computed the ratio of R&D expenses to the total assets of the firm. The division by the amount of total assets is done to offset any bias due to the size of the firm. Then the median of that ratio is used to distinguish between firms that had high R&D expenses from the firms that had low R&D expenses. To determine the cutoff date for time period of adoption a cutoff date of February 16, 2005 is used. This is the date for the beginning of the implementation of the landmark Kyoto protocol that was adopted in Kyoto, Japan on December 11, 1997 [8]. Firms making GSCM announcements before this date are considered to be early adopters. The announcements that are related to recycling or remanufacturing are identified by reading the text of the announcement. Among the 104 announcements, 79 belonged to this subsample. Total assets have often been used as a proxy for firm size. We used the natural logarithm of total assets of the firm (1 year prior to the date of the announcement) as a proxy for firm size. The median value is used as the cutoff point to distinguish between big and small firms. The world components of the DJSI are studied (http://www.sustainability-index.com/07_html/data/djsiworld.html) to determine if the firm is included in this index on not. To distinguish between high and low growth potential firms, we listed the market-to-book ratio for all firms, and determined the median for all firms, which is used as the cutoff. Firms with market-to-book ratio greater than or equal to the median are
put in the ‘high growth potential’ subsample, and the firms with a ratio less than the median are put in the ‘low growth potential’ subsample. Finally, the correlations between all factors used in the subsampling are computed. For doing this, for each announcement the corresponding subsampling factor is assigned a value of either 0 or 1. For example, for the size of the firm, ‘big’ is assigned a value of 1, and ‘small’ is assigned a value of 0. Next, all pairwise correlations between the seven subsampling factors are computed. All correlations are found to be small, and are found to range between $-0.258$ and $0.427$. This indicates that the subsampling factors are weakly correlated with each other, and may be analyzed separately through individual hypothesis development.

5. Discussion of results

Table 5 presents cumulative abnormal returns (CAR) observed by the firms making announcements of green supply chain related efforts. According to standard event study research we compute the CARs for different event windows. In particular, we list the CARs obtained on the day before the announcement (i.e., $[-1]$) to see if there is any leakage of the news, on the day of the announcement (i.e., $[0]$) to see if there is immediate impact, and also on the day following the announcement (i.e., $[1]$) to show if there is any delayed impact. We also show the CARs aggregated over different combinations of event windows. The results indicate that the most significant impact happens in the event window $[0]$. This is expected as the investors perceive green initiatives positively, and react soon after the announcements are made. For this time window, while the nonparametric test is statistically significant (with p-value of the test statistic being less than 0.1) the parametric test is not significant at the 10% significance level. The mean CAR is found to be positive and $0.2\%$. There are more announcements generating positive returns than negative returns. Hence, we can conclude that Hypothesis 1 is

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Manufacturing</th>
<th>Others</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>79</td>
<td>25</td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>Mean CAR</td>
<td>0.02%</td>
<td>-0.02%</td>
<td>0.48%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Z test p-value</td>
<td>0.06</td>
<td>0.45</td>
<td>0.08</td>
<td>0.29</td>
</tr>
<tr>
<td>No. of +ve:–ve returns</td>
<td>45:34</td>
<td>12:13</td>
<td>33:18</td>
<td>24:29</td>
</tr>
<tr>
<td>Sign test p-value</td>
<td>0.08</td>
<td>0.48</td>
<td>0.01</td>
<td>0.26</td>
</tr>
</tbody>
</table>

5. Discussion of results

Table 5 presents cumulative abnormal returns (CAR) observed by the firms making announcements of green supply chain related efforts. According to standard event study research we compute the CARs for different event windows. In particular, we list the CARs obtained on the day before the announcement (i.e., $[-1]$) to find if there is any leakage of the news, on the day of the announcement (i.e., $[0]$) to see if there is immediate impact, and also on the day following the announcement (i.e., $[1]$) to see if there is any delayed impact. We also show the CARs aggregated over different combinations of event windows. The results indicate that the most significant impact happens in the event window $[0]$. This is expected as the investors perceive green initiatives positively, and react soon after the announcements are made. For this time window, while the nonparametric test is statistically significant (with p-value of the test statistic being less than 0.1) the parametric test is not significant at the 10% significance level. The mean CAR is found to be positive and 0.2%. There are more announcements generating positive returns than negative returns. Hence, we can conclude that Hypothesis 1 is

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Manufacturing</th>
<th>Others</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>79</td>
<td>25</td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>Mean CAR</td>
<td>0.02%</td>
<td>-0.02%</td>
<td>0.48%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Z test p-value</td>
<td>0.06</td>
<td>0.45</td>
<td>0.08</td>
<td>0.29</td>
</tr>
<tr>
<td>No. of +ve:–ve returns</td>
<td>45:34</td>
<td>12:13</td>
<td>33:18</td>
<td>24:29</td>
</tr>
<tr>
<td>Sign test p-value</td>
<td>0.08</td>
<td>0.48</td>
<td>0.01</td>
<td>0.26</td>
</tr>
</tbody>
</table>

5. Discussion of results

Table 5 presents cumulative abnormal returns (CAR) observed by the firms making announcements of green supply chain related efforts. According to standard event study research we compute the CARs for different event windows. In particular, we list the CARs obtained on the day before the announcement (i.e., $[-1]$) to find if there is any leakage of the news, on the day of the announcement (i.e., $[0]$) to see if there is immediate impact, and also on the day following the announcement (i.e., $[1]$) to see if there is any delayed impact. We also show the CARs aggregated over different combinations of event windows. The results indicate that the most significant impact happens in the event window $[0]$. This is expected as the investors perceive green initiatives positively, and react soon after the announcements are made. For this time window, while the nonparametric test is statistically significant (with p-value of the test statistic being less than 0.1) the parametric test is not significant at the 10% significance level. The mean CAR is found to be positive and 0.2%. There are more announcements generating positive returns than negative returns. Hence, we can conclude that Hypothesis 1 is
partially supported. As the hypothesis is not fully supported, we proceed to investigate if GSCM initiatives have greater impact in specific situations as stipulated in hypotheses H2 through H8. For the subsampling analysis, the event window [0] is chosen as it showed partial significance for H1.

Table 6 shows the results from analyses performed on various subsamples to test hypotheses H2 through H8. Panel A of Table 6 shows the effect of GSCM initiatives for manufacturing firms. Both parametric test (p-value of Z test being 0.06) and non-parametric test (p-value of sign test being 0.08) confirms that manufacturing firms indeed observe greater positive change in stock price by undertaking such initiatives, as hypothesized earlier in H2.

Hypothesis 3 (H3) suggests that firms with high R&D expenses show strong positive impact. However, R&D expenditure may vary widely according to the size of the firm. Hence, we normalize the measure by using the ratio of R&D expenses and total assets. Panel B of Table 6 shows that firms with higher ratio have statistically significant positive change in return compared to the firms with lower value of the ratio. Both the parametric and non-parametric tests have p-values less than 0.1, which strongly supports confirmation of H3.

Hypothesis 4 (H4) suggests that firms that are early adopters of GSCM initiatives show greater positive impact. However, results shown in Panel C of Table 6 imply the hypothesis cannot be confirmed by either of the two tests in the event window [0]. We investigate further if the other event window has any effect on the analysis. Panel A of Table 7 demonstrates that both parametric test (with p-value of 0.08) and non-parametric test (with p-value of 0.10) confirm the hypothesis in the event window [1]. This is an interesting finding. Although it implies the early adopters of green supply chain receive positive reaction from the investors, it is delayed by a day. This may be due to the fact that the concept of green supply chain is shaping up in the early years and people are not as aware about GSCM as they are at the current time. Thus the market takes a longer time to react to the announcements.

Hypothesis 5 (H5) suggests that the firms that made announcements related to remanufacturing and/or recycling will show strong positive result. The results, as shown in Panel D of Table 6, indicate the hypothesis cannot be confirmed by either of the two tests in event window [0]. Subsequently, we test the hypothesis in the event window [1]. The results in Panel B of Table 7 show that the hypothesis cannot be supported even in the event window [1]. This implies that while the investors may view overall green supply chain initiatives positively, they may not be keen to know the details. Probably there is not enough knowledge among the investors about the impact of these two specific green operations.

Hypothesis 6 (H6) implies that small firms show strong positive impact. Panel E of Table 6 illustrates that both parametric test (with p-value of 0.03) and non-parametric test (with p-value of 0.04) confirm the hypothesis in event window [0]. This finding is expected because of the reasons provided in the hypothesis development section, which is presented earlier in the manuscript. Hypothesis 7 (H7) states that firms not listed in the Dow Jones Sustainability Index (DJSI) show strong positive result. Both parametric test (with p-value of 0.02) and non-parametric test (with p-value of 0.08), as shown in Panel F of Table 6, provide statistically significant support for the hypothesis. Hypothesis 8 (H8) suggests that firms with low growth potential show strong positive impact. The results, as shown in Panel G of Table 6, indicate that the hypothesis can be statistically confirmed by both parametric (with p-value of 0.02) and non-parametric test (with p-value of 0.04).

6. Managerial implications and conclusion

Several managerial insights may be obtained from the study. Overall, the study shows that plans for adopting GSCM initiatives have positive impact on shareholders’ value of the firm. While this inference is partially supported in our initial analysis of the data, subsequent analyses of the subsamples support the claim further. More specifically, we find that green supply chain initiatives may yield greater positive influence under certain situations. We describe them as follows.

We find that investors tend to view green supply chain projects in manufacturing firms more favorably compared to those in non-manufacturing firms. This suggests that executives of manufacturing firms are in an advantageous position to deal with sustainability issues, and contribute significantly to overall success of their firms. This advantage should be tapped to its full potential.

Research and development (R&D) plays a crucial role in successful implementation of new ideas, technologies, and/or systems. Green supply chain is no exception. Firms with higher R&D intensity tend to generate more positive reaction among investors in implementing green supply chain projects. Higher R&D investment by the firms can be viewed as a proxy for innovativeness. When innovative firms adopt green supply chain practices, the market adjudges it more positively by associating innovativeness with higher chance of successful implementation. This is encouraging news for innovative companies. It also bolsters the importance of proper R&D infrastructure for undertaking meaningful green initiatives.

In early years, although the market reacts positively to green supply chain announcements, the reaction is a little slower compared to the more recent announcements. It may be attributed to the fact that acceptance of new ideas takes time. While this may not be an issue currently for implementing green supply chain practice in general as considerable time has passed since inception of the practice, specific novel ideas within the paradigm of green supply chain may face similar delayed reaction from the market. Although we do not have conclusive evidence in support of the argument as the scope of our study is limited to the study of short-term effects, this research provides some indirect indications in favor of the conjecture. It may be worthwhile to investigate it in future.

Since a significant number of green supply chain initiatives, particularly the ones related to closed-loop supply chain, deal with remanufacturing and/or recycling issues [36] we thought investors will react positively to the announcements that are related to these two issues. Our analysis does not find it to be significant, and this may appear to be counter-intuitive. However, it may be argued that investors may not be interested in specific types of initiatives within the domain of GSCM. Also, they may not be aware of the technical details of green supply chain operations, and unlike financial data the information is not readily available from commercial databases. While the issue is outside the scope of our current manuscript, future studies may be conducted to understand and compare the success potential of diverse initiatives within the green supply chain practice including environmentally friendly product and process design, elimination/reduction of excess waste and energy use in production and distribution, adherence to environmental quality standards, and dynamic value recovery through recycling and remanufacturing operations. In addition, we do see probable scope for executives of the firms adopting green supply chain to educate investors about the issues, and possibly even harness untapped potential for generating additional value for the firms.

We find smaller firms, firms not listed in the Dow Jones Sustainability Index (DJSI), and firms with low growth potential receive

<table>
<thead>
<tr>
<th>Panel A: impact of period of adoption</th>
<th>Panel B: impact of nature of operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic</td>
<td>Early</td>
</tr>
<tr>
<td>Sample size</td>
<td>13</td>
</tr>
<tr>
<td>Mean CAR</td>
<td>1.26%</td>
</tr>
<tr>
<td>Z test p-value</td>
<td>0.08</td>
</tr>
<tr>
<td>No. of +ve returns</td>
<td>8.5</td>
</tr>
<tr>
<td>Sign test p-value</td>
<td>0.10</td>
</tr>
</tbody>
</table>
strong positive reaction from the market when they make announce-
ments of adoption of green supply chain practices. This substantiates
our initial conjecture that investors probably do not have high expec-
tations about these types of firms, and when their actions surpass the
expectation level investors view them quite positively. This is an in-
teresting finding as it indicates that the potential to be successful in
adopting green supply chain practices is not limited to the large and
renowned firms. Smaller and lesser known firms can also be equally
accomplished, if not more, in such initiatives with proper infrastruc-
ture and appropriate managerial stewardship.

We believe that the results of our research will be quite useful
for operations managers. Although operational decision making is
dependent on accounting metrics such as profitability, these figures
are usually not available as soon as the firm makes a public announce-
ment of a GSCM initiative. Sometimes, “direct productivity related mea-
sures may require many months or even years of observation” [39]. At
the same time, such metrics may not always be a true reflection of the
true financial impact of an initiative because “managers can manipulate
accounting profits because they can select accounting procedures” [65].
In the absence of such measures, financial impact analysis using an
event study and the corresponding findings as listed in this paper will
be deemed quite important for the managers of the firm.

We must point out some of the limitations of our current study. The
study is limited to analysis of short-term impact of announce-
ments related to green supply chain initiatives. It will be important
to investigate how the impact unfolds in the long-term. In such
long-term studies, it will be useful to investigate if the market reac-
tion to successful initiatives is different from that to the unsuccessful
ones. At the same time, the long-term studies can also focus on the
impact of GSCM initiatives on performance metrics such as profitabil-
ity. Also, the research suffers from the limitations of an event study as
it only deals with publicly listed firms. It will be worthwhile to study
how impact of green supply chain may vary across different industry
sectors as more announcements become available in future. Another
valuable stream of research may be in exploring the use of other
methodologies such as case studies and survey analysis to find the
impact of GSCM and conduct comparative studies.

While the concept of green supply chain has received prominence
in industrial practice as well as in media, still organizations are debat-
ing its merits. Many even view the green supply chain projects as
mere tools for achieving compliance with environmental laws and
regulations. Of course, there are organizations that have understood
the benefits and are avidly continuing green operations at present.
A number of research studies have discussed various measures of
benefits, details of which are discussed in the early part of the manu-
script. However, to the best of our knowledge no previous studies
have analyzed the impact of green supply chain initiatives on the
stock prices of the firm. The event study method adopted in this
study has been used widely in accounting and finance literature,
and is capable of shedding light on how the market values certain ac-
tions taken by the firms. Hence, the findings may provide useful infor-
mation for the investors as well as for the firms. Our analysis does
substantiate that adoption of green supply chain practice indeed cre-
ates value for the firms and the promise of success is not limited to
the elite few. The evidence of smaller and lesser known firms being
successful suggests potential low barriers to entry into this arena.
Truly, green supply chain management is poised to improve the triple
bottom line—profit, people, and planet.

Acknowledgment

The first author gratefully acknowledges financial support re-
ceived from the University of Hong Kong in the form of Small Project
Funding. He also acknowledges research assistance received from Mr.
Shipeng Yan.

Appendix A

Sample announcement

Cummins now offering remanufactured ISX engines
Adam Ledlow
290 words
2 November 2006
eSource Canada Business News Network
COLUMBUS, Ind.—Cummins is now remanufacturing ISX en-
gines on a new state-of-the-art production line at the San Luis
Potosi, Mexico, plant. “The Cummins ReCon ISX is an extremely
important product for Cummins and our loyal customer base,”
said Allen Pierce, general manager of parts and service
manufacturing. “We must provide the very best in quality and
value, which is why we’ve handpicked people at all levels includ-
ing several from the original equipment plant in Jamestown, N.Y.
and brought them here for the duration of the implementation
process. All the latest quality tools and Six Sigma processes
are being used to ensure our best ReCon engine launch to date.”
Plant manager Aaron Borunda added, “The new ReCon ISX line
represents a major investment in the talented and dedicated em-
ployees at our facility. We have sufficient capability to meet all
forecasted orders, plus we have the expansion capacity available
to meet future growth needs.” Unlike rebuilt or reconditioned en-
gines, every ReCon ISX is completely disassembled, thoroughly
inspected, remanufactured and tested on the production line to
verify that it meets factory specifications, the company says.
Materials and components are upgraded to the latest technology
using only genuine Cummins new or ReCon parts, which include
a one-piece forged-steel piston, a new one-piece head gasket for
better coolant control, a flat-top induction-hardened cylinder lin-
er for better cylinder sealing, and an improved piston pin and lu-
brication for longer life-to-overhaul. Cummins is offering a two-
year/200,000-mile (321,869 km) warranty, twice as long as previous standards. Extended coverage plans are also available.
Current production is limited to engines produced between

List of notations and acronyms

<table>
<thead>
<tr>
<th>Notations/abbreviations</th>
<th>Explanation/extended terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSCM</td>
<td>Green Supply Chain Manage</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organizati</td>
</tr>
<tr>
<td>Modular design</td>
<td>It is an approach that div</td>
</tr>
<tr>
<td>Recycling</td>
<td>Recycling is processing of</td>
</tr>
<tr>
<td>Remanufacturing</td>
<td>Remanufacturing is the pr</td>
</tr>
<tr>
<td>Reverse logistics</td>
<td>Reverse logistics is the p</td>
</tr>
</tbody>
</table>

Appendix A

Sample announcement

Cummins now offering remanufactured ISX engines
Adam Ledlow
290 words
2 November 2006
eSource Canada Business News Network
COLUMBUS, Ind.—Cummins is now remanufacturing ISX en-
gines on a new state-of-the-art production line at the San Luis
Potosi, Mexico, plant. “The Cummins ReCon ISX is an extremely
important product for Cummins and our loyal customer base,”
said Allen Pierce, general manager of parts and service
manufacturing. “We must provide the very best in quality and
value, which is why we’ve handpicked people at all levels includ-
ing several from the original equipment plant in Jamestown, N.Y.
and brought them here for the duration of the implementation
process. All the latest quality tools and Six Sigma processes
are being used to ensure our best ReCon engine launch to date.”
Plant manager Aaron Borunda added, “The new ReCon ISX line
represents a major investment in the talented and dedicated em-
ployees at our facility. We have sufficient capability to meet all
forecasted orders, plus we have the expansion capacity available
to meet future growth needs.” Unlike rebuilt or reconditioned en-
gines, every ReCon ISX is completely disassembled, thoroughly
inspected, remanufactured and tested on the production line to
verify that it meets factory specifications, the company says.
Materials and components are upgraded to the latest technology
using only genuine Cummins new or ReCon parts, which include
a one-piece forged-steel piston, a new one-piece head gasket for
better coolant control, a flat-top induction-hardened cylinder lin-
er for better cylinder sealing, and an improved piston pin and lu-
brication for longer life-to-overhaul. Cummins is offering a two-
year/200,000-mile (321,869 km) warranty, twice as long as previous standards. Extended coverage plans are also available.
Current production is limited to engines produced between

List of notations and acronyms

<table>
<thead>
<tr>
<th>Notations/abbreviations</th>
<th>Explanation/extended terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSCM</td>
<td>Green Supply Chain Manage</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organizati</td>
</tr>
<tr>
<td>Modular design</td>
<td>It is an approach that div</td>
</tr>
<tr>
<td>Recycling</td>
<td>Recycling is processing of</td>
</tr>
<tr>
<td>Remanufacturing</td>
<td>Remanufacturing is the pr</td>
</tr>
<tr>
<td>Reverse logistics</td>
<td>Reverse logistics is the p</td>
</tr>
</tbody>
</table>
References


[105] M. Wilson, Staples aims for a greener planet, Chain Store Age 82 (December 2006) 60–66.


Raktim Pal is an associate professor at the College of Business, James Madison University. He has a Ph.D. and two M.S. degrees—all from Purdue University. He holds a B. Tech. (Hons.) degree from the Indian Institute of Technology, Kharagpur. Prior to joining James Madison University he worked in industry for several years and was involved in a number of supply chain management projects at well-known organizations. His research interests are in the areas supply chain management and logistics, project management and IS/OM interfaces, transportation systems modeling and analysis, and applied operations research. His research papers have appeared in Communications of the ACM, Communications of the AIS, Computers & Operations Research, European Journal of Operational Research, Information & Management, International Journal of Production Economics, Journal of Transportation Engineering, and Transportation Research Record. He serves on the editorial board of International Journal of Applied Decision Sciences. He is listed in Marquis Who’s Who in America 2005, Marquis Who’s Who of Emerging Leaders 2007, and America’s Registry of Outstanding Professionals 2003. He is a member of Decision Sciences Institute, Production and Operations Management Society, and Institute for Operations Research and the Management Sciences.