Green supply chain management in China: pressures, practices and performance

Qinghua Zhu
Institute for Eco-planning and Development, Dalian University of Technology Dalian, Liaoning Province, People's Republic of China

Joseph Sarkis
Graduate School of Management, Clark University, Worcester, Massachusetts, USA, and

Yong Geng
Institute for Eco-planning and Development, Dalian University of Technology Dalian, Liaoning Province, People's Republic of China

Received March 2003
Revised September 2004
Accepted November 2004

Abstract

Purpose – Green supply chain management (GSCM) has emerged as a key approach for enterprises seeking to become environmentally sustainable. This paper aims to evaluate and describe GSCM drivers, practices and performance among various Chinese manufacturing organizations.

Design/methodology/approach – Based on a literature review, four propositions are put forward. An empirical study using survey research was completed. The survey questionnaire was designed with 54 items using literature and industry expert input. An exploratory factor analysis was conducted to derive groupings of GSCM pressures, practice and performance from the survey data which included 314 responses. A categorical and descriptive nature of the results is then presented with an evaluation and comparative analysis with previous research findings.

Findings – Chinese enterprises have increased their environmental awareness due to regulatory, competitive, and marketing pressures and drivers. However, this awareness has not been translated into strong GSCM practice adoption, let alone into improvements in some areas of performance, where it was expected.

Research limitations/implications – The investigation and its findings are still relatively exploratory. Future research can investigate relationships identified in this work, as well as tease out mediating and moderating relationships. A more broadly-based and random sample study across China would also provide a better picture of this GSCM situation.

Practical implications – Efforts made by Chinese enterprises together with the Chinese government have established a good foundation for further development. After China's entry into the WTO, a win-win relationship between foreign companies and Chinese manufacturers is still possible.

This work is supported by the CIDA Tier 1 ECOPLAN China Project (S-61562), the National Natural Science Foundation of China Project (70202006), the Social Science Foundation of China (03CJY001), The Ninth Huo-yingdong Young Faculty Foundation (91082), the Scientific Research Foundation for the Returned Overseas Chinese Scholars, State Education Ministry, the Liaoning Doctoral Startup Project (2001102090), and a research grant by The Hong Kong Polytechnic University.

International Journal of Operations & Production Management
Vol. 25 No. 5, 2005
pp. 449-468

0144-3577
DOI 10.1108/01443570510593148

Originality/value – This work is one of the few and pioneering efforts to investigate GSCM practices in China.

Keywords Green marketing, Supply chain management, International relations, Operations management

Paper type Research paper

Introduction

Balancing economic and environmental performance has become increasingly important for organizations facing competitive, regulatory, and community pressures (Shultz and Holbrook, 1999). With increased pressures for environmental sustainability, it is expected that enterprises will need to implement strategies to reduce the environmental impacts of their products and services (Lewis and Gretsakis, 2001; Sarkis, 1995, 2001). To establish their environmental image, enterprises have to re-examine the purpose of their business (Hick, 2000). Success in addressing environmental items may provide new opportunities for competition, and new ways to add value to core business programs (Hansmann and Claudia, 2001). Approaches, such as cleaner production, environmental management systems and eco-efficiency, have been implemented for green management practices. In 1994, the Confederation of British Industries (CBI) identified the factors driving the competitive advantage through environmental performance as market expectations, risk management, regulatory compliance and business efficiency. Green supply chain management (GSCM) has a key role in ensuring that all of these factors are addressed (Hutchison, 1998). Environmental impacts occur at all stages of a product's life cycle. Therefore, GSCM has emerged as an important new archetype for enterprises to achieve profit and market share objectives by lowering their environmental risks and impacts and while raising their ecological efficiency (van Hock and Erasmus, 2000).

China is one country where the issues related to GSCM have become even more critical. Recent studies have shown that a majority of world's manufacturing will be carried out in Asia in the next couple of decades (US-AEP, 1999). As a major manufacturing country, China has many opportunities, but they also face substantial environmental burdens with this opportunity (Rao, 2002). Moreover, developing countries such as China are becoming increasingly industrialized. As part of supply chains, China has been used as a point of disposal of end-of-life products for multinational organizations and developed countries. For example, the end-of-life products have been shipped to developing countries, such as China, where these developing countries do not have the infrastructure or tools available to care for the end-of-life products (Puckett and Smith, 2002), causing greater environmental burden on these nations. The appropriate development of GSCM concepts and practices may indeed aid these countries by lessening the environmental burden of both manufacture and disposal of products, while even potentially improving their economic positioning.

With the relative scarcity of resources and the potential pressure of "green barriers" to trade, both the Chinese government and enterprises have had increased reasons to initiate corporate and industrial environmental management measures. Some of the measures which are being promoted are environmental impact assessment, ISO 14001 certification and recently GSCM. Given this emerging organizational and competitive environment faced by Chinese industry, this paper describes the empirical results

of a GSCM-based survey and site visits at various Chinese manufacturing organizations. Initially, in this paper, we introduce current environmental awareness, practices, and performance of GSCM in general and in Chinese enterprises, this background sets the foundation for various issues (propositions) that will be evaluated using the empirical data. An outline of our research method is then presented. Research findings of a categorical and descriptive nature are then discussed with an evaluation and comparative analysis with previous research findings. The paper concludes with some suggestions with a particular emphasis on what Chinese manufacturing company managers and policy makers should be concerned with, in light of our findings, in future operations of GSCM.

Literature review

The literature in GSCM has been growing as organizations and researchers begin to realize that the management of environmental programs and operations do not end at the boundaries of the organization. Overall, research in corporate environmental management and its operations relationships have been growing in recent years with a number of papers outlining these relationships (Angell and Klassen, 1999; Geyer and Jackson, 2004; Gupta, 1995; Hanna and Newman, 1996; Sarkis, 2001; Melnyk *et al.*, 2002), including the identification of a need to investigate GSCM. GSCM is strongly related to inter-organizational environmental topics as industrial eco-systems, industrial ecology, product life cycle analysis, extended producer responsibility and product stewardship. In a broader sense, GSCM also falls within the purview of the burgeoning literature of ethics and sustainability which incorporates other social and economic influences. Research is increasingly investigating many of these "triple bottom-line" issues (Carter, 2000; Zaklad *et al.*, 2004).

GSCM's definition has ranged from green purchasing to integrated supply chains flowing from supplier, to manufacturer, to customer and reverse logistics, which is "closing the loop" as defined by supply chain management literature (Zhu and Sarkis, 2004). Similar to the concept of supply chain management, the boundary of GSCM is dependent on the goal of the investigator. In this case, for our paper, we shall focus on a single level supplier-manufacturer-customer relationship. The research in GSCM addresses a variety of issues ranging from organizational research and practice in GSCM (Geffen and Rothenberg, 2000; Hall, 2001; Theyel, 2001; Zsidisin and Siferd, 2001) to prescriptive models for evaluation of GSCM practices and technology (Faruk *et al.*, 2002; Handfield *et al.*, 2002; Sarkis, 2003).

The remainder of the literature review will focus on the major areas we will be investigating in our empirical study including issues relevant to GSCM adoption pressures and drivers, adoption of GSCM practices, and performance perceptions from these adoptions.

GSCM drivers for adoption

Investigation of pressures and drivers for adoption and improving environmental performance arises from a number of external and internal groups or "stakeholders". The literature has identified a number of potential groups that will influence organizational adoption of GSCM and other environmental practices. For example, Christmann and Taylor (2001) suggested that export and sales to foreign customers are two major drivers for improving the environmental performance of enterprises in

China. Chinese enterprises have started to experience pressures from green barriers when exporting their commodities. During the three years from 1997 to 1999, the value of the commodities that were rejected because of such barriers has been estimated to be approximately 20 billion US dollars (Xinhua News Agency, 2001). For example, many countries require a certificate for wood products in order to show that their harvest does not harm their forest's sustainable development. Many Chinese enterprises have failed to sell their wood products because they do not have this particular certification. Another example is that shoes made in Fujian, a province in southeast China, could not be exported because the glue used in shoe manufacturing does not satisfy the environmental requirements of the customers. Some countries, including Japan, the United States, the Netherlands, Norway, France and Sweden, have also put forward different environmental requirements for the fabrics and dyes of clothes imported from China (Ministry of Foreign Trade and Economic Cooperation of PRC, 2002). Thus, the benefits from China's entry into the World Trade Organization (WTO) could be diminished unless it meets the relevant international environmental standards.

Consumer pressures and drivers may also exist, but are still evolving. For example, Chan and Lau (2001) compared green purchasing behaviors between American and Chinese consumers, and concluded that the translation of green purchasing intention to corresponding behavior is more effective among American consumers. However, Chinese consumers, especially younger consumers are developing an increasingly heightened environmental awareness and are starting to prefer "green" products (Lo and Leung, 2000).

China has received substantial direct foreign investment in the last five years, and China should be able to attract increasing foreign investments after joining the WTO. However, most joint ventures or foreign direct investment (FDI) enterprises in China purchase key raw materials and components mainly from their home countries, or from upstream enterprises in their supply chains already operating in China, mainly due to Chinese enterprises' inabilities to provide materials and products that meet these foreign enterprises' environmental requirements (Zhu and Geng, 2001). For example, some leading enterprises from developed countries evaluate not only their direct suppliers, but also second-tier suppliers (suppliers' suppliers). In this regard, it is noteworthy that in their investigation Walton *et al.* (1998) put forward ten top environmental supplier evaluation criteria and that, among these, environmentally friendly practice evaluation of second-tier suppliers is the second most important criterion.

The scarcity of resources, degradation of environment, and increasing pressure from Chinese consumers have caused the Chinese government, both local and national to also exert pressures through increasing environmental regulatory and tax policies. To control over-exploitation and over-consumption of resources, the Chinese government has levied resource taxes and implemented quota-pricing systems for some resources such as water (Bai and Hidefumi, 2001).

Thus, we can see that pressures may potentially arise from regulators, supply chain partners, competitors and the market (consumers and customers). Our initial investigation in this study seeks to determine where Chinese organizations are feeling these pressures for adoption of GSCM practices. Our initial general proposition that will be evaluated with empirical data is as follows:

P1. Chinese enterprises are feeling significant pressure to introduce GSCM principles and practices and these pressures arise from a variety of sources.

GSCM practice

Given that there is a multidimensional expansion of the literature in the area of corporate environmental management, this paper focuses on four GSCM practices (internal environmental management, external GSCM including green purchasing and cooperation with customers including environmental requirements, investment recovery, and eco-design practices). These four areas represent some of the main internal and external activities and functions within organizational supply chain management (Zhu and Sarkis, 2004).

There is consensus within the literature that internal environmental management is a key to improving enterprises' performance (Carter *et al.*, 1998). It is well known that senior managers' support is necessary and, often, a key driver for successful adoption and implementation of most innovations, technology, programs and activities (Hamel and Prahalad, 1989). To ensure complete environmental excellence, top management must be totally committed (Zsidisin and Siferd, 2001; Rice, 2003). Carter *et al.* (1998) concluded that support from mid-level managers is also key to successful implementation of EMS practices. Bowen *et al.* (2001) used middle managers to find positive relationships between middle managers' perceptions of corporate environmental proactivity and environmental management. Communication between business managers and environmental professionals is also important in the successful business and environment relationship (Aspan, 2000).

External GSCM practice (in what traditionally is viewed as the scope of supply chain management) has also grown in importance. By investigating purchasing managers in Germany, the UK and the USA, Zsidisin and Hendrick (1998) identified key factors for environmental purchasing such as providing design specification to suppliers that include environmental requirements for purchased items, cooperation with suppliers for environmental objectives, environmental audit for supplier's internal management and suppliers' ISO14001 certification.

Investment recovery and eco-design are two emerging environmental practices in China that have significant internal and external influences on GSCM. Both United States and European enterprises have considered investment recovery as a critical aspect for GSCM (Zsidisin and Hendrick, 1998), which may occur at the back end of the supply chain cycle. In China, the government, to improve investment recovery and better design of processes and systems, has changed its policies from a focus on resource subsidies to levying taxes for some resources such as coal and natural gas. No matter where in the product life cycle a product or process lies, most of the environmental influence is "locked" in at the design stages when materials and processes are selected and product environmental performance is largely determined (Lewis and Gretsakis, 2001).

As we have mentioned in our previous section, China has encouraged (pressured) GSCM practice adoption to help spur economic development. For example, by encouraging the adoption and certification of the global environmental system standard ISO14001, the Chinese government has contributed to organizational GSCM practices adoption such as integrating environmental considerations into supplier selection.

Green marketing, together with eco-design and green purchasing, is a necessary element of improved environmental performance for Chinese companies and/or their products/services. However, it has been found elsewhere, and may be true in China, that there seems to be a gap between the desirability of GSCM in awareness or theory and the slow implementation of GSCM at the aggregate level across enterprises (Bowen *et al.*, 2001). Using this literature we have identified a number of GSCM practices that may be grouped into our four major groupings (part of our study is to help justify these groupings). The second portion of our exploratory study will determine the progress of our sample of Chinese manufacturing organizations for adopting GSCM practices. Given that China research and focus on corporate environmental issues is a recent phenomena we make two general propositions.

P2. Chinese enterprises are in the initial stages of GSCM practice adoption.

P3. GSCM practice adoption in Chinese enterprises lags behind the GSCM pressures they have experienced.

GSCM performance

Previous research has explored the relationships between GSCM practices and performance including environmental, economic and operational performance. Literature has offered insight on potential patterns of supply-chain relations for improving environmental performance (Florida, 1996; Florida and Davison, 2001; Geffen and Rothenberg, 2000; Green *et al.*, 1996; Handfield *et al.*, 2002; Sarkis, 1995). The literature for supporting such positive relationships is relatively strong. For example, Frosch (1994) argued that an inter-firm linkage facilitated by proximity could lead to improvement in environmental performance. Geffen and Rothenberg (2000) suggested that relations with suppliers aid the adoption and development of innovative environmental technologies. In addition, the interaction of customer and supplier staff, partnership agreements and joint research and development lead to improvements in environmental performance.

Whether GSCM practices cause or relate to positive or negative economic performance is still mixed (Wagner *et al.*, 2001). Alvarez *et al.* (2001) indicated that environmental management such as GSCM has a positive relationship with an organization's economic performance. Dodgson (2000), Dyer and Singh (1998), von Hippel (1988) and others argued that inter-firm relations provide formal and informal mechanisms that promote trust, reduce risk and in turn increase innovation and profitability. However, through examination, Bowen *et al.* (2001) suggested economic performance is not being reaped in short-term profitability and sales performance.

Limited research still indicates a positive relationship between environmental management and operational performance. Szwilski (2000) put forward that an environmental management system is an innovative environmental policy and information management tool for industry to improve organizational operational performance. Using a case study of the first Japanese integrated mill of pulp and paper that gained the certification of ISO14001, Tooru (2001) demonstrated that environmental management systems can improve operational performance of a firm. Hanna *et al.* (2000) found a strong relationship between meeting operational goals and staff involvement on environmental management.

It is still not clear whether benefits or costs dominate when adopting GSCM practices in China. Thus, whether managers perceive improvements in environmental, economic and operational performance due to adoption of GSCM practices will be the third major issue we shall investigate. Given the strength of the overall literature in supporting the "win-win" scheme, even though it is still mixed, we present our final proposition.

P4. GSCM practice adoption in Chinese enterprises has improved organizational and environmental performance of those adopting organizations.

Methodology

Questionnaire development

The data used in this study consist of questionnaire responses from managers in Chinese manufacturing and processing industries that have profound impact on the environment. The questionnaire contains three sections, items affecting implementation (pressures/drivers), current practices and corresponding performance. Thirteen items in part one (pressures/drivers) were based on a number of sources from the literature (Min and Galle, 1997; Carter and Carter, 1998; Christmann and Taylor, 2001; Chan and Lau, 2001) and questions were answered using a five-point Likert-type scale (e.g. 1 = not at all important, 2 = not important, 3 = not thinking about it, 4 = important, 5 = extremely important). Twenty-one items in part two (GSCM practices) were based on industrial expert input and from the literature (Zsidisin and Hendrick, 1998; Walton *et al.*, 1998; Carter *et al.*, 2000). Questions in part two were answered using a five-point scale (1 = not considering it, 2 = planning to consider it, 3 = considering it currently, 4 = initiating implementation, 5 = implementing successfully). The third section of 20 questions developed by the authors focused on environmental performance, financial performance and operational performance. Questions about the influence of implementing GSCM on these performance factors were answered using a five-point scale (1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant and 5 = significant). To avoid confusing respondents on three different five-point Likert scales, we provided a brief explanation of the three groups of items at the beginning of each survey section.

Data collection and sample characteristics

The data collection was administered through three steps:

(1) *Pilot test*. A pilot test was completed to test and refine the questionnaire. The pilot test was conducted during two workshops for managers on environmental management in the Tianjin Economic and Technological Area (TEDA) and Dalian Economic and Technological Development Zone (DETDZ), the largest and the second largest industrial zones in China according to GDP. A total of 28 valid questionnaires were collected in the pilot test. Based on the suggestions from respondents in the two workshops, minor modifications were made to the questionnaire.

(2) *Convenience sampling*. For initial results we completed convenience sampling of respondents through workshops in the School of Management at Dalian University of Technology[1], as well as interviews and site visits in the Dalian High-tech Zone in Liaoning province and the Zibo Industrial Zone in Shandong province. Initially, 158 unique and usable manufacturing enterprises

responses were received. Interviews and site visits confirmed that respondents had a clear definition and understanding of the three different five-point Likert-type scales used for the three item groupings. To narrow research targets and avoid bias as much as possible, we chose respondents mainly from three types of enterprises throughout China, namely, FDI enterprises and joint ventures, enterprises exporting products or becoming suppliers of foreign enterprises, and traditional heavy polluters such as petroleum refineries, chemicals, paper and pulp, textile and metallurgical industry. Owing to higher awareness or pressure, it can be argued that these enterprises in China are innovators in GSCM and their experiences will diffuse to other enterprises.

(3) *Random surveys in Dalian*. To avoid the biases associated with convenience sampling, we also completed some random surveys through regular postal mail, followed by telephone calls within the Dalian metropolitan area. The targeted companies are from the list of Dalian manufacturers primarily within the three industrial organizational characteristics mentioned above. Out of a total of 1,000 questionnaires mailed, a total of 128 usable manufacturing enterprise responses were received (a 12.8 percent response rate).

The biases associated with the pilot and convenience samples were assessed by dividing the total 314 responses into two groups, namely, early from the pilot test and the convenience sampling ($n = 186$, 59.2 percent) and late from the more random mailing ($n = 128$, 40.8 percent). Responses from the two groups to the 54 questionnaire items were compared using a series of *t*-tests. The test results indicated that in all 54 items no statistical differences existed between the mean scores of the early and late respondents (this was true at the 5 percent or better level of significance). Thus, we are able to effectively use the full data set of 314 responses to evaluate our propositions.

Table I shows the distribution of respondent enterprises in terms of industry and enterprise size using employment levels. Notice that respondents are mainly from four typical industries, that is, automobile, power generating, chemical/petroleum and

Table I.
Distribution of survey respondent enterprises by industry and size

	Total	Percentage
Industry		
Automobile	82	26.1
Power generating	70	22.3
Chemical/petroleum	50	15.9
Electrical and electronic	39	12.4
Textile	15	4.8
Steel	15	4.8
Food processing	13	4.1
Pharmaceutical	10	3.2
Other	20	6.4
Total	314	100
Size (employees)		
>2000	95	30.3
300-2,000	151	48.1
<300	68	21.6
Total	314	100

electrical/electronic industry. Enterprise sizes ranged from under 300 to over 2,000 employees with about half of companies falling into the relatively large company classification of between 300 and 2,000 employees.

Factor analysis

An exploratory factor analysis was conducted to derive groupings of GSCM pressures, practice and performance from the survey data. Factors were extracted using the maximum likelihood method, followed by a varimax rotation. The Kaiser criterion (eigenvalues > 1) was employed in conjunction with an evaluation of scree plots. Both the scree test and initial eigenvalue test suggested the presence of four factors for pressure, practice and performance that were retained. This factor analysis empirically grouped the scale items of GSCM pressures as predicted, see Table II, further validating our original item groupings. The four GSCM pressure/driver factors explain 68.6 percent of the inherent variation in their items. A similar factor analysis of the GSCM practice and performance items also grouped the scale items as predicted, see Tables III and IV. The four GSCM practice factors explain 70.5 percent of the inherent variation while four performance factors explain 74.8 percent of the inherent variation. We labeled the four factors on GSCM pressures as supply chain pressure, cost-related pressure, marketing and regulations. Further analysis confirms the reliability of these four factors with Cronbach's alpha, of 0.83, 0.84, 0.80 and 0.78, respectively, for each group. Four factors of practices are labeled as internal environmental management, external GSCM, eco-design and investment recovery. Further analysis confirms the reliability of these four factors with Cronbach's alpha, of 0.91, 0.92, 0.86 and 0.83, respectively, for each group. The four factors on performance can be labeled as environmental performance, operational performance, positive economic performance and negative economic performance. Further analysis also confirms the reliability of these four factors with levels of Cronbach's alpha equal to 0.94, 0.93, 0.90 and 0.87, respectively. All Cronbach's alpha values are well above the limit of 0.70 established by Nunnally (1978) to ensure the constructs' internal consistency and validity.

Items	Component 1	2	3	4
Central governmental environmental regulations	0.275	0.088	0.147	0.831
Regional environmental regulations	0.127	0.141	0.114	0.880
Export	0.194	0.200	0.872	0.150
Sales to foreign customers in China	0.281	0.197	0.830	0.135
Supplier's advances in developing environmentally friendly goods	0.769	0.032	0.112	0.246
Supplier's advances in developing environmentally friendly packages	0.797	0.108	0.260	0.115
Environmental partnership with suppliers	0.759	0.121	0.168	0.063
Competitors' green strategies	0.649	0.312	0.069	0.171
Industrial professional group activities	0.557	0.371	0.029	0.168
Enterprise's environmental mission	0.597	0.286	0.265	0.046
Cost for disposal of hazardous materials	0.134	0.816	0.060	0.100
Cost of environmentally friendly goods	0.180	0.831	0.228	0.059
Cost of environmentally friendly packaging	0.293	0.801	0.221	0.121

Note: Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization. [a]Rotation converged in five iterations

Table II.
Rotated factor matrix[a] on GSCM drivers/pressure

Survey items	1	2	3	4
Providing design specification to suppliers that include environmental requirements for purchased items	0.302	0.574	0.341	0.048
Cooperation with suppliers for environmental objectives	0.393	0.595	0.289	0.116
Environmental audit for suppliers' internal management	0.167	0.791	0.037	0.082
Suppliers' ISO14000 certification	0.309	0.752	0.013	−0.004
Second-tier supplier environmentally friendly practice evaluation	0.235	0.774	0.076	0.111
Cooperation with customer for eco-design	0.234	0.682	0.251	0.223
Cooperation with customers for cleaner production	0.200	0.652	0.225	0.313
Cooperation with customers for green packaging	0.137	0.770	0.180	0.193
Investment recovery (sale) of excess inventories/materials	0.110	0.227	0.249	0.758
Sale of scrap and used materials	0.124	0.089	0.125	0.861
Sale of excess capital equipment	0.039	0.159	0.038	0.817
Design of products for reduced consumption of material/energy	0.248	0.124	0.803	0.247
Design of products for reuse, recycle, recovery of material, component parts	0.167	0.191	0.817	0.116
Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process	0.390	0.285	0.733	0.101
Commitment of GSCM from senior managers	0.819	0.194	0.254	0.154
Support for GSCM from mid-level managers	0.838	0.204	0.187	0.147
Cross-functional cooperation for environmental improvements	0.745	0.208	0.295	0.150
Total quality environmental management	0.834	0.277	0.212	0.078
Environmental compliance and auditing programs	0.772	0.172	0.314	0.140
ISO 14001 certification	0.692	0.404	−0.018	−0.076
Environmental management systems exist	0.797	0.310	0.039	−0.003

Table III.
Rotated factor matrix[a] on GSCM practices

Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization. [a]Rotation converged in seven iterations

Items for each factor on GSCM pressure, practice and performance, as well as other descriptive data, including means, standard deviations and sample size per question, are shown in Tables V, VI and VII.

Results and discussion

Evaluating propositions

To evaluate our initial propositions we will do a general comparison of the mean scores of each of the major factors determined by the factor analysis.

P1 posits that Chinese enterprises have pressures/drivers to adopt and implement GSCM, and that these pressures and drivers originate from a variety of sources. Table V shows that all four means of the factors of GSCM pressure are over 4.00 (important), that is, 4.10 for supply chain pressure, 4.03 for cost related pressure, 4.10 for marketing and 4.51 for regulations (in our five-point scale, 4 = important, 5 = extremely important). Thus, *P1* is supported with clear pressures and/or drivers present from a variety of sources.

P2 posits that Chinese enterprises have initiated or adopted some GSCM practices. This proposition is partly supported by practices of internal environmental management, eco-design and investment recovery with means of 3.57, 3.52 and 3.39, respectively (within the range of 3 = considering it currently to 4 = initiating implementation from our five-point scales). This proposition is not supported for external GSCM practice adoption with a mean of only 2.91.

	Component			
	1	2	3	4
Reduction of air emission	0.780	0.282	0.191	0.227
Reduction of waste water	0.814	0.258	0.217	0.174
Reduction of solid wastes	0.742	0.158	0.288	0.321
Decrease of consumption for hazardous/harmful/toxic materials	0.773	0.235	0.150	0.305
Decrease of frequency for environmental accidents	0.772	0.289	0.186	0.176
Improve a enterprise's environmental situation	0.744	0.347	0.170	0.149
Increase of investment	0.456	0.268	0.192	0.600
Increase of operational cost	0.256	0.119	0.217	0.816
Increase of training cost	0.264	0.191	0.089	0.764
Increase of costs for purchasing environmentally friendly materials	0.168	0.057	0.397	0.752
Decrease of cost for materials purchasing	0.255	0.226	0.650	0.356
Decrease of cost for energy consumption	0.183	0.286	0.768	0.229
Decrease of fee for waste treatment	0.216	0.328	0.814	0.186
Decrease of fee for waste discharge	0.288	0.267	0.825	0.163
Increase amount of goods delivered on time	0.230	0.749	0.207	0.300
Decrease inventory levels	0.222	0.755	0.141	0.282
Decrease scrap rate	0.228	0.748	0.224	0.254
Promote products' quality	0.260	0.822	0.185	0.100
Increased product line	0.295	0.789	0.284	−0.025
Improved capacity utilization	0.274	0.803	0.269	−0.028

Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization. [a]Rotation converged in seven iterations

Table IV.
Rotated factor matrix[a] on GSCM performance

Items	Mean	SD	*N*
Supply chain pressure ($\alpha = 0.83$)	*4.10*	*0.586*	*302*
Supplier's advances in developing environmentally friendly goods	4.05	0.787	310
Supplier's advances in developing environmentally friendly packages	3.96	0.864	310
Environmental partnership with suppliers	3.97	0.770	308
Competitors' green strategies	4.22	0.836	311
Industrial professional group activities	3.87	0.841	309
Enterprise's environmental mission	4.45	0.754	313
Cost related pressure ($\alpha = 0.84$)	*4.03*	*0.702*	*308*
Cost for disposal of hazardous materials	4.13	0.850	311
Cost of environmentally friendly goods	4.02	0.780	311
Cost of environmentally friendly packaging	3.92	0.797	310
Marketing ($\alpha = 0.80$)	*4.10*	*0.842*	*297*
Export	4.16	0.963	301
Sales to foreign customers in China	4.05	0.883	303
Regulations ($\alpha = 0.78$)	*4.51*	*0.673*	*313*
Central governmental environmental regulations	4.61	0.694	314
Regional environmental regulations	4.41	0.792	313

Notes: 1=not at all important; 2=not important; 3=not thinking about it; 4=important; 5=extremely important

Table V.
Descriptive statistics on GSCM pressures

Items	Mean	SD	*N*
Internal environmental management ($\alpha = 0.91$)	*3.57*	*0.980*	*286*
Commitment of GSCM from senior managers	3.81	1.128	307
Support for GSCM from mid-level managers	3.60	1.037	310
Cross-functional cooperation for environmental improvements	3.63	1.058	308
Total quality environmental management	3.65	1.130	304
Environmental compliance and auditing programs	3.77	1.065	303
ISO 14001 certification	3.23	1.340	297
Environmental Management Systems exist	3.37	1.219	304
External GSCM ($\alpha = 0.92$)	*2.91*	*0.989*	*268*
Providing design specification to suppliers that include environmental requirements for purchased item	3.28	1.270	307
Cooperation with suppliers for environmental objectives	3.06	1.289	308
Environmental audit for suppliers' internal management	2.74	1.314	300
Suppliers' ISO14000 certification	3.15	1.309	297
Second-tier supplier environmentally friendly practice evaluation	2.70	1.300	300
Cooperation with customer for eco-design	2.69	1.266	302
Cooperation with customers for cleaner production	3.04	1.226	301
Cooperation with customers for green packaging	2.94	1.243	296
Eco-design ($\alpha = 0.86$)	*3.52*	*1.020*	*297*
Design of products for reduced consumption of material/energy	3.67	1.110	300
Design of products for reuse, recycle, recovery of material, component parts	3.35	1.180	301
Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process	3.57	1.164	304
Investment recovery ($\alpha = 0.83$)	*3.39*	*1.033*	*291*
Investment recovery (sale) of excess inventories/materials	3.43	1.274	302
Sale of scrap and used materials	3.48	1.171	308
Sale of excess capital equipment	3.34	1.155	299

Table VI.
Descriptive statistics on GSCM practices

Notes: 1=not considering it; 2=planning to consider it; 3=considering it currently; 4=initiating implementation; 5=implementing successfully

P3 posits that GSCM practice in Chinese enterprise lags behind the GSCM pressures and drivers they have experienced. This proposition seems to be supported by the results shown in Tables V and VI. All four factors of GSCM pressures have means over 4.00 while four factors of GSCM practices have means below 3.60. Further, we compared the mean values of two composite factors of GSCM pressure and practice, that is, 3.34 and 4.20, respectively, which also tends to support *P3*. Even though we observe this result, care must be taken in that the scales for these two groups of factors (pressures and practice adoption) are not the same.

P4 posits that adoption of GSCM practice in Chinese enterprises has improved their performance. It is supported by two factors, namely, environmental performance and operational performance factors with means of 3.72 and 3.45 (in our five-point scale, 3 = to some degree, 4 = relatively significant), respectively. The factor of positive economic performance has a mean of 3.13, which shows that GSCM practices have to some degree improved economic performance. However, the mean of positive economic performance is lower than the mean of negative economic performance (3.45). Thus, the general proposition is not supported for economic performance factors.

Items	Mean	SD	*N*
Environmental performance ($\alpha = 0.94$)	*3.72*	*0.963*	*291*
Reduction of air emission	3.58	1.192	300
Reduction of waste water	3.72	1.093	302
Reduction of solid wastes	3.61	1.090	300
Decrease of consumption for hazardous/harmful/toxic materials	3.67	1.136	297
Decrease of frequency for environmental accidents	3.75	1.100	295
Improve a enterprise's environmental situation	3.90	1.041	302
Operational performance ($\alpha = 0.93$)	*3.48*	*0.928*	*281*
Increase amount of goods delivered on time	3.50	1.135	290
Decrease inventory levels	3.31	1.109	294
Decrease scrap rate	3.34	1.104	291
Promote products' quality	3.69	1.013	297
Increased product line	3.53	1.063	292
Improved capacity utilization	3.58	1.053	295
Positive economic performance ($\alpha = 0.90$)	*3.13*	*0.950*	*288*
Decrease of cost for materials purchasing	3.32	1.077	294
Decrease of cost for energy consumption	3.27	1.038	294
Decrease of fee for waste treatment	2.97	1.089	297
Decrease of fee for waste discharge	2.97	1.108	294
Negative economic performance ($\alpha = 0.87$)	*3.45*	*0.889*	*275*
Increase of investment	3.64	1.049	298
Increase of operational cost	3.48	1.010	295
Increase of training cost	3.38	1.059	297
Increase cost of purchasing environmentally friendly materials	3.31	1.067	280

Notes: 1=not at all; 2=a little bit; 3=to some degree; 4=relatively significant and 5=significant

Table VII.
Descriptive statistics on GSCM performance influences

Discussions of main item findings

From Table V we can see that our sample of Chinese manufacturing enterprises has a broad set of pressures, drivers and influences on GSCM practices. Every single item listed in our set has been viewed as having some level of importance on our investigated items with means over or close to 4.00 (in our five-point scale, 4 = important). The only item whose mean (3.87) falls somewhat below important (4.0) is industrial professional group activities. Thus, it may be seen that the influences are very strong and that Chinese managers are quite aware of these pressures to address GSCM and environmental issues. Regulatory factors still seem to be the most important pressure. Supply chain pressures and marketing drivers are not as strong. Even so, enterprises' environmental missions seem to be one of the more highly rated drivers with a mean of 4.45. Cost related factors have the lowest mean, 4.03, which demonstrates that managers may not view environmental programs as providing strong economic advantages.

The results suggest that a lag may exist between the pressures being felt by Chinese organizations in Chinese manufacturing enterprises and their adoption of these practices. These Chinese manufacturing enterprises may still be in the early learning stages of corporate environmental programs and practices. This result also points to the need for Chinese enterprises to become better educated in and raising awareness of GSCM practices. Some practices seem to be at the forefront of adoption and implementation. The internal environmental management and eco-design factors are

further along in adoption, albeit at very early stages. It is not surprising that commitment of GSCM by senior managers is the furthest along (3.81 mean rating). Without this initial upper management commitment, most programs are bound to fail, much less be truly initiated. Organizations have also considered or initiated environmental compliance and audit programs with a mean of 3.77 and total quality environmental programs with a mean of 3.65. In addition, Chinese companies could be realizing that these issues and practices require inter-disciplinary cross-functional cooperation (3.63 mean score), which relates to the need for more senior management commitment to enable this cooperation. Another highly rated practice related to early adoption and cross-functional efforts is in the design of products (3.52). This finding is not surprising either and is even encouraging. The design of products (and related design of processes) is critical to the early "Design for the Environment" philosophies that the most effective way to reduce environmental impacts is through prevention and better design. Once a product is designed well, then procurement of parts and materials may occur. These results also point to a more traditional product development process where much of the eco-design input is from internal teams rather than supplier and customer input (2.91). The major communication with suppliers seems to be providing them design specifications of products (3.28) rather than cooperative eco-design programs. Even simple environmental audits of suppliers, which have become a popular GSCM tool by many organizations is lagging behind other aspects of GSCM practice in China (2.74). What is evident is that the GSCM practices that have economic aspects are only behind management support and internal management programs.

Our findings are similar to what Russel (1998) found for overall Western industry. Despite alleged benefits ranging from straightforward cost reduction to facilitating the development of co-operative relationships with suppliers, and even encouraging a life-cycle, holistic approach in managerial decision-making, there appears to be a gap between the increasing environmental awareness (and pressures) and the slow implementation of GSCM across enterprises (Russel, 1998). It will take some time to turn the awareness and pressures into practices and performance.

The perceived performance implications of GSCM practice were the last major issues we targeted in our survey of the manufacturing enterprises, see Table VII. It is not surprising that the major influences of GSCM practices seemed to be on the environmental performance dimension with the more general "improving an enterprises environmental situation" receiving the highest mean score (3.90). It also seems that managers thought that the benefits (decreases in costs) were not as prevalent as the increases in costs under economic performance. The economic performance results overall were not as good as the operational and environmental performance. For operational performance, GSCM practices were perceived to have a large influence on promoting a product's quality. It also seems that the GSCM practices may have influenced capacity utilization and product line offerings (a proxy for product flexibility). Overall, GSCM practices may still have a difficult time in terms of acceptance and adoption if the perception is that they provide environmental benefits, and that operational and economic performance is less influenced, especially in beneficial ways. Without the economic payback, managers will need to somehow be able to convince management of the strengths of the other benefits.

Comparative analysis of findings

Comparing results from our investigation with that of some of the literature (Min and Galle, 1997), similarities and differences were found. To provide this comparative analysis we took the major pressures for selecting suppliers from an environmental perspective, which appeared in the previous literature, and compared them to our pressures for GSCM practice which appeared in Table V. One exception that is not presented in Table V is potential liability for disposal of hazardous material because this item is not clearly loaded on any of the four factors. The wording for our survey was slightly broader than those of previous surveys that focused on selecting suppliers, but the pressure and driver items were the same. Given this difference in focus, the drivers and pressures that were identified in these US and Chinese enterprises have similar key factors that affect a buying firm's choice of suppliers (Table VIII). The rankings were based on the mean scores in Table V. The factors were only rank ordered differently if there was a significant statistical difference between the values of the mean rankings based on a *t*-test. That is why a number of driver factors have equal ranking.

These results show some commonality in the rankings. However, US enterprises highlight potential liability and cost for disposal of hazardous materials while Chinese enterprises are more concerned with regulatory issues. It also seems that a buying firm's environmental mission is more important for Chinese enterprises. This result may be due to the reason that export and sales to foreign enterprises in China are two important incentives for Chinese enterprises.

One area of comparative GSCM practice where information exists is that of investment recovery (our results in Table VI). Zsidisin and Hendrick (1998) found that in the US and Germany, enterprises highlight investment recovery as the most important practice for green purchasing. In China, investment recovery has received much less attention than developed countries such as the US and Germany due to Chinese waste management policies and lack of recycling systems. To attract more investment, industrial zones in China such as TEDA provide subsidies for enterprises to cover solid waste disposal. Since treatment for waste recovery can be quite

Factors	Rank of importance in Chinese enterprises[a]	Rank of importance in US enterprises[b]
Central governmental environmental regulations	1	2
Buying firm's environmental mission	2	4
Regional environmental regulations	2	2
Potential liability for disposal of hazardous materials	3	1
Cost for disposal of hazardous materials	4	2
Supplier's advances in developing environmentally friendly goods	4	5
Cost of environmentally friendly goods	5	3
Supplier's advances in developing environmentally friendly packages	5	5
Environmental partnership with suppliers	5	5
Cost of environmentally friendly packages	5	3

Notes: [a]Data are from this investigation; [b]date are from Min and Galle, 1997; [c]the rank is adjusted by *t*-test; the same adjusted rank indicates no statistically significant difference in means at $p = 0.05$

Table VIII.
Key pressures that affect a buying firm's green supplier management and selection

expensive, our interviews indicate that many Chinese enterprises consider investment recovery such as material recycling and recovery a costly function too. Moreover, recycling and recovery sometimes are difficult in China due to lack of recycling systems and relevant technologies. "Scavenger" organizations, enterprises that feed off the wasted resources of other companies in the system, and "decomposer" organizations, enterprises that use the resources from other companies and transform them back into the system, are necessary for resource recovery (Geng and Cote, 2002). Lack of scavengers and decomposers for potential resources affect investment recovery in China. The integrated approach to green supply chain systems may help to improve resource recovery just like an eco-industrial development (Zhu and Cote, 2004).

Implications and conclusions

Recently, Chinese enterprises have increased their environmental awareness due to regulatory, competitive, and marketing pressures and drivers (as supported by our *P1*). Chinese enterprises highlight their exporting philosophies by pursuing such international organizational standards as ISO9000 serial and ISO14001 certification. At the same time, in support of our second proposition, Chinese enterprises have sought to implement a variety of GSCM practices to improve their environmental performance in response to this export philosophy so that they can more effectively serve as suppliers to foreign enterprises in China. Internal environmental management, especially commitment from top-level managers and support from mid-level managers, will be necessary for development of any GSCM programs in China. This is not different from any enterprise almost any place in the world. Thus, education (raising awareness) of management in GSCM practices is one of the initial crucial steps in this arena.

However, GSCM is still in its infancy in China. Chinese enterprises have recognized its importance, but have lagged in the implementation of these principles into practice (in support of our third proposition). It is not clear what the barriers are for this implementation, but the lack of necessary tools, management skills and knowledge, and most likely the lack of an economic justification in terms of performance, may all be barriers. Therefore, even with higher environmental awareness and pressures in Chinese enterprises, this awareness has not translated into strong GSCM practice adoption, let alone to improvements expected in some areas of performance (as shown in our discussion of *P4*). It seems that the Chinese government has stipulated new policies to promote GSCM and other corporate environmental practices primarily to export more products and to attract more foreign investments. For example, some local government agencies have helped enterprises to pass ISO14001 certification by providing training and subsidizing part of certification fee. To realize both environmental and economic performance, investment recovery by altering current policies and establishing recovery system infrastructures that help "close the loop" is something that should be highlighted by Chinese national policy makers.

This work is one of the few efforts to investigate GSCM practices in China. Thus, our investigation and its findings are still relatively exploratory. Future research can also include investigation of longitudinal relationships identified in this work and can help identify long-term patterns in one of the world's largest countries and one that will truly have a global impact on the environmental and economic direction of society over the next few decades. In addition, future research should try to tease out various

relationships, including mediating and moderating relationships, that may exist between various items and factors we have identified. A more broadly-based and random sample study across China would also provide a better picture of these practices and what is occurring throughout China, not only in special economic zones.

Despite the limited research and relative novelty of GSCM in China, efforts made by Chinese enterprises together with the Chinese government have established a good foundation for further development. After China's entry into the WTO, more foreign enterprises have established joint ventures or FDI enterprises in China. By improving both quality and environmental image, Chinese enterprises can cooperate with foreign enterprises in China such as becoming long-term suppliers of their foreign customers. This is a road that may also improve operations and business performance for these organizations. Win-win is still possible at the national and organizational level if GSCM practices are seriously given consideration.

Note

1. Convenience surveys at Dalian University of Technology. The National Center for Industrial Science and Technology in the School of Management at Dalian University of Technology was established in 1980. The center was directly proposed by Mr Deng Xiaoping. The center is the first joint training project between Chinese and American stakeholders. Since 2001, it has been one of nine training bases for industries in China designated by the State Economic and Trade Commission. In recent years, the center has provided training for manager in four main industries targeted by our study. Since managers involved in training programs are representatives from these industries throughout China, we can argue that responses from them can generally represent situations in China for these industries.

References

Alvarez Gil, M.J., Jimenez, J.B. and Lorente, J.C. (2001), "An analysis of environmental management, organizational context and performance of Spanish hotels", *Omega*, Vol. 29 No. 6, pp. 457-71.

Angell, L.C. and Klassen, R.D. (1999), "Integrating environmental issues into the mainstream: an agenda for research in operations management", *Journal of Operations Management*, Vol. 17 No. 5, pp. 575-98.

Aspan, H. (2000), "Running in nonconcentric circles: why environmental management isn't being integrated into business management", *Environmental Quality Management*, Vol. 9 No. 4, pp. 9-75.

Bai, X.M. and Hidefumi, I. (2001), "Towards sustainable urban water resource management: a case study in Tianjin, China", *Sustainable Development*, Vol. 9, pp. 24-35.

Bowen, F.E., Cousins, P.D., Lamming, R.C. and Faruk, A.C. (2001), "Horse for courses: explaining the gap between the theory and practice of green supply", *Greener Management International*, No. 35, pp. 41-60.

Carter, C.R. (2000), "Ethical issues in international buyer-supplier relationships: a dyadic examination", *Journal of Operations Management*, Vol. 18 No. 2, pp. 191-208.

Carter, C.R. and Carter, J.R. (1998), "Interorganizational determinants of environmental purchasing: initial evidence from the consumer products industry", *Decision Sciences*, Vol. 29 No. 3, pp. 28-38.

Carter, C.R., Ellram, L.M. and Kathryn, L.M. (1998), "Environmental purchasing: benchmarking our German counterparts", *International Journal of Purchasing & Materials Management*, Vol. 34 No. 4, pp. 28-38.

Carter, C.R., Kale, R. and Grimn, C.M. (2000), "Environmental purchasing and firm performance: an empirical investigation", *Transportation Research Part E*, Vol. 36, pp. 219-88.

Chan, R.Y.K. and Lau, L.B.Y. (2001), "Explaining green purchasing behavior: a cross-cultural study on American and Chinese consumers", *Journal of International Consumer Marketing*, Vol. 14 Nos. 2/3, pp. 9-41.

Christmann, P. and Taylor, G. (2001), "Globalization and the environment: determinants of firm self-regulation in China", *Journal of International Business Studies*, Vol. 32 No. 3, pp. 439-58.

Dodgson, M. (2000), *Management of Technology*, Routedge, London.

Dyer, J.H. and Singh, H. (1998), "The relations view: co-operative strategy and sources of inter-organizational competitive advantage", *Academy of Management Review*, Vol. 23, pp. 660-79.

Faruk, A.C., Lamming, R.C., Cousins, P.D. and Bowen, F.E. (2002), "Analyzing, mapping and managing environmental impacts along the supply chain", *Journal of Industrial Ecology*, Vol. 5 No. 2, pp. 13-36.

Florida, R. (1996), "The environment and the new industrial revolution", *California Management Review*, Vol. 38, pp. 80-115.

Florida, R. and Davison, D. (2001), "Gaining from green management: environmental management systems inside and outside the factory", *California Management Review*, Vol. 43 No. 3, pp. 64-84.

Frosch, R. (1994), "Industrial ecology: minimizing the impact of industrial waste", *Physics Today*, Vol. 47 No. 11, pp. 63-8.

Geffen, C. and Rothenberg, S. (2000), "Sustainable development across firm boundaries: the critical role of suppliers in environmental innovation", *International Journal of Operations & Production Management*, Vol. 20 No. 2, pp. 166-86.

Geng, Y. and Cote, R. (2002), "Scavengers and decomposers", *International Journal of Sustainable Development & World Ecology*, Vol. 9 No. 4, pp. 333-40.

Geyer, R. and Jackson, T. (2004), "Supply loops and their constraints: the industrial ecology of recycling and reuse", *California Management Review*, Vol. 46 No. 2, pp. 55-73.

Green, K., Morton, B. and New, S. (1996), "Purchasing and environmental management: interaction, policies and opportunities", *Business Strategy & the Environment*, Vol. 5, pp. 188-97.

Gupta, M. (1995), "Environmental management and its impact on the operations function", *International Journal of Operations & Production Management*, Vol. 15 No. 8, pp. 34-51.

Hall, J. (2001), "Environmental supply-chain innovation", *Greener Management International*, No. 35, pp. 105-19.

Hamel, G. and Prahalad, C.K. (1989), "Strategic intent", *Harvard Business Review*, Vol. 67, pp. 63-76.

Handfield, R., Walton, S.V., Sroufe, R. and Melnyk, S.A. (2002), "Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process", *European Journal of Operational Research*, Vol. 141 No. 1, pp. 70-87.

Hanna, M.D. and Newman, W.R. (1996), "Operations and the environment: an expanded focus for TQM", *International Journal of Quality & Reliability Management*, Vol. 12 No. 6, pp. 38-53.

Hanna, M.D., Newman, W.R. and Johnson, P. (2000), "Linking operational and environmental improvement through employee involvement", *International Journal of Operations & Production Management*, Vol. 20 No. 2, pp. 148-65.

Hansmann, K.W. and Claudia, K. (2001), "Environmental management policies", in Sarkis, J. (Ed.), *Green Manufacturing and Operations: from Design to Delivery and Back*, Greenleaf Publishing, Sheffield, pp. 192-204.

Hick, S. (2000), "Morals make the money", *Austrian CPA*, Vol. 70, pp. 72-3.

Hutchison, J. (1998), "Integrating environmental criteria into purchasing decision: value added?", in Russel, T. (Ed.), *Green Purchasing: Opportunities and Innovations*, Greenleaf Publishing, Sheffield, pp. 164-78.

Lewis, H. and Gretsakis, J. (2001), *Design + Environment: A Global Guide to Designing Greener Goods*, Greenleaf Publishing, Sheffield.

Lo, C.W. and Leung, S.W. (2000), "Environmental agency and public opinion in Guangzhou: the limits of a popular approach to environmental governance", *The China Quarterly*, Vol. 163, pp. 677-704.

Melnyk, S.A., Sroufe, R.P. and Calatone, R. (2002), "Assessing the impact of environmental management systems on corporate and environmental performance", *Journal of Operations Management*, Vol. 21 No. 2, pp. 329-51.

Min, H. and Galle, W.P. (1997), "Green purchasing strategies: trends and implications", *International Journal of Purchasing and Materials Management*, Vol. 33 No. 3, pp. 10-17.

Ministry of Foreign Trade and Economic Cooperation of PRC (2002), "A key impediment for clothes export is green barrier after China's entry into the WTO", available at: www.moftec.gov.cn. (accessed 19 June, 2002) (in Chinese).

Nunnally, J.C. (1978), *Psycometric Theory*, McGraw-Hill, New York, NY.

Puckett, J. and Smith, T. (2002), *Exporting Harm: The High-Tech Trashing of Asia. Basel Action Network, Asia Pacific Environmental Exchange*, Seattle, Washington, DC.

Rao, P. (2002), "Greening the supply chain: a new initiative in South East Asia", *International Journal of Operations & Production Management*, Vol. 21 No. 6, pp. 632-55.

Rice, S. (2003), "Commitment to excellence: practical approaches to environmental leadership", *Environmental Quality Management*, Vol. 12 No. 4, pp. 9-22.

Russel, T. (Ed.) (1998), *Green Purchasing: Opportunities & Innovations*, Greenleaf Publishing, Sheffield.

Sarkis, J. (1995), "Manufacturing strategy and environmental consciousness", *Technovation*, Vol. 15 No. 2, pp. 79-97.

Sarkis, J. (2001), "Manufacturing's role in corporate environmental sustainability: concerns for the new millennium", *International Journal of Operations & Production Management*, Vol. 21 Nos. 5/6, pp. 666-85.

Sarkis, J. (2003), "A strategic decision making framework for green supply chain management", *Journal of Cleaner Production*, Vol. 11 No. 4, pp. 397-409.

Shultz, C.J. II and Holbrook, M.B. (1999), "Marketing and tragedy of the commons: a synthesis, commentary and analysis for action", *Journal of Public Policy and Marketing*, Vol. 18 No. 2, pp. 218-29.

Szwilski, T.B. (2000), "Using environmental management systems to systematically improve operational performance and environmental protection", *International Journal of Surface Mining, Reclamation and Environment*, Vol. 14 No. 3, pp. 183-91.

Theyel, G. (2001), "Customer and supplier relations for environmental performance", *Greener Management International*, No. 35, pp. 61-9.

Tooru, S. (2001), "Certification and operational performance of ISO14001", *Kamipa Gikyoshi*, Vol. 55 No. 1, pp. 52-8.

US-AEP (1999), *US-AEP Sector Based Public Policy in the Asia-Pacific Region*, US-AEP.

van Hock, R.I. and Erasmus (2000), "From reversed logistics to green supply chains", *Logistics Solutions*, No. 2, pp. 28-33.

von Hippel, E. (1988), *The Source of Innovation*, Oxford University Press, Oxford.

Wagner, M., Schaltegger, S. and Wehrmeyer, W. (2001), "The relationship between the environmental and economic performance of firms: what does theory propose and what does empirical evidence tell us?", *Greener Management International*, Vol. 34, pp. 95-108.

Walton, S.V., Handfield, R.B. and Melnyk, S.T. (1998), "The green supply chain: integrating suppliers into environmental management process", *International Journal of Purchasing and Materials Management*, pp. 2-11, Spring.

Xinhua News Agency (China) (2001), "How should China do to meet with the challenge of green barriers", *Economy Daily*, 21 August, pp. A2 (in Chinese).

Zaklad, A., McKnight, R., Kosansky, A. and Piermarini, J. (2004), "The social side of the supply chain: align three factors, and hitting the jackpot is a sure bet", *Industrial Engineer*, Vol. 36 No. 2, pp. 40-4.

Zhu, Q. and Cote, R. (2004), "Integrating green supply chain management into an embryonic eco-industrial development: a case study of the Guitang Group", *Journal of Cleaner Production*, Vol. 12 Nos. 8-10, pp. 1025-35.

Zhu, Q. and Geng, Y. (2001), "Integrating environmental issues into supplier selection and management: a study of large and medium-sized state-owned enterprises in China", *Greener Management International*, No. 35, pp. 27-40.

Zhu, Q. and Sarkis, J. (2004), "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises", *Journal of Operations Management*, Vol. 22 No. 3, pp. 265-89.

Zsidisin, G.A. and Hendrick, T.E. (1998), "Purchasing's involvement in environmental issues: a multi-country perspective", *Industrial Management & Data Systems*, Vol. 7, pp. 313-20.

Zsidisin, G.A. and Siferd, S.P. (2001), "Environmental purchasing: a framework for theory development", *European Journal of Purchasing & Supplying Management*, Vol. 7, pp. 1-73.