Int. J. Production Economics 147 (2014) 460–471

Contents lists available at ScienceDirect

Int. J. Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Critical barriers in implementing reverse logistics in the Chinese manufacturing sectors

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ARTICLE INFO

Article history:
Received 2 April 2012
Accepted 5 August 2012
Available online 15 August 2012

Keywords:
Barriers
China
Manufacturing
Reverse logistics

ABSTRACT

Reverse logistics (RL) is gaining momentum worldwide due to global awareness and as a consequence of resource depletion and environmental degradation. Firms encounter RL implementation challenges from different stakeholders, both internally and externally. On the one hand, various governmental agencies are coming out with different environmental regulations while on the other hand academics and researchers are contributing solutions and suggestions in different country contexts. In a real sense however, the benefits of RL implementation is not yet fully realized in the emerging economies. This paper proposes a theoretical RL implementation model and empirically identifies significant RL barriers with respect to management, financial, policy and infrastructure in the Chinese manufacturing industries such as automotive, electrical and electronic, plastics, steel/construction, textiles and paper and paper based products. Key barriers from our study, with respect to these four categories, are: within management category a lack of reverse logistics experts and low commitment, within financial category a lack of initial capital and funds for return monitoring systems, within policy category a lack of enforceable laws and government supportive economic policies and, finally, within infrastructure category a the lack of systems for return monitoring. Contingency effect of ownership was carried out to understand the similarities and differences in RL barriers among the multinational firms and domestic firms investigated.

1. Introduction

Reverse logistics (RL) is considered by firms as an undervalued part of supply chain in general due to the following reasons: minimal interest of top management, insufficient time commitment, change in functional priorities among and within firms, a lack of integrated corporate supply chain design target towards RL, a lack of awareness of the high potential value of integrating operations (PricewaterhouseCoopers' report, 2008; Jindal and Sangwan, 2011; Gunasekaran and Ngai, 2012). In the real sense it has been highlighted that best reverse logistics operations would lead to higher sales revenue and reduced operational costs (PricewaterhouseCoopers' report, 2008; Frota Neto et al., 2008). Furthermore, researchers have also reported several benefits that could be achieved with RL, such as efficient resource utilization and environmental protection (Gunasekaran and Spalanzani, 2011; Fernández et al., 2009; Tsai et al., 2008).

Interestingly most of the prior research on the drivers and barriers of RL implementation are concentrated on developed countries, with relatively little attention being devoted to developing countries, such as China (see Rogers and Tibben-Lembke, 1999, 2001; Ferguson and Browne, 2001; Lau and Wang, 2009; Zhu and Geng, in press; Jindal and Sangwan, 2011; Miao et al., 2011). Of the few studies on developing countries, Lau and Wang (2009) investigated RL in Chinese electronic industry using case study on only four companies. The study by Jindal and Sangwan (2011) on RL barriers in India, on the other hand, was based on general organizational, market and government related barriers that are not related to any particular industry sector in India. Both studies acknowledged limitations in the scope of their studies and methodologies employed and encourage appropriate future large-scale empirical study within and across different industry sectors; the exact objective of the present study. That few RL studies focused on developing countries is hardly surprising because whereas RL is a mandatory part of supply chain in developed countries, it is still in its infancy state in developing countries (Zhang et al., 2011; Sarkis et al., 2011).

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http://dx.doi.org/10.1016/j.ijpe.2012.08.003

The on-going rapid industrialization and presence of 22% of the world population in China has led to enormous production and consumption in the Chinese economy. The downside of this unprecedented economic growth has been extremely high resource consumption and serious environmental pollution, such as contaminated water and solid waste per unit of GDP, which is much higher than in developed countries (Fang et al., 2007). The waste generated in different sectors of China's economy can be comprehended by the statistics reported by Ma (2004) which point to 5 million tons of waste steel, 200,000 t of non-ferrous metal, 14 million tons of waste paper, a large amount of waste plastics and glass which have been never recycled. Furthermore, China occupies the second position in the world, after the USA, in landfilling and incineration of e-waste residues (Zoeteman et al., 2009).

This motivated us to look into the issues related to RL implementation, specifically to identify the key barriers in different Chinese manufacturing sectors. Few studies have been carried out to understand RL implementation in general in the Chinese context but most of them are related to the e-waste sector. To the best of our knowledge they have used case study in particular as a method to study the issues, which has limitations such as small sample size which restricts the generalization of findings to reflect the circumstance of the whole population (Merriam, 1985).

The major intention of this study is to empirically understand various RL implementation barriers from manufacturing firms' perspective in different Chinese manufacturing sectors. RL barriers can be categorized into four major factors and they are internal and external to firms. The internal barriers are management, financial and infrastructure while policy is considered as an external barrier to a firm. Beyond this contingency analysis on the effect of ownership is carried out to understand the similarities and differences in barriers among multinational firms and Local (domestic) firms operating in China.

The rest of the paper is organized as follows: Background for the research is highlighted in Section 2. A theoretical model for RL implementation is discussed in Section 3. Methodology adopted to empirically study the implementation barrier is detailed in Section 4. The outcome of the study is reported in Section 5. The managerial implications are narrated in Section 6. Finally the paper concludes with a summary and outlines future scope of research.

2. Background for the research

Waste is considered as a valuable item in the Chinese context and the existence of an informal recycling network provides a large amount of employment in rural parts of China. A large proportion of China's waste comes from scrapped electrical and electronic products. For example, solid waste from waste electrical and electronics equipment (WEEE) in China is reported as being three times greater than common waste (Wang et al., 2009; Koh et al., 2012). About 20% of all e-waste in China is made of mostly scrapped electronic appliances and computers and this portion of the waste is growing at an annual rate of around 20% (Veenstra et al., 2009).

The European Union (EU) has made a substantial effort at creating awareness among the emerging economies' companies to realize the effect of WEEE regulatory norms. The EU also reported that China has a relatively good level of awareness of WEEE issues. It found that a legal framework similar to WEEE, which emphasizes three aspects, such as take-back issues, controls of hazardous substances and assurance of good environmental management was developed in around 2008 in China. While the Chinese regulations on take-back of End of Life (or end-of-use) products requirements and the associated financial responsibilities are vaguely defined, it gained popularity among the Chinese public in terms of its environmental concern (Chung and Zhang, 2011). According to Chung and Zhang (2011), that although a multiple enforcement agency approach prevents full and effective enforcement of the relevant legal requirements, China now has satisfactory resources available to enforce reduction in environmental pollution at Chinese WEEE plants.

2.1. Significance of industries considered in this study

China has become the world's top consumer of natural resources due to its rapid industrialization, urbanization and modernization. The resulting impact has, since 1993, shifted China from net exporter to net importer of raw materials such as steel, plastics and other minerals (Cunat, 2010). For example, China's steel consumption has increased by 15% p.a. over the last decade to reach a total of 556 million tons in 2009, accounting for 51% of total global consumption (Cunat, 2010). China's iron and steel sector is one of the largest in the world and plays a key role in China's economy with construction and manufacturing industries sustaining its growth. The iron and steel waste generation is enormous due to urbanization and therefore effective reuse of material should be mandatory. Similar pressures are placed on plastics and paper and paper based products sectors each of which has seen decades of tremendous growth. The paper industry provided 1.5 million employment in 2009, with a total export value of US $ 3.14 billion in the same year, while the plastics manufacturing sector employed 2.6 million workers and generated a total export value of US $ 14.40 billion in 2009. The literature indicates that other than WEEE (or e-wastes), China's waste stream is growing fastest in paper and plastics industries (World Bank, 2005; Veenstra et al., 2009; Zhang et al., 2010; Chi et al., 2011; Oliveira et al., 2012). These two sectors are therefore well-positioned to use recycled product.

China is also now the largest automobile producer in the world and a key market for global players in the automobile industry. China is "set to become a global point of reference in terms of technology and industry practices for the automobile industry" due to the huge domestic market potential for automobiles, aided by rapidly increasing high disposable income in China (CEIBS, 2011). The sector employs about 3 million people and pressure is building on them to reuse end of life (EoL) products. According to China's National Development and Reform Commission (NDRC), "by 2010, the recycling rate of all imported and domestic commercial vehicles in China should reach 85% and the rate of reusing the materials should reach 80% and from 2012 onwards, recycling rate of imported and domestics vehicles targets are at 90% and 80% of all materials reused" (Chinadaily report, 2012). Similarly, China's textile sector employed about 6.17 million people and generated total export value of US $ 167.02 billion in 2009. This industry is thinking of extracting valuable raw materials by reusing the recoverable waste in future.

These sectors will have different drivers, pressures, experiences and capability in coping with the sectors' exponential growth rates, upgrades and innovation, high rate of obsolescence and waste. Each sector will therefore have varying degrees of implementation of RL practices, which needs detailed investigation.

2.2. RL studies in Chinese context

We summarize several Chinese RL studies in Table 1. Our intention in this summary is to find out the type of RL study previously carried out, which industry sector are usually studied,

Table 1
Summary of RL studies in Chinese context.

Source	Type of RL study	Industry	Method used	Broad conclusion
Tong and Wang (2004)	Explored the global flows of e-waste and concentration of related recycling in coastal China	E waste	Case study	Recycling sector (authorized and illegal) has played a significant role in rural industrialization and local environment without considering environmental protection.
Liu (2006)	Predicted the amount of electronic equipment from urban household in Beijing	E waste	Interview	To understand statistics of e waste due to urbanization and how it can be handled in future.
Zhou et al. (2007)	Analyzed current battery recycling system in China	Battery recycling	Soft system and Benchmarking	lack of governmental policies, technical guidance and administrative resources, but more importantly lacking aspect is cost-effective recycling technologies, funding resources and public participation.
Yang et al. (2008)	Described and investigated national level WEEE flow	E waste	Case study	Need to augment capacity and suitable WEEE treatment to protect environment.
Lau and Wang (2009)	Investigated whether current reverse logistics theories and models can be applied in China	Electronic industry	Case study	Major barriers to reverse logistics implementation are external and they are lack of enforceable law, regulations or directives to motivate manufacturers', economic support and preferential tax policies, low public awareness of environmental protection and underdevelopment of recycling technologies.
Wu and Cheng (2006)	Compared the characteristics of reverse logistics in the publishing industry among China, Hong Kong and Taiwan	Publishing industry	Case study	RL in publication industry is at an early stage and found RL cost as a significant factor.
Chung and Zhang (2011)	Evaluated the legislative measures on electrical and electronic waste in the people's republic of China	electrical and electronic industry	Critical evaluation	Presence of large number of loop holes in Chinese WEEE regulations and they are poor law making skills, poor level of technical knowledge, lack of all-inclusive consideration and consultation and lack of inter-ministerial communication, coordination and support.
Ying (2009)	Studied cause and effects of house hold appliances reverse logistics in China	Electrical and Electronic appliances (House hold appliances)	Theoretical and comparative	China has not yet realized the importance of house hold appliances reverse logistics, many manufacturers have not engaged in household appliances RL with no qualifications.
Fang et al. (2007)	Examined the state of eco-industrial development in China, industrial sustainability constraints in China and suggested future prospectus for sustainable development	Process industry (Sugar making industry and chemical industry)	Case study	Eco-industrial development in China is in its infancy stage and future prospect lies on closed loop involving chains and industrial symbiotic web.
Ongondo et al. (2011)	Reviewed the management of electrical and electronic wastes with a detailed review on Chinese context	Electrical and electronic waste	Review	Literature review provides detailed statistics of electrical and electronic waste management in China. Role of import and export of end of life waste electrical equipment, recycling procedures and regulations. Stated the difficultly in managing the waste electrical and electronic products compared to developed countries.
Veenstra et al. (2009)	Investigated through Markov chain model how far the existing recycling system matches with newly proposed circular economy promotion law of people's republic of China	E-waste	Empirical	Active involvement of dealers and retailers to fully realize the extended producer responsibility in recycling.
Wang et al. (2009)	Analyzed the significant impact of WEEE legislation on manufacturing, recycling, treatment and exportation and importation	Household industry	Interview	Absence of detailed regulations and technical standards hinders successful implementation of law and regulation.
Zhang et al. (2011)	Presented some problems before during and after manufacturing in automotive remanufacturing	Automotive	Conceptual	To understand the responsibility of government and OEM to recycle their products, establishment of standards and techniques to strengthen quality and reliability of remanufactured products, involvement of research institutes and universities.
Miao et al. (2011)	Proposed five dimensional structure of logistics social responsibility. It includes clan culture, business ethics, pressures from customers, suppliers and competitors and law and regulations	Manufacturing	Empirical	Identified clan culture and business ethics has a major effect on logistics social responsibility. It is also reported that pressure from suppliers, customers, competitors and law regulations have certain effects.

methodology adapted and to identify the major research gaps in them.

The major observations of this review are as follows: Most of the research was focused towards e-waste and their intention was to study the global flow, predict the outcome, analyze cause and effect, review WEEE management and, assess the impact of legislation of WEEE. Few studies have been carried out to understand the characteristics of RL, battery recycling, the adaptability of existing theories to the Chinese context, the problems in remanufacturing, evaluation of legislative measures and eco industrial development in China. Quite interestingly, we found few studies in the process, automotive and publishing industries. We found only two empirical studies on the electrical and electronic industry and manufacturing which discussed logistics' social responsibility, the rest were based on case study.

We identified gaps from these studies with respect our four categories of classifications such as management, financial, policies and infrastructure. We found future study prospects with respect to management aspects such as: difficulty in minimizing waste, manufacturers' responsibility, involvement of members, poor level of technical knowledge and lack of communication. In terms of policies and regulations we found few critical aspects such as responsibility of government and original equipment manufacturer (OEM) in promoting standards and external major barriers that included the lack of enforceable law, policies and loop holes in existing regulations, poor law making skills, establishment of standards and techniques, public awareness, concentration of recycling in costal China and public participation. With respect to infrastructure barriers, the gaps identified are: the importance of closed loop supply chain, the under development of recycling technologies and non-availability of cost effective recycling technologies, lack of coordination and support, technical guidance and administrative resources. We found few aspects such as preferential tax policies, RL cost as a significant factor, and funding resources related to financial category.

Based on these reviews, and in the light of China's WTO accession over 10 years ago, our intention is to investigate in the recent context, China's RL implementation status. The objective is to establish what affects, or otherwise, RL implementation from Chinese manufacturers' perspective and to establish the effect of ownership, if any, on RL implementation in China. Our final objective is to provide critical insights that would bring about better understanding of RL barriers in Chinese context that would hopefully lead to the elimination and/or reduction of the identified RL barriers in the Chinese manufacturing sectors.

3. A theoretical model for RL implementation

There are quite a few studies which have analyzed the major barriers to RL implementation in the context of developed countries. Even though enough evidence in terms of regulations, awareness, public participation, resources and government support exist in Europe, they found few criticalities in implementing RL. It is well known that RL is mandatory in European countries, however we find some key barriers in implementing RL in European context, such as little senior management attention, difficulties in extended producer responsibility across countries, little recognition of RL as a competitive factor, a lack of appropriate performance management system, tax issues, little collaboration, limited forecasting and planning, a lack of clear return policies, a lack of awareness of environmental regulations (PricewaterhouseCoopers' report, 2008; Ciliberti et al., 2008; Jindal and Sangwan, 2011; Hassini et al., 2012; Zailani et al., 2012). The above issues can be grouped as management, financial, infrastructure and policy barriers.

In the Chinese context the scenario is entirely different as Chinese consumers find more value in selling their e-wastes to individual collectors, with nearly 60% of the generated e-wastes being sold to private individual collectors and passed to informal recycling processes (Liu et al., 2006a, 2006b; Streicher-Porte and Geering, 2010; Chi et al., 2011). More than 90% of Chinese citizens are reluctant to pay for the recycling of their e-waste (Liu et al., 2006a, 2006b). Two channels exist for e-waste collection: one is formal (developed by government facilities) and the other one is the presence of informal network (hawkers, peddlers and individual vendors recycled for components and raw materials). Development of informal recycling has serious adverse impacts on the environment and human health in some regions in China (Hicks et al., 2005; Jindal and Sangwan, 2011). Recovery of material from informal sectors acts as a barrier to the formal recycling business because it prevents major parts of EoL products from reaching official/formal recycling and disposal centers thereby negatively affect the economy of scale needed to encourage manufacturers to embark on RL practices (Jindal and Sangwan, 2011). Given this background we intend to study the real barriers, according to the manufacturers' view of what the major issue in RL implementation is. We view the Chinese issues under four categories of barrier classifications and they are management, financial, policy and infrastructure. To study these issues we identified some barriers reported in the literature with respect to our classification as discussed below.

3.1. Management barriers

Management barriers includes firms' strategy, planning, involvement, hiring and training personnel, digesting extended responsibility, requirement of performance measurement system, eager to learn best practices and proper support structures. Studies which reported different types of management barriers are shown in Table 2.

3.2. Financial barriers

Financial barriers are mostly centered on RL support activities, training, monitoring mechanisms and preferential tax policies. This is one of the critical barriers for firms which expect to realize immediate benefits. Table 3 depicts financial barriers reported in literature.

3.3. Policy barriers

Policy barriers include both external and internal stakeholders' views on firms. It is obvious from the literature review that most of the barriers are oriented towards the regulators' point of view. Table 4 reports important policy barriers from this perspective and they are legal issues, waste management practices, motivation, awareness and transparency in take-back to customers.

3.4. Infrastructure barriers

Infrastructure plays a vital role in RL implementation. Researchers and practitioners felt that affordable recycling technologies with the support and coordination of all the members would enhance the success of RL implementation (Rogers and Tibben-Lembke, 2002; Dibenedetto Bill, 2007; Jack et al., 2010). The existence of good RL infrastructure provides a company with the capability to quickly and efficiently handle returns and/or

Table 2
Management barriers in RL implementation.

Source	Type of barriers
Rogers and Tibben-Lembke (2001), PricewaterhouseCoopers' report (2008), Zhou et al. (2007), Ravi and Shankar (2005), Chung and Zhang (2011)	Importance of reverse logistics relative to other issues Company polices Competitive issues Management commitment/little senior management attention Personnel resources (Training, poor level of technical knowledge) Difficulties in extended producer responsibility across countries lack of appropriate performance management system Lack of shared understanding of best practices Lack of strategic planning and structure for reverse logistics

Table 3
Financial barriers in RL implementation.

Source	Type of barriers
Rogers and Tibben-Lembke (2001), Zhou et al. (2007), Ravi and Shankar (2005), Lau and Wang (2009)	Financial resources/constraints/ funds for training/return monitoring system/storage and handling Preferential tax policies

recalls (Dibenedetto Bill, 2007; Jack et al., 2010). The presence of good returns-handling system can be a source of significant cost savings and even function as a profit center (Stock et al., 2002). Conversely, a lack of RL infrastructure will impede a company's ability to quickly and efficiently deal with returns and/or recalls and any effort at handling returns will be a financial burden with the costs exceeding the benefits (Jack et al., 2010). Significant infrastructure barriers are shown in Table 5.

Table 4
Policy barriers in RL implementation.

Source	Type of barriers
Rogers and Tibben-Lembke (2001), Ravi and Shankar (2005), Zhou et al. (2007), Lau and Wang (2009), Chung and Zhang (2011); Miao et al. (2011), Rahman and Subramanian (2012), Chaabane et al. (2012); Koh et al. (2012)	Legal issues/lack of supportive policies Loop holes in Chinese WEEE regulations Lack of enforceable law/lack of waste management practices All-inclusive consideration and consultation and lack of inter-ministerial communication Regulations or directives to motivate manufacturers' Lack of awareness in environmental regulations Customers not informed of take back channels

Table 5
Infrastructure barriers in RL implementation.

Source	Type of barriers
Rogers and Tibben-Lembke (2001), Ravi and Shankar (2005), Zhou et al. (2007); PricewaterhouseCoopers' report (2008), Chung and Zhang (2011), Lau and Wang (2009), Rahman and Subramanian (2012)	Lack of systems/EDI standards/ Underdevelopment of recycling technologies Coordination and support/ collaboration/reluctance of support from members Limited forecasting and planning/ Lack of In-house facilities

We find most of the barriers exist in the management category compared to the other three categories. It is also interesting to note that there are a lot of barriers under policy aspects next to management barriers category. We find few barriers related to financial aspects. Based on the above review we considered most the relevant barriers related to the Chinese context and they are shown in Fig. 1.

Both multinational and domestic manufacturing firms are operating in China. We thought RL implementation barriers would be different in the two categories of firms. We studied the influence of ownership with respect to the barriers as shown in Fig. 2. We did a separate contingency study on firms from all sectors with the foreign and domestic ownership to compare and contrast their influence on RL barriers. We certainly believe that firms with foreign ownership would have fewer barriers compared to locally owned firms.

4. Research methodology

To evaluate barriers to RL implementation in the Chinese manufacturing industry, we selected manufacturing firms that demonstrated, or appears to have demonstrated, a certain level of RL practices from the literature and are located in cities with certain levels of logistics infrastructures. Consequently, the sample of companies who participated in this study were selected from cities in key regions of coastal China with the highest concentration of the major industries. Ningbo, Shanghai, Guangzhou, Foshan and Shenzhen were selected for study. These cities have the most advanced industrial and businesses, with well-developed infrastructure, advanced communications networks and highly developed logistics facilities in comparison with most other Chinese cities; criteria that are critical for meaningful and successful reverse logistics to take place. The industry sectors chosen for this study all have long-term international experiences and, therefore, the implementation of reverse logistics in these sectors was expected to be widespread (Zhu et al., 2007). Using these selection criteria, we targeted six Chinese industries: automobile, steel/construction, electronic/computer, textile, plastics and paper/paper based products industrial sectors. These industries all have

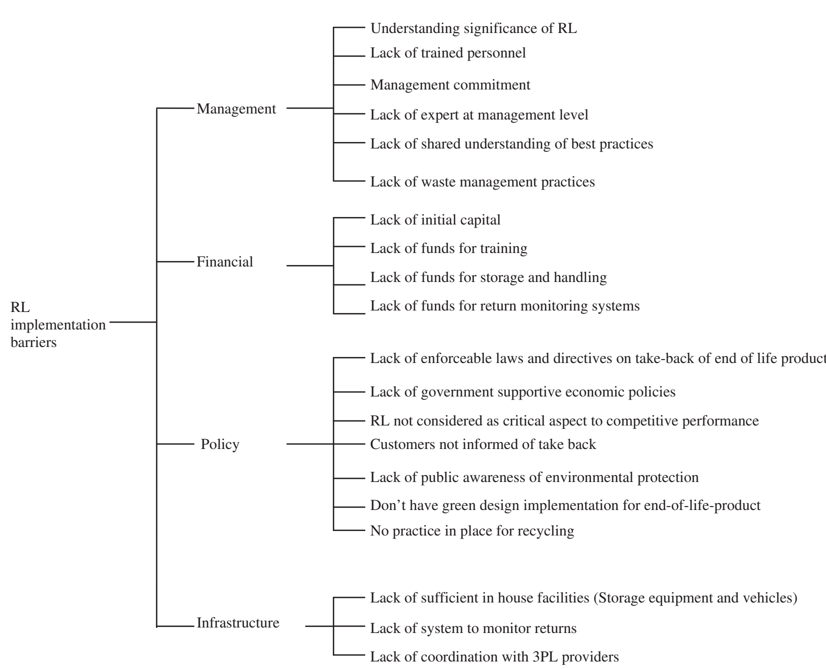

Fig. 1. RL implementation barriers.

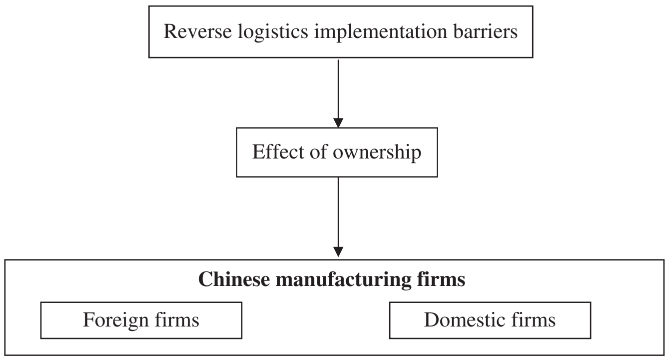

Fig. 2. Mediating effect of ownership on RL implementation.

long-term relationship with international businesses either by exporting finished products or as suppliers of parts and components to foreign buyers and collaborators.

4.1. Scales and measures

The survey questionnaire administered to Chinese manufacturing includes four sections with twenty items on the barriers to RL implementation developed on the basis of expert opinions and the literature (Rogers and Tibben-Lembke, 1999; Lau and Wang, 2009; Jindal and Sangwan, 2011). The four categories of barriers investigated are management (Rogers and Tibben-Lembke, 1999; Ravi and Shankar, 2005; Xiaoming and Olorunniwo, 2008; Lau and Wang, 2009), financial (Ravi and Shankar, 2005; Zhou et al., 2007; Lau and Wang 2009; Zhao et al., 2010), policy (Ravi and Shankar, 2005; Lambert et al., 2011; Zhang et al., 2011) and infrastructure (Xiaoming and Olorunniwo, 2008; Jack et al., 2010; Lau and Wang, 2009; Rahman and Wu, 2011). A five point Likert scale (1—strongly disagree, 5—strongly agree) was used to measure the degree to which listed barrier variables in the four categories of the management, financial, policy and infrastructure impede RL implementation in the target companies.

We carried out a pilot test to evaluate and refine the survey questionnaire. The test was conducted during a workshop for Ningbo entrepreneurs at the University of Nottingham Ningbo China. Based on the feedback from 17 CEO respondents at the workshop, minor modifications were made to the questionnaire.

4.2. Data collection

The survey questionnaires, with several reverse logistics activity related variables, was designed and distributed to manufacturing companies during a three month period from August to October 2011. The targeted manufacturing companies were identified from the list of manufacturers in each city within six industries. Past studies highlight the challenges faced in using representative sampling techniques in China, where a general distrust of outsiders results in low response rate to mail-based surveys (Tabachnick and Fidell, 2000; Zheng et al., 2006). To overcome these challenges, survey questionnaires were distributed with the help of intermediaries who were either representatives of private entrepreneur associations or local government officials in Ningbo (37.24%), Shanghai (9.21%), Guangzhou (15.48%), Foshan (28.45%) and Shenzhen (9.62%) cities. The intermediaries were used to provide introductions about the research team, aid the understanding of the questionnaire items and to assure the respondents that replies would be kept confidential and used for academic research only. Respondents were also promised a summary report of the final research findings. Details of respondents are shown in Table 6. Among the participants, 31.8% were from steel and construction industry, 24.7% from electronics and computer industry, 13.8% from the automotive industry, 6.3% from plastics industry, 10% from the paper and paper based products industry, and 13.4% from the textile industry.

Table 6
Sample characteristics.

	Sample	
	Total	**Percentage (%)**
Respondent position		
First line manager	44	18.4
Middle line manager	126	52.7
Top manager	69	28.9
Ownership		
Local	167	69.9
Foreign	72	30.1
Years since establishment		
< 5 years	49	20.5
5 to 10 years	106	44.4
11 to 20 years	66	27.6
> 20 years	18	7.5
Annual sales (recent fiscal year)		
< 50 million	93	38.9
50 to 100 million	74	31.0
100–300 million	42	17.6
> 300 million	30	12.5
Number of employees		
< 100 workers	59	24.7
100–500 workers	88	36.8
501–1000 workers	55	23.0
> 1000 workers	37	15.4
Annual sales for locally owned		
< 50 million	74	44.3
50 to 100 million	56	33.5
100–300 million	22	13.2
> 300 million	15	9.0
Annual sales for foreign owned		
< 50 million	19	26.4
50 to 100 million	18	25.0
100–300 million	20	27.8
> 300 million	15	20.9
Industry		
Steel and construction	76	31.8
Electronics and computer	59	24.7
Automotive	33	13.8
Plastics	15	6.3
Paper and paper based products	24	10.0
Textiles	32	13.4

Over 36% of manufacturers who took part in this survey employed between 100 and 500 employees while over 38% employed between 500 to over 3000 employees. Based on China's guidelines on enterprise scale standards, a company is classified as SME if its business volume is less than 300 million RMB (currently, US$1 I equals RMB 6.34) (Rahman and Wu, 2011). Among the returned samples, when judged by their business volume, most of the companies fell into the SMEs category (over 87%), while over 12% of the respondents were their larger counterparts. Over 44% of the companies have been established for over five years. The questionnaires were mostly answered by middle line managers (approximately 52%), followed by top managers (approximately 29%). Out of a total of 650 questionnaires distributed, a total of 315 were returned out of which, due to missing responses, 239 were included in the final analysis (36.76% response). The response rate is far better than previous empirical study which has 16.75% carried out by Lai and Wong (2012) in Chinese context with respect to green logistics management and performance.

Table 7
Factor analysis of reverse logistics barriers (for whole sector).

Reverse logistics barriers	Factor loadings	Variance explained (%)	Cronbach's alpha	Range of item-total correlation
(A) Management barrier (KMO=.861, Bartlett's Sig=.000)		63.73	0.857	0.613–0.746
(A1) Lack of RL expert at mgt. level	0.805			
(A2) Lack of trained personnel	0.805			
(A3) Low commitment	0.853			
(A4) Lack of waste mgt. practices	0.750			
(A5) Lack of shared understanding of best practices	0.775			
(B) Financial barrier (KMO=.816, Bartlett's =.000)		72.98	0.876	0.690–0.778
(B1) Lack of initial capital	0.884			
(B2) Lack of funds for training	0.841			
(B3) Lack of funds for storage and handling	0.823			
(B4) Lack of funds for return monitoring systems	0.867			
(C) Policy barrier (KMO=.701, Bartlett's Sig=.000)		60.89	0.783	0.545–0.673
(C1) Lack of enforceable laws and directives on take-back of end-of-life	0.852			
(C2) Lack of govt. supportive economic policies	0.830			
(C3) RL not consider critical to performance	0.694			
(C4) Lack of public awareness on EP	0.735			
(D) Infrastructure barrier (KMO=.667, Bartlett's Sig=.000)		68.04	0.764	0.594–0.668
(D1) Lack of systems (hardware/software) to monitor returns	0.828			
(D2) Lack of in-house facilities (storage, handling equipment and vehicles)	0.773			
(D3) Lack of coordination with 3PL providers	0.871			

5. Results

Descriptive statistics, alpha coefficients, and item-total correlation were used to initially analyze the survey data. Factor analysis (FA) was used to evaluate and shortlist the RL barriers in the industries studied. Table 7 presents a summary of the factor analysis for the whole manufacturing sector and shows all relevant statistics on how each RL barrier variables loaded strongly on individual category (management, finance, policy and infrastructure), each category having a total variance explained percentage greater than 60% (Stevens, 2002; Tabachnick and Fedell, 2007). Similarly, Tables 8 and 9 presents the factor analysis results for the local and foreign owned firms, respectively. The reliability analysis validated the questionnaire with Cronbach alpha varying between 0.764–0.876 which is higher than 0.70, the threshold value as recommended by Nunnally and Bernstein (1994). Additionally, all the factors have high item-total correlation values, i.e., >0.53 (Table 7). In order to identify significant barriers in individual industry within manufacturing sector studied as shown in Table 10 we use descriptive statistics to discriminate most and least influential barriers due to heterogeneous industry sample size. Although there are only marginal differences in the mean score values within each industry, the barrier with highest mean score is reported as the most influential and lowest is the least influential.

5.1. Management barrier

In general our results show that the key management barriers to RL implementation in Chinese manufacturing sector are low commitment to RL practices and lack of RL experts at management level in the firms investigated. Based on factor loadings, low commitment is reported the major management barrier in Chinese manufacturing sector (Table 7). Surprisingly, a lack of waste management practices is not reported as a major barrier while a lack of shared understanding of RL best practices is reported as the least barrier to RL implementation in the industries investigated.

Effect of ownership results also shows that low commitment and a lack of RL experts at management level are the key barrier to RL implementation in foreign firms operating in China (Table 9) while local firms' biggest barrier to RL implementation are low commitment to RL practices and a lack of trained personnel (Table 8).

Specifically, the lack of shared understanding of RL best practices is most influential management barrier in automotive, plastics and paper/paper based products industries (Table 10). The steel/construction industry suffers most from low commitment while electronic/computer industry has a lack of trained personnel as the most influential management barrier to their RL implementation. A lack of waste management practices is most influential RL barrier in textile industry.

5.2. Financial barrier

Lack of initial capital and lack of funds for returns monitoring systems are the major financial barriers to RL implementation in the Chinese manufacturing industry. This is followed by a lack of funds for storage and in-house handling of returns as a major financial barrier in many of the industries studied (Table 7).

Predictably, ownership results show that a lack of initial capital is the dominant and most influential financial barrier to RL in local firms (Table 8). However, foreign owned firms investigated indicated a lack of funds for storage and handling as their most influential financial barrier to RL implementation (Table 9). Interestingly, a lack of funds for training as barrier to RL implementation is more of an issue for locally owned firms than for foreign firms while the lack of funds for returns monitoring systems affect both local and foreign firms equally, occupying a third position, based on factor loadings for this variable in each category (Tables 8 and 9).

The most influential financial barrier in automotive, steel/construction, electronic/computer and plastics industries is the lack of initial capital for RL implementation, while a lack of funds for training is most influential financial barrier in textile and paper/paper based products industries.

5.3. Policy barrier

Two key policy barriers to the implementation of RL in the Chinese manufacturing sector are reported as the lack of

Table 8
Factor analysis of reverse logistics barriers for local firms.

Reverse logistics barriers	Factor loadings	Variance explained (%)	Cronbach's alpha	Range of item-total correlation
(A) Management barrier (KMO=.848, Bartlett's Sig =.000)		61.46	0.842	0.604–0.720
(A1) Lack of RL expert at mgt. level	0.766			
(A2) Lack of trained personnel	0.786			
(A3) Low commitment	0.840			
(A4) Lack of waste mgt. practices	0.732			
(A5) Lack of shared understanding of best practices	0.791			
(B) Financial barrier (KMO=.779, Bartlett's =.000)		69.44	0.852	0.611–0.745
(B1) Lack of initial capital	0.871			
(B2) Lack of funds for training	0.846			
(B3) Lack of funds for storage and handling	0.769			
(B4) Lack of funds for return monitoring systems	0.845			
(C). Policy barrier (KMO=.726, Bartlett's Sig=.000)		63.75	0.807	0.526–0.737
(C1) Lack of enforceable laws and directives on take-back of end-of-life	0.883			
(C2) Lack of govt. supportive economic policies	0.855			
(C3) RL not consider critical to performance	0.730			
(C4) Lack of public awareness on EP	0.711			
(D) Infrastructure barrier (KMO=.665, Bartlett's Sig=.000)		67.24	0.754	0.532–0.661
(D1) Lack of systems (hardware/software) to monitor returns	0.807			
(D2) Lack of in-house facilities (storage, handling equipment and vehicles)	0.782			
(D3) Lack of coordination with 3PL providers	0.868			

Table 9
Factor analysis of reverse logistics barriers for foreign firms.

Reverse logistics barriers	Factor loadings	Variance explained (%)	Cronbach's alpha	Range of item-total correlation
(A) Management barrier (KMO=.789, Bartlett's Sig=.000)		66.10	0.870	0.617–0.769
(A1) Lack of RL expert at mgt. level	0.868			
(A2) Lack of trained personnel	0.856			
(A3) Low commitment	0.880			
(A4) Lack of waste mgt. practices	0.749			
(A5) Lack of shared understanding of best practices	0.696			
(B) Financial barrier (KMO=.825, Bartlett's =.000)		76.77	0.898	0.672–0.818
(B1) Lack of initial capital	0.903			
(B2) Lack of funds for training	0.803			
(B3) Lack of funds for storage and handling	0.905			
(B4) Lack of funds for return monitoring systems	0.890			
(C). Policy barrier (KMO=.604, Bartlett's Sig=.000)		78.42	0.688	0.531–0.657
(C1) Lack of enforceable laws and directives on take-back of end-of-life	0.885			
(C2) Lack of govt. supportive economic policies	0.874			
(C3) RL not consider critical to performance	0.916			
(C4) Lack of public awareness on EP	0.744			
(D) Infrastructure barrier (KMO=.645, Bartlett's Sig=.000)		67.52	0.754	0.546–0.648
(D1) Lack of systems (hardware/software) to monitor returns	0.869			
(D2) Lack of in-house facilities (storage, handling equipment and vehicles)	0.719			
(D3) Lack of coordination with 3PL providers	0.868			

enforceable laws, regulations and directives on take-back of EoL products and lack of supportive government economic policies for RL implementation (Table 7). A lack of public awareness of environmental protection and RL not considered critical to performance were reported as third and fourth in the overall influence of management barriers to RL, respectively.

With respect to ownership, locally owned firms consider the lack of enforceable laws, regulations and directives on take-back of end-of-life product as the biggest barrier to their RL implementation while foreign owned firms reported RL not considered critical to performance as their major policy barrier. Interestingly however, local manufacturers reported the lack of supportive government economic policies as their second major barrier to their RL implementation, while foreign firms reported a lack of enforceable laws, regulations and directives on take-back of end-of-life product as their second major barrier to their RL implementation (Tables 8 and 9).

A lack of public awareness of environmental protection is most influential policy barrier in automotive, steel/construction and paper based products industries while a lack of enforceable laws, regulations and directives on take-back of end-of-life product is the most influential in electronic/computer and textile industries. The plastics industry suffers most from a lack of government supportive economic policies barrier (Table 10).

5.4. Infrastructure barriers

Industrial cluster results show two key barriers to RL implementation in Chinese manufacturing sectors. These are the general lack of systems (hardware/software) to monitor returns and

Table 10
Synthesis of dominant RL implementation barriers in different industries.

Barriers	Most/least influential	Automotive	Steel/construction	Electronic/computer	Textiles	Plastics	Paper/paper based products
Management	Most influential	Lack of shared understanding of RL best practices	Low commitment	Lack of trained personnel	Lack of waste mgt. practices	Lack of shared understanding of RL best practices	Lack of shared understanding of RL best practices
	Least influential	Lack of waste mgt. practices	Lack of waste mgt. practices	Low commitment	Lack of expert at mgt. level	Lack of expert at mgt. level	Lack of waste mgt. practices
Financial	Most influential	Lack of initial capital	Lack of initial capital	Lack of initial capital	Lack of funds for training	Lack of initial capital	Lack of funds for training
	Least influential	Lack of funds for return monitoring systems	Lack of funds for storage and handling	Lack of funds for training	Lack of initial capital	Lack of funds for training	Lack of funds for storage and handling
Policy	Most influential	Lack of public awareness on EP	Lack of public awareness on EP	Lack of enforceable laws/ directives on take-back of end-of-life products.	Lack of enforceable laws/ directives on take-back of end-of-life products.	Lack of govt. supportive economic polices	Lack of public awareness on EP
	Least influential	RL not considered critical to performance	RL not considered critical to performance	Lack of public awareness on EP	RL not considered critical to performance	Lack of public awareness on EP	RL not considered critical to performance
Infrastructure	Most influential	Lack of coordination with 3PL providers	Lack of systems (hardware/ software) to monitor returns	Lack of coordination with 3PL providers	Lack of systems (hardware/software) to monitor returns	Lack of in-house facilities (storage, handling and vehicles)	Lack of coordination with 3PL providers
	Least influential	Lack of in-house facilities (storage, handling and vehicles)	Lack of in-house facilities (storage, handling and vehicles)	Lack of in-house facilities (storage, handling and vehicles)	Lack of in-house facilities (storage, handling and vehicles)	Lack of systems (hardware/ software) to monitor returns	Lack of in-house facilities (storage, handling and vehicles)

the lack of coordination with 3PL providers. This is in addition to the reported lack of in-house facilities such as storage, handling equipment and vehicles for the movement of EoL products (Table 7).

Ownership effect also shows that local and foreign firms investigated suffer from the combination of a lack of systems to monitor returns and a lack of in-house facilities (storage, equipment and vehicles) as the key barrier to their RL implementation (Tables 8 and 9). For the local firms, it is the lack of coordination that is the most influential policy barrier while a lack of systems (hardware/software) for monitoring returns is the most influential barrier for the foreign owned firms operating in China (Tables 8 and 9).

The most influential infrastructure barrier in the automotive, electronic/computer and paper and paper based products industries is a lack of coordination with 3PL providers. Both steel and textile industries on the other hand reported a lack of systems (hardware and software) to monitor returns as their most influential infrastructure barrier. A lack of in-house facilities (storage, handling and vehicles) is reported as the most influential barrier in the plastics industry.

6. Discussions

This section provides detail insights of our study on a general level based on the six manufacturing industries investigated. To provide a clear overview, ownership effect study insights are discussed immediately following the overall industry insights on each critical barrier.

6.1. RL management barriers

Based on the findings of the empirical study, it can be seen that full and matured RL implementation in the Chinese manufacturing sector still has a long way to go. The general results show that the key management barriers to RL implementation in Chinese manufacturing sector are the low commitment to RL practices and the lack of RL experts at the management level in the manufacturing firms investigated. These management barriers are common to whole sector surveyed, with a low management commitment being the most influential barrier for the whole industry (Table 7). The findings of a lack of personnel resources (RL experts and trained personnel) and management's low commitment to RL practices are in line with previous studies (Rogers and Tibben-Lembke, 1999; Ravi and Shankar, 2005; Lau and Wang, 2009). Having trained personnel and experts are prime requirements for achieving success in any organization. In addition to knowledge and expertise, top management commitment has been reported as the dominant driver of corporate endeavors (Mintzberg, 1973). Furthermore, low commitment and the lack of expert at management level may also be positively correlated. A high commitment and/or presence of RL expert at management level should lead to the full realization of the importance of RL to business operation and its potential for firms' future competiveness. It should also help reduce the reported lack of shared understanding of best RL practices as management barrier in to manufacturing sector studied.

Considering ownership levels, foreign firms suffer more from a low commitment and a lack of RL experts at the management level as their key barrier to RL implementation in China. Locally owned firms on the other hand suffer most from low commitment to RL practices and a lack of shared understanding of best practices as barriers to RL implementation. This implies that both foreign and local firms are unlikely to hire competent specialists and/or engage 3PL provider services for RL implementation, if and when they become available, because of their low commitment to the RL practices.

6.2. RL financial barriers

As indicated by the results on the six manufacturing industries investigated, the biggest financial barrier to RL implementation in Chinese manufacturing is the lack of initial capital (Table 7). This finding is reported in all industries and for all firms (local and foreign) investigated and it is the most influential financial barrier in the automotive, steel/construction electronic/computer and plastics industries (Table 10). This is closely followed by the lack of funds for return monitoring systems for both local and foreign manufacturing firms in China. Cost considerations as key constraints to RL activities is not surprising as previous studies have shown that high setup and operating costs of reverse logistics systems and infrastructure prohibits its widespread implementation because these costs add to the total cost of production (Lancioni, 1994; Ferguson and Browne, 2001; Wu and Cheng, 2006; Lau and Wang, 2009). With Chinese manufacturers reported as being highly cost conscious in order to remain competitive in a global environment and focusing more on short-term gains than long-term benefits (Wu and Cheng, 2006; Lau and Wang, 2009), RL implementation faces a unique challenge in China. According to Zhao et al. (2006), Chinese manufacturers are compelled to be cost conscious as they believe that it is the lower cost of production in China that makes it the global manufacturing base.

In addition to lack of initial capital, the steel/construction, textile and paper industries see lack of funds for training as a major financial barrier while a lack of funds for return monitoring are reported in textile, electronic/computer and plastics industries.

Not surprisingly, ownership effect findings for both local and foreign firms are the same as above for all the industries. That is the lack of initial capital and lack of funds for returns monitoring systems for RL implementation constitute major financial barriers to the implementation of RL for all local and all foreign firms investigated.

6.3. RL policy barriers

The key policy barriers to RL implementation reported in this study are the lack of enforceable laws, regulations and directives on take-back of EoL products and a lack of supportive government economic policies (Table 7). These twin findings reported are affecting the whole manufacturing sector, though the lack of government supportive economic policies was reported mostly by the locally owned Chinese firms (Table 8). These external barriers to RL implementation also ranked as the most influential policy barrier in electronic/computer, textiles and plastics industries (Table 10). These findings are in line with the literature which suggests that the Chinese central government is not eager to impose stringent environmental legislations on local businesses for the fear that it might overly restrain economic growth (Lau and Wang, 2009). Chinese officials believe that the country's manufacturing sector, the majority of which are SMEs competing on cost, may find it difficult to maintain their competitive advantage or even survive if strict laws - such as the RoHS (Restriction of Hazardous Substances), REACH (European Community Regulation on chemicals (EC 190/2006) which deals with the registration, evaluation, authorization and restriction of chemical substances (REACH) and WEEE that makes it mandatory for original manufacturers to undertake the responsibility for the collection, treatment, and recycling of EoL products—are imposed on them. Predictably, the lack of enforceable legislations and economic incentives from government has acted as a major disincentive for the Chinese manufacturers to invest and/or collaborate in RL implementations and practices (Lau and Wang, 2009).

Other studies that support our findings above gave divergent views for their findings. Ying (2009) suggested that many Chinese manufacturers have not engaged in RL because China has not yet realized its importance and benefits. This view is contrary to our results which show that in automotive, steel/construction, textile and paper/paper based products industries investigated, RL not being considered critical to their performance ranked as the least influential policy barrier to RL implementation (Table 10). Yet, a lack of all-inclusive consideration and consultation and a lack of inter-ministerial communication, coordination and support for effective technical guidance and administrative resources policy formulation have also been faulted as a major barrier to effective policy measure on recycling of electrical and electronic waste in the China (Chung and Zhang, 2011; Zhou et al., 2007).

It however appears that recent efforts at various levels by the Chinese government at creating environmental awareness in the Chinese public are gaining grounds. This is because, despite being well reported in literature (Lau and Wang, 2009), a lack of public awareness of environmental protection was reported only in automotive industries, but not in any other industries, as a major RL barrier to the companies in this study. Similarly, customers not being informed of take-back channels for EoL products is not reported as a significant barrier in any of the sectors investigated.

Interestingly however, locally owned firms reported the lack of supportive government economic policies as their major barrier to RL implementation, and it is the most influential barrier in plastic industry. The expected government support by local firms may not be unconnected with their being reported as being highly cost conscious in order to remain competitive in a global environment and their being focused more on short-term gains than long-term benefits. Foreign firms, on the other hand, may be less reliant on government support for their RL implementation due to the fact that they have greater awareness and acceptance of environmental protection legislations and directives similar to those in the their country of origins and which are yet to be established in China.

6.4. RL infrastructure barriers

The findings of this study revealed that a lack of coordination with 3PL providers is a major barrier to RL implementation in Chinese manufacturing sector. This is in addition to a lack of systems (hardware/software) to monitor returns and the lack of in-house facilities such as storage, handling equipment and vehicles for the movement of EoL products reported in specific industries such as steel, textile and plastics industries as their dominant RL implementation barrier (Table 10). These findings are not surprising as literature suggests the absence of good RL systems in most manufacturing firms (Rogers and Tibben-Lembke, 1999, 2001; Lau and Wang, 2009; Rahman and Wu, 2011). Specifically, Lau and Wang (2009) reported the dearth of RL systems, infrastructure and technology in China where even a 3PL provider's WEEE recycling center was found using "primitive tools in the recycling process." They further stated that "the process is mainly manual with no automated processing or special equipment installed." There is also very little collaboration/coordination between the firms in this study with 3PL providers, with the exception of the paper and paper based products sector. All these imply that there is lack of alternative cost-effective RL technologies and resources for manufacturing firms in China as noted by Zhou et al. (2007) in their study of the battery industry in China.

7. Concluding remarks

Reverse logistics is gaining momentum worldwide due to rising costs of materials, resources scarcity, global awareness and consequences of climate change. Proactive manufacturing companies often implement RL practices such as recycling, reuse and general waste management strategies developed to gain competitive advantage while meeting increasing local and international demands for environmental protection. In the light of increasing resource scarcity, global take-back of EoL products legislations and consequences of climate change, it is imperative that China – the global factory – is part of the global manufacturing sustainability efforts. Yet, limited empirical evidence on RL practices in Chinese manufacturing context provides little clue on the level of RL implementation and the sustainability of RL in the Chinese manufacturing sector.

Based on empirical study of Chinese manufacturing companies located in five major coastal cities with the most advanced logistics infrastructures in China, we identified reverse logistics implementation barriers with respect to management, financial, policy and infrastructure in six of China's key manufacturing industries: automotive, electronic/computer, plastics, steel/construction, textiles and paper and paper based industries.

Our study findings indicate that, at both industry and ownership levels, the lack of financial resources, such as lack of initial capital and lack of funds for returns monitoring systems, constitute major financial obstacles to RL implementation in the whole of Chinese manufacturing industry. Low commitment and lack of RL experts at business management levels constituted major management barriers to RL implementation in Chinese manufacturing.

While China may be enacting several environmental laws similar to those in developed world, the Chinese central government is in reality soft-pedaling on the imposition of such stringent environmental legislations for the fear that it might overly restrain economic growth and competitiveness, or even threaten the survival of the majority of the country's manufacturing firms that are largely SMEs (Lau and Wang, 2009). This has impeded the implementation of RL in China's manufacturing industry. We found the lack of enforceable legislation on take-back of EoL products and lack of economic incentives from government as the biggest policy barriers to RL implementation and practice in the Chinese manufacturing sector.

As revealed by this study, a set of comprehensive and concerted efforts are required from both manufacturing sectors and the government to remove some of the external barriers identified in this study because of their close linkages. For example, external barriers such the lack of enforceable legislations on the take-back of EoL products and the lack of economic incentives from the government, reduce motivation and initiative to invest in RL training infrastructure and technology by companies. This supports the argument that there are linkages between external RL implementation factors (Lau and Wang, 2009).

It appears that recent efforts at various levels by the Chinese government at creating environmental awareness in the Chinese public is gaining ground, This is because, despite being well reported in literature, a lack of public awareness of environmental protection was not indicated as a major barrier to the companies in this study. Similarly, customers not being informed of take-back channel for EoL products were not reported as a significant barrier in any of the industries investigated. Some limitations that could be addressed in future are: further examination of each industry of the manufacturing sectors to understand in detail RL implementation barrier specific to each industry. In future, valuable insights could be gained through studying the moderating effects of firm size, efficiency and performance on RL implementation with various hypotheses in each sector for deeper understanding.

Acknowledgement

This work is supported by research grant (SRG/10MA 01.02. 01.01.2003) of the University of Nottingham Ningbo, China.

Appendix A. questionnaire items

Management barriers to reverse logistics implementation

MB1: We do not understand the significance of reverse logistics—item dropped

MB2: We do not have logistics experts at management level in the company

MB3: We do not have any trained personnel for handling returns

MB4: We do not have waste management practices in place for recycling

MB5: There is a lack of shared understanding of best reverse logistics practices

MB6: Management commitment is low to reverse logistics

MB7: Other (Please specify)…………………………

Financial barriers to reverse logistics implementation

FB1: We lack enough financial resources for reverse logistics—item dropped

FB2: We not have the initial capital for the RL storage and handling equipment costs.

FB3: We do not have funds to train personnel in handling returns.

FB4: We do not have funds for returns monitoring systems (hardware or software).

FB5: We do not have funds for the storage and handling cost of returns.

FB6: Other (Please specify)…………………………

Policy barriers to reverse logistics implementation

PB1: Lack of enforceable laws, regulations, and directives on take-back of end-of-life products.

PB2: Lack of government supportive economic policies.

PB3: We do not consider reverse logistics critical to our competitive performance.

PB4: Our customers are not informed of our take-back channels—item dropped

PB5: Lack of public awareness of environmental protection.

PB6: We do not have green design implementation in place to facilitate take-back of end-of-life products—item dropped

PB7: Other (Please specify)…………………………

Infrastructure barriers to reverse logistics implementation

IB1: We have no systems (hardware or software) to monitor returns.

IB2: We do not have sufficient in-house facilities (storage, equipment and vehicles) to handle returns.

IB3: We do not have any collaborations/coordination with outside logistics service providers (3PL providers).

IB4: Other (Please specify)…………………………

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