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The role of customer integration in extended producer responsibility: A study of Chinese export manufacturers and their performance

Abstract

Extended producer responsibility (EPR) is increasingly emphasized by manufacturing enterprises to improve eco-efficiency and to satisfy the growing environmental requirements expected in the market. This trend is salient for exported-oriented manufacturers mandated to comply with environmental regulatory requirements before entry is granted for their products in the requisite overseas countries. Drawing on the contingency theory, we examine the EPR practices undertaken by export-oriented manufacturers and the market and financial performance outcomes when such practices are characterized with low and high levels of customer integration in their implementation. Survey data collected from 134 manufacturing exporters in China show positive association of EPR practices with the performance outcomes. Using split group analysis, we found performance differences between the high and low manufacturer groups in customer integration for their EPR practices implementation. Particularly, the high customer integration group achieves better market performance whereas the low group weak in customer integration reap greater financial benefits. Managers need to understand the role of customer integration and the financial and market performance implications of implementing EPR practices to align with their performance goals and to build their supply chain system capabilities in the age of global complexity.

1. Introduction

Extended producer responsibility (EPR) originated from Europe as a policy concept aimed at extending producers’ responsibility for their products to the post-consumption stage of their product life with the presumption that manufacturers have the capability to reduce environmental impacts (OECD, 2001). The policy objective is to shift the burden of the waste management costs resultant from products at the end of their lifecycle from local tax payers back to those original manufacturers offering products in the market. There are two major impetuses for governments to promote EPR for environmental protection. The first motivation relates to the relief of financial burdens by local governments on waste management. Second, by providing incentives to reduce consumption of primary resources, manufacturers are encouraged to utilize more secondary materials and undertake product design changes for reducing disposal and waste in production activities (Link & Naveh, 2006). This EPR concept emphasizes the principle of waste prevention by manufacturers with supporting practices such as recycling, reprocessing, and reusing the components and materials with residual values. An important goal of EPR is to reduce disposal, waste, and consumption of resources by encouraging manufacturers to use sustainable materials and design products for recycling. This policy-oriented environmental initiative has led to the response by many industries such as automobile (Milanez & Buhrs, 2009; Wang & Ming, 2011) and electronics (Khetriwal, Kraeuchi, & Widmer, 2009a) to establish industry standards as reference for manufacturers to develop corresponding solutions for mitigating disposal and waste of reusable materials or components caused by their industrial activities. This policy trend for extending the environmental responsibility to upstream producers suggests that EPR practices can be a feasible way for manufacturing enterprises to seek more sustainable forms of development by improving their overall eco-efficiency.

In recent years, we have seen growing concern on environmental degradation in emerging countries (e.g., China) due to their rapid industrialization and fast growing consumption pattern. As a popular policy instrument, EPR mandates manufacturers to treat or dispose their products at the end-of-life with the potential to protect the environment and reduce costs incurred from developing landfill. The aim is to reduce waste generation at the source, encourage environmentally-friendly product design, and support achievement of the public goal on 3Rs pertaining to reduction, recycling, and reuse in materials management. On the managerial side, manufacturers remain unsure how EPR can be applied as an organizational practice to improve their financial and market performance. The literature on EPR tends to focus on anecdote from governmental views with a confine to policy implications (Khetriwal et al., 2009a) as well as the effect on manufacturers' businesses and consumer prices (Atasu, Van Wassenhove, & Sarvary, 2009; Webster & Mitra, 2007). The importance of EPR for managing wastes in consumption based society is recognized, yet its pursuit as key management practices by manufacturers to achieve financial and market performance goals remains an inchoate field of study. This paper adds knowledge to this important topic by investigating various EPR practices including recycle, reprocess, reuse, inspection and separation of parts, adoption of modular design, and cannibalization as well as their links with performance outcomes. Specifically, we empirically test the EPR practices-performance relationship to ascertain the business value of EPR, providing managerial insights into the contributions of EPR practices to manufacturers' performance goals.

Another study objective is to investigate the role of customer integration in the performance outcomes of EPR implementation. While EPR emphasizes managing the post-use products, it implicitly assumes that customers would fulfill their responsibility voluntarily by returning the end-of-life products to the product manufacturers where participation by the former is presumably beneficial to the latter (Forslind, 2005). Although end consumer participation has been acknowledged as a critical success factor of EPR implementation (e.g., Nicol, 2007), there is no empirical evidence regarding whether the integration of customer participation by manufacturer determines the performance results of organizational EPR efforts. In particular, there is a knowledge gap on the role of customer integration in the EPR-performance link. *Customer integration* is concerned with participation of customers in the product return process and their attention and efforts made to facilitate the manufacturers' EPR practices. Integrating with customers is an important part of EPR for manufacturers to meet the performance objectives. This is particularly salient for export-oriented manufacturers mandated to comply with environmental regulatory requirements before their products are allowed for distribution and sales in the requisite overseas countries. In this study, producer is sampled in scope as product manufacturers with overseas customers targeted as the primary market for their output items. Undertaking EPR may incur costs because organizational efforts are needed to coordinate with customers, fulfill customer expectations to carry out environmental audits, and manage the retrieval of usable products. Prior analytical studies have found that such customer integration may lead to excess or shortage of returned products, which makes inventory management difficult for manufacturers (Guide Jr., Jayaraman, Srivastava, & Benton, 2000). In a similar vein, the economic and social costs of disposal for excessively returned products, particularly those classified as unsuitable for remanufacturing, can be high. Based on the contingency theory with empirical evidence, we examine the market and financial impact of EPR practices implementation under different levels of customer integration with managerial insights on the business value of EPR practices and implementation. While the importance of EPR for manufacturing operations and its performance benefits are recognized in view of the escalating public quest for environment protection, the literature pays scant attention to the EPR practices-performance link and the role of customer integration in the process. To address this research void, this study seeks to answer the following research questions:

Question 1: Do EPR practices bring performance benefits to manufacturing enterprises?

Question 2: What is the role of customer integration on the implementation of EPR practices by manufacturers? In what ways does customer integration affect the EPR practices-performance relationship?

Answering these two research questions make two important contributions to the literature. This study is one of the first studies to empirically examine the EPR-performance link. The results shed light on the value of EPR practices for manufacturers to undertake their environmental responsibility and seek performance gains. Considering the customer role for manufacturing enterprises to build their supply chain system capability, this study advances knowledge on how integrating customers in the implementation of EPR practices differentiate their market and financial performance outcomes.

2. Research background and hypothesis development

2.1 Conceptualization of EPR

In this study, we define EPR as management practices including take-back, recycling, and final disposal of products that are helpful for manufacturing enterprises to relieve the environmental burdens bought by their products. While EPR focuses on utilizing reusable materials and components by incorporating modular design and capturing residual values from returned products, EPR is different from the notion of green supply chain management, green purchasing, and corporate environmental management. Green supply chain management focuses on inter-organizational efforts in managing the supply chain processes to reduce adverse environmental impact from purchasing of materials, production, to distribution of finished products (Sarkis, Zhu, & Lai, 2011). Green purchasing can be considered as one of the major processes of green supply chain management. As EPR manages residual values of returned products, green purchasing takes account of organizational sourcing decision with a focus on reducing use of environmentally unsustainable materials by developing purchasing policy, defining environmental objectives, and monitoring performance of suppliers (Chen, 2005; Wu, Melnyk, & Calantone, 2008). Lastly, EPR is different from the concept of organizational environmental management that is confined to organizational efforts and practices to reduce their adverse environmental impact through product and process stewardship with an emphasis on reducing liability and costs (Nicol, 2007). In comparison to the environmental management standard on ISO 14000 which is about process control with environmental consideration, EPR is concerned with the management practices by manufacturing enterprises on product take-back, recycling, and final disposal to reduce harms caused by their products to the environment.

One major goal of EPR is to mitigate the environmental damages by reducing disposal to landfill at the end of a product life. There are also economic values of EPR practices for manufacturers to collect and process the returned products through which to capture the residual values by remanufacturing, reprocessing, recycling, and reusing the reusable components. The return product streams cover packaging, electrical appliances and electronics, batteries, used oil, tires, and end-of-life vehicles. A major element of any EPR policy is the take-back requirement mandating individual manufacturers to collect and treat the resultant waste. Alternatively, product manufacturers are charged with financial obligations for these take-back activities. It is highly desirable that manufacturers incorporate environmental consideration at the product design stage to facilitate their subsequent take-back activities. This product stewardship emphasis improves and expedites the treatment of returned products (Subramanian, Gupta, & Talbot, 2009) because the responsible manufacturers need to inspect dissembled parts, separate reusable parts, recycle, reprocess, and reuse the reusable parts in the product take-back process (Chung & Wee, 2008). This collection of EPR practices is expected to enhance the producer's ability to competently satisfy both the international and local requirements on environmental protection.

Many manufacturing enterprises in emerging countries (e.g., China and Brazil) produce items targeted at global markets. At the same time, they must comply with related EPR legislations enforced by different governments, e.g., European Community Directives on Waste Electrical and Electronic Equipment (WEEE), if approval is necessary for their products to enter the market. For regulatory compliance, manufacturing exporters are required to provide a program or system of collecting and processing their products sold in the markets. Such requirement aims at mitigating the environmental damages caused by manufacturers through closing the supply chain loop of their products(Lai & Wong, 2012; Lai, Wong, & Cheng, 2012). To undertake this extended responsibility needs organizational effort for coordination with downstream customers, e.g., retailers and distributors, to collect the returned products for fulfilling the collection, recovery, and recycling regulatory objectives imposed by the local market. It is crucial that products are designed and made in such a way that makes it easy for the original manufacturers to recycle and remanufacture the reusable components throughout the product life cycle.

2.2 Chinese manufacturing and EPR

There is an increasing trend for China-made products entering international markets in recent decades and servicing the global production demands. This internationalization trend of Chinese manufacturing enterprises is noteworthy because they are often found to be less environmentally conscious and responsible relative to their developed-country counterparts. The commensurate emissions that are generated during the manufacturing processes have caused substantial environmental problems and resource scarcity within China. There are also serious environmental concerns such as air and water pollution, global warming, and ozone depletion attributable to China's increasing economic prowess.

While the Chinese manufacturing export expands, the environmental burdens brought by China-made products will be worsening. Such development highlights the important need of EPR practices by Chinese manufacturers to meet the growing environmental requirements in international markets while relieving the damages caused to the natural environment. This shift of environmental responsibility to upstream manufacturers will accelerate because a growing number of governments (e.g., the Chinese government) have incorporated EPR into their environmental policy. Meanwhile, the Chinese government is promoting the development of a circular economy so as to alleviate the contradiction between rapid economic growth and shortage of resources (Zhu, Geng, & Lai, 2010). The development of a circular economy requires economic systems to operate according to the materials, water, and energy cycling principles in support of natural systems. Such principles are characterized with eco-systemic self-sustaining properties emphasizing recycling of essential materials and energy, improvement of capacity for the wastes by one entity to be used as a resource by another entity, and development of self-organization capacities. This development approach as circular economy is prompted by the Chinese government as a national strategy to achieve sustainability, particularly as excessive resources consumption and pollution are critical hurdles compromising continuous economic growth of the country. Under this environmental initiative, the manufacturing industry is a targeted sector for the management of environmental protection and resource issues encountered in China.

As a viable means for Chinese manufacturers to resolve both the domestic and international pressures for preserving the environment, EPR practices are also a valuable organizational mechanism for performance benefits and alignment with public expectation on environmental protection and resource conservation. For an EPR initiative to succeed, the importance of supply chain coordination for managing the life-cycle of environmental performance of products should not be neglected (Subramanian et al., 2009). Manufacturers need to understand the role of customer integration in supply chain coordination for environmental initiatives to be successfully implemented (Zhu, Geng, & Lai, 2011). Recent research has also highlighted the essence of customer integration for a greener supply chain (Wong, Boon-itt, & Wong, 2011).

2.3 EPR and performance

Success in addressing environmental issues may provide opportunities to add business value and gain market acceptance. Recent studies also suggest that practicing EPR can improve the performance of enterprises with less environmental damage (Subramanian et al., 2009). One appeal for practicing EPR is that it enables manufacturers to internalize costs relating to environmentally-friendly products with the assumption that products are designed in such a way that components remain at the end of the product's life and there are opportunities for recycling and disposal for the used products. For instance, if electronic appliances were collected and contents such as rare earth materials in component parts are extracted for recycling, the need to consume virgin materials for manufacturing new units will be reduced. Products manufactured this way can gain market attraction, especially for environmentally-conscious customers, due to less waste generation and long-term residues damaging the environment. Building an environmentally responsible corporate image can be difficult for competitors to imitate as it helps gain customers' confidence in the environmental impact of the products and encourage customer patronizing the products (Fombrun, 1996). Manufacturers also receive more business opportunities and are in a superior position to negotiate for better terms of exchange when trading and collaborating with international partners that emphasize waste prevention and disposal to their local market (Ginsberg & Bloom, 2004), meaning improved ability to access international markets. Moreover, the adoption of modular design in EPR and the recovery of reusable parts for reuse in repairing, refurbishing, or remanufacturing of other products can be helpful for shortening the product manufacturing lead time. Modular design is part of the EPR practices that allows disassembly of components by manufacturers for product take-back, recycling, and disposal of their products. The modularity allows manufacturers to assemble a product from a set of smaller modules designed in an independent way which can function collectively as a whole (Baldwin & Clark, 1997). The modular product design is beneficial for organizational flexibility and managing systems in the supply chain (Sanchez & Mahoney, 1996). Such product stewardship also brings performance benefits to manufacturing enterprises in pollution reduction and financial gains due to cost saving (Wong, Lai, Shang, Lu, & Leung, 2012). The recycling or reusing the usable components from returned products also reduces the lead time of new product development due to decreased needs of sourcing for new supplies. The faster processing is beneficial for manufacturers to develop market advantage because of enhanced efficiency. For example, Levi Strauss's returns-processing system, known as R.I.S.E. (returns, irregulars, samples, exit strategy) helps shorten the time needed to process returned products from weeks to days by sorting the returned products and shipping them to different locations for reprocessing or resell (Anonymous, 2001). These EPR practices are valuable for manufacturers to establish a green corporate image and gain acceptance in the marketplace and hence better chances of selling products in the international market. Therefore, we expect that:

H1: Manufacturers implementing EPR practices more intensively tend to achieve better market performance.

The eco-efficiency achieved through EPR can reduce consumption of materials and decrease waste production; thus, the costs for materials acquisition and waste treatment can be lowered (Nahman, 2009). The product stewardship emphasis on EPR serves to reduce environmental burden with less use of hazardous and nonrenewable materials for product manufacturing. Although the implementation of EPR requires collaboration with downstream partners to perform such activities as product collection, disassembly, and inspection, EPR contributes business value by attracting and retaining environmentally conscious customers. Adoption of modular design as part of EPR promotes recycling and reuse of product components with eco-design as well as the adoption of recyclable parts and packaging for cost savings by reducing inventory investment and cost of disposal. EPR practices such as inspection of disassembled parts and separation of reusable parts are useful for recovery of assets and cost containment concerning returned products and hence reduction of materials acquisition costs and inventory requirements. For example, as part of Gap's "solid waste and recycling program," it uses less corrugated cardboard and utilizes recyclable materials for their containers. Doing so helps reduce cardboard waste by 57,000 tons and saves US$20 million per year. There are also financial performance benefits of EPR practices on recycling, reuse, reprocessing, and recovery to save disposal costs and generate revenue from resale. Such green practices are also helpful for generating revenues by capturing reusable components to be sold at after-market (Barnett & Salomon, 2006; Linton & Jayaraman, 2005). For example, to avoid disposal, IKEA uses its returned/damaged products as spare parts or restores them to saleable condition at reduced price. These practices allow the manufacturers to disassemble component parts for capturing residual values of returned products from the market and lessen consumption of new inputs by utilizing reusable parts recovered from returned products. A focus on EPR helps manufacturers reduce the risk of creating waste and excessive consumption of virgin materials, which not only improve cost savings (Hindo & Arndt, 2006), but also avoid regulation violation. Accordingly, we anticipate that:

H2: Manufacturers implementing EPR practices more intensively tend to achieve better financial performance.

2.4 Moderating Role of Customer Integration

The contingency theory views a firm as an open system, where its performance is affected by the environment (Van de Ven & Drazin, 1985). The alignment of organizational processes with the business environment determines how a firm performs (Thompson, 1967). The organizational process is endogenous that is decided and controlled by firms, whereas the business environment is exogenous that firms have relatively less control over the conditions (Astley & Van de Ven, 1983). This contingency theoretic view suggests that the performance of EPR practices is dependent not only on how well a firm handles the returned products, but also the level of customer integration in support of the processes. In managing the supply chain as a system, it is important to involve related parties including customers to achieve such supply chain system capabilities on lean and agility for greater cost reduction and shorter lead-time (Gunasekaran, Lai, & Cheng, 2008). The development of such capabilities through implementing EPR practices and to achieve the desired financial and market performance outcomes should pay attention to the performance contingencies influenced by the related parties. While customer integration in EPR demands commitment from not only manufacturers but also their respective customers, the contingency theory provides a theoretical ground to examine the financial and market performance implications of EPR when the practices are implemented with customer integration that is relatively less controllable by manufacturers.

We argue that the performance outcomes of implementing EPR practices are attributable to the match between its strategic action and its situational conditions. Implementation of EPR practices is considered a strategic action beneficial to the performance of manufacturers. Nevertheless, they should not ignore customer integration as the situational condition that affects the EPR practices-performance link. According to the contingency theory, manufacturers need a match with customer integration to bring the performance benefits of EPR practices. The success of EPR practices needs cooperation from downstream customers for product take-back, recycling, and final disposal. Hence, the EPR practices-performance relationship can be contingent on how well customers consider their responsibility to retrieve usable products from the markets, carry out environmental audits of the focal manufacturers, and take part in product return programs. Furthermore, there are marketing and financial perspectives on the role of customer integration in the implementation of EPR practices. The first perspective implies customer perception and participation in the product return program, highlighting their interest in EPR and the related efforts. With an emphasis on EPR, manufacturers can develop a reputation of being environmentally responsible and committed (Rindova, Williamson, Petkova, & Sever, 2005; Roberts & Dowling, 2002). Such corporate reputation is valuable for manufacturers to improve their public image, obtain customer support, and enter international markets with strict EPR regulations. Customer integration allows better market access to manufacturers with which they can expedite lead time of product manufacturing due to additional source of materials and components. Such integration also provides market information on the latest environmental protection requirements and expectations, enabling manufacturers to strategize their EPR program to better meet the market needs. The increased customer integration can therefore be helpful for improving corporate image and organizational positioning in the marketplace. Thus, according to the contingency theory, the relationship between EPR and performance depends on the extent to which firms integrate with their customers in the implementation of ERP practices.

Hypothesis 3: The positive relationship between implementing EPR practices and the market performance of the manufacturers is strengthened when customer integration in the implementation is at a high level.

From the financial perspective, customer integration introduces uncertainty to the implementation of EPR practices by manufacturers. Customer integration increases uncertainty in their environmental efforts because the amount and delivery time of returned products is highly dependent on customer willingness to cooperate and facilitate the EPR practices (Guide, Jayaraman, & Linton, 2003; Subramanian et al., 2009). These uncertainties can introduce excessive or shortage of returned products that increase the difficulty of managing inventory and hence administrative and operational tasks (e.g., documentation) to satisfy customer requirements and monitor the performance outcomes of implementing EPR. Customer integration in EPR may raise customers' scrutiny in the performance outcomes of EPR practices as customers consider themselves as part of an EPR program with high expectation on the resultant environmental improvement. As such, customer integration may incur costs to manufacturers because extra organizational efforts are required to handle uncertainties of incoming inventory and satisfy evolving customer expectations. Hence, we propose the following relationship. Figure 1 depicts the research framework guiding this study.

Hypothesis 4: The positive relationship between implementing EPR practices and the financial performance of the manufacturers is weakened when customer integration in the implementation is at a high level.

<Insert Figure 1 about here>

3. Methodology

3.1 Sample Characteristics and Data Collection

As this study investigates EPR practices and the role of customer integration in their implementation that are highly relevant to the manufacturing industry, the sample organizations for this study were drawn from the global manufacturing base – China – that produces and exports manufactured items worldwide. With the global presence of China-made products, customer integration through such means as taking part in a product return program and carrying out environmental audits of Chinese manufacturers plays an important role in the success of any EPR program. Also, China's fast progression of industrialization has aroused international concerns on its pollution causing health issues ranging from birth defects and pre-mature death (Liu & Diamond, 2005) and turning grasslands to deserts. The desertification problem in China created the nation's worst sandstorm in March 2010, which caused serious air pollution in the inland and nearby regions (e.g., Hong Kong, Taiwan, Japan, and Korea) (Wassener, 2010). Moreover, there is a global trend of enterprises implementing sustainable sourcing and procurement. The pollution problems in China have raised serious international doubt of the environmental efforts of China's manufacturing exporters in mitigating their impact on the environment, where the country's economic development can be threatened (Kahn & Yardley, 2007). With the Chinese government striving for improvement in environmental conditions and active participation in international dialogue to mitigate climate change, it is timely and appropriate to investigate EPR practices of manufacturing exporters in China and how the implementation of these practices are related to their financial and market performance. Drawing study sample from the manufacturing industry in China improves generalizability of findings to other emerging economies particularly those position manufacturing as a pillar industry contributing to their economic development.

To collect data related to EPR practices, we randomly drew a sample of Chinese manufacturers from the database *Dun & Bradstreet.* In the sampling process, we did not target specific manufacturing industries with the aim to improve the generalizability of our study findings. The database provided contact information and job title of senior executives, company name, address, phone number, and company profile. We obtained objective data on annual sales volume and company size in terms of number of employees from the database as control variables. Based on the position title of senior executives available in the database, we identified a qualified key informant who is knowledgeable in environmental management practices in each sample firm. Their ability in responding to the survey is ensured with direct contact prior to the questionnaire administration. The senior executives were asked to suggest an appropriate manager by providing his/her name and contact information, if they feel the manager is relatively more knowledgeable. To improve the response rate and reduce common method variance, respondents were assured that their answers are only reported in aggregate with others, and their identity and company details are kept confidential.

A total of 800 sample manufacturers from the database were contacted. In the first wave of mailing, a survey package enclosing the questionnaire, self-addressed pre-paid reply envelop, and a cover letter explaining the purpose of this study, were mailed to each key informant. We made follow-up calls or sent emails two days after the initial mailing to seek acknowledgement of the survey package and to emphasize the importance of their responses to this study. Two weeks after the follow-up calls and emails, we sent another survey package to the non-respondents with a cover letter to stress the importance of their response and solicit their participation. We made follow-up telephone calls or sent emails, and dispatched a third survey package to the non-respondents two weeks subsequent to the second mailing. We concluded our data collection three weeks after the final mailing and received 134 completed questionnaires, representing a response rate of 16.75%. We eliminated six returns due to significantly missing data, resulting in an effective response rate of 16% which is comparable to other survey-based management studies (e.g., Delmas & Toffel, 2008).

3.2 Bias Issues

We took three steps to determine whether common method variance (CMV) posed a serious threat to this study. First, we collected data from different sources. The executives provided information about the strategic elements of this study, such as extended producer responsibility, market performance, financial performance, and customer integration, while information on company size and annual sales volume were obtained from the database *Dun & Bradstreet.* Second, we applied Harmon's one-factor test to assess whether a single latent factor would account for all the theoretical constructs. We conducted chi-square difference test on a single-factor model and the hypothesized four-factor model to assess CMV. The one-factor model yielded a chi-square value of 480.78 (df = 102). A significant difference between the chi-square values of the two models ($\Delta\chi^2$ = 330.53; Δdf = 3, $p < 0.001$) indicated that the fit in the one-factor model was significantly worse than it was in the measurement model. This provided preliminary evidence that CMV was not a problem in this study. Third, we followed the procedures recommended by Lindell and Whitney (2001) and popular in the literature (Craighead, Ketchen, Dunn, & Hult, 2011) to evaluate whether the potential CMV is serious. We used the type of organizational ownership (i.e., publicly-owned vs. privately-owned) as the marker variable to perform the CMV analysis because the marker variable is theoretically unrelated to the dependent variables (i.e., financial and market performance). The ownership type is not significantly correlated to financial performance with $p = 0.95$ and market performance with $p = 0.43$. The correlations between all constructs in the measurement model and the ownership type are summarized in Table 1. In addition, the partial correlations between the constructs are significant after partialing out the effect of CMV, and the partial correlations are reported in Table 1. We concluded that the measurement model possessed reasonable fit with the data, the constructs exhibited both convergent and divergent validity, and CMV did not pose serious threat to the interpretation of our study results.

<Insert Table 1 about here>

3.3 Measurement Development

A structured survey instrument was developed to measure manufacturers' practices of EPR, their customer integration, and their market and financial performance. We conducted exploratory qualitative studies to understand the environmental-based operations management issues and problems by interviewing executives in Chinese manufacturers. We explored the key practices that were implemented in their EPR program. One example showing the need for EPR-based operations is the WEEE Directive (Waste Electrical and Electronic Equipment Directive) in Europe, which mandates collection, recycling and recovery of electrical goods. This environmental regulatory requirement leads manufacturing enterprises to manage product's cycle life for compliance. Their adoption of EPR practices couple with the trend for environmental protection. In China, there is also Chinese WEEE version (废弃电子电器设备指令) where a list of manufactured items are subject to take-back and recycling requirements and manufacturers need to undertake measures to showcase their EPR (生产者责任延伸). Based on the conceptualization of EPR, the interview results, and the EPR literature, EPR is concerned with manufacturers' responsibility in managing the environmental impacts of the lifecycle of their products spanning product modular design to the processes involved in capturing the residual values of returned products. This product cycle loop extends beyond a mere take-back system to incorporate product design from upstream through to end use in downstream in the management processes. EPR is therefore operationalized to assess the extent of such EPR practices as adoption of modular design, inspection of disassembled parts, separation of re-usable parts, recycle, reprocess, reuse, and recover reusable parts and reuse them in repairing, refurbishing, or remanufacturing of other products, that were implemented by the manufacturers to mitigate the environmental impact of the products made by them. In addition, we adopted the existing measurement evaluating customer integration (Carter & Carter, 1998; Chen, 2005), market performance(Venkatraman & Ramanujam, 1986), and financial performance (Autry, Daugherty, & Richey, 2001; Ayres, Ferrer, & van Leynseele, 1997; Wong, Lai, Cheng, & Lun, 2012) from the literature. Customer integration refers to customer participation in the EPR initiative of the focal manufacturer. Market performance evaluates improvements in lead time, market position, sales opportunity, and corporate image in the marketplace; while financial performance generally assesses cost saving and revenue increase of the manufacturers due to EPR practices implementation. The measurement items were amended with practitioner inputs to reflect the manufacturing and environmental management context. The measurement issues, the survey administration procedures, and discussion of potential bias problems are also reported in a related study (Lai, Wu, & Wong, 2013). The final measurement scales are summarized in Appendix A.

4. Analysis and Results

4.1 Measurement Models

We evaluated the measurement properties of the theoretical constructs by conducting confirmatory factor analysis (CFA) with AMOS 18.0 on four variables, including EPR practices, market performance, financial performance, and customer integration. Following the guidelines by Gerbing and Anderson (1988) and consistent with other organizational-level latent construct analyses (e.g., Nadkarni & Narayanan, 2007; Williams, 2007), we used maximum likelihood estimation with sample covariance matrix as input in the CFA.

We assessed the unidimensionality of the constructs by Cronbach's alpha. The alpha values were well above the threshold value of 0.70 in the range of 0.79 to 0.90, indicating that the construct measures are sufficiently reliable. As shown in Table 1, composite reliability coefficients of the four latent constructs were in the range from 0.81 to 0.90, suggesting internal consistency for each set of observed variables in its respective latent construct (Fornell & Larcker, 1981). The four-factor measurement model exhibits a good fit with the data (χ^2 = 248.20, df = 162; CFI = 0.93; RMSEA = 0.06; IFI = 0.94; TLI = 0.92). All items loaded significantly on their respective constructs at $p < 0.05$ level with standardized factor loadings exceeding 0.52, providing evidence of convergent validity in our measures. In addition, the average variance extracted is larger than the recommended minimum value of 0.50 (Fornell & Larcker, 1981), indicating strong convergent validity. Composite reliability, Cronbach's alpha, and average variance extracted are summarized in Table 1.

We followed Fornell and Larcker's (1981) guidelines, which are widely adopted by other researchers (e.g., Delmas & Toffel, 2008; Murillo-Luna, Garces-Ayerbe, & Rivera-Torres, 2008), to examine discriminant validity of our study measurement. We compared the average variance extracted (AVE) of each construct with the highest variance that each construct shares with the other constructs in the model. The AVE for each construct is greater than the highest shared variance, suggesting that all constructs exhibit discriminant validity. In addition, we examined discriminant validity by comparing the chi-square difference for all pairs of constructs (Anderson & Gerbing, 1988). Since the chi-square values for the unconstrained models, where each pair of constructs co-varies freely, are significantly lower than the constrained models (with the estimated correlation for each pair of constructs constrained to one), the presence of discriminant validity for all the constructs is evidenced. We assessed convergent validity by examining the significance of loading of each measurement item on its theoretical respective construct using CFA. The results as shown in Appendix A indicate that the loadings of the measurement items loaded significantly on their respective constructs. These results suggest convergent validity of the measurement scales.

<Please insert Table 1 about here>

4.2 The Structural Model

The structural model used to test the hypotheses consisted of the three factors validated in the measurement model, excluding the moderating variable (i.e., customer integration). The model fit measures indicated acceptable agreement with the covariance in the data (χ^2 = 150.25; df = 99; CFI = 0.95; RMR = 0.06; IFI = 0.95; TLI = 0.94). We found that EPR practices were positively associated with market (β = 0.29, $p < 0.05$) and financial (β = 0.21, $p < 0.05$) performance, providing support for H1 and H2. The hypothesis test results for H1-H2 are summarized in Table 2.

<Insert Table 2 about here>

4.3 Moderating Effect of Customer Integration

Another aim of this study is to determine the importance of customer integration in EPR practices of manufacturers. Specifically, what are the performance outcomes if manufacturers have a high versus low customer integration in the implementation? Following the procedures proposed by Byrne (2004), we used multi-group analysis within AMOS 18.0 to assess the structural model at a high versus low customer integration in the implementation of EPR practices. We divided the sample into high (n = 63) and low (n = 65) customer integration groups with median split. The multi-group analysis was conducted in four steps. First, we developed a model where the structural parameters vary freely across the two groups to form a baseline model (Model 1). The baseline model has a value of χ^2=292.89 with df=198. Second, the structural parameters were constrained to be equal across the two groups (Model 2), generating an estimated covariance matrix for each group and an overall chi-square value for the sets of sub-models as part of a single structural system. The constrained model has the value of χ^2=316.99 with df=217. Third, the moderator effects were tested by assessing whether statistical differences exist between the two chi-square values. We conducted a χ^2difference test to compare the constrained model (Model 2) with the unconstrained one (Model 1). The χ^2difference test results in χ^2_{M2}-χ^2_{M1} = 24.10 with df = 19 at $p < 0.05$, which is statistically significant. A significant change in the chi-square value indicates the moderator effect of customer integration, such that invariance is found attributable to customer integration.

Then, we examined the moderator effect of customer integration on the paths in our research model by assessing the equality across two groups using a chi-square difference test between a model with a specific path set to be equal across two groups (a constrained model) and a model where path coefficient varies freely (a baseline model). For example, to test H3, we constrained the EPR practices→ market performance path equally across the high and low customer integration groups, and obtained the $\chi^2_{(df=199)}= 301.08$. The $\Delta\chi^2_{(\Delta df=1)} = 8.19$ ($p< 0.05$) suggests that across the two groups, the EPR practices→ market performance path is not equal. The path coefficient is higher and significant ($\beta = 0.36$, $p< 0.05$) than that under high customer integration (See Table 3). The results support Hypothesis 3, indicating that the positive relationship between EPR practices and market performance is stronger when customer integration is high than when it is low. The results shown in Table 3 revealed that the EPR practices→financial performance path is significantly different across the high- and low-customer integration groups. The study findings also lend support for H4 that the EPR practices→financial performance path is stronger and significant when there is a low level of customer integration ($\beta = 0.25$, $p< 0.05$) than when there is a higher level of customer integration ($\beta = 0.17$, $p> 0.05$).

<Insert Table 3 about here>

5. Discussion and Implications

Today's globalized business situation has caused China to face numerous social and economic pressures. China's integration into the world's economy began three decades ago. There has been substantial growth experienced in the Chinese economy after its entry into the World Trade Organization (WTO). This economic integration made China, particularly for those of the manufacturing exporters, depend more upon international trade. In light of the escalating international community quest for product take-back, Chinese manufacturers begin to integrate EPR practices into their operations to satisfy the market expectation. One major concern for manufacturing enterprises to undertake EPR practices relates to the performance benefits. It also remains unclear whether customers play a role in the EPR practices-performance link, in particular how firms may reap the benefits of EPR through customer integration. The study results suggest that the integration of customers on EPR practices to recycle, reprocess, and reuse their products can improve their market acceptance but also incur expenses due to the costs for coordinating the related activities.

While prior studies and real-life cases have shown the success of EPR in reducing waste and disposal that is beneficial to the environment and community (Khetriwal, Kraeuchi, & Widmer, 2009b; Mont, 2002; Tsai & Hung, 2009), we examine the financial and market impact of implementing EPR practices from the organizational perspective. This research advances knowledge on the business value of EPR practices, providing references for manufacturers to decide on whether to adopt EPR practices and the implications for market as well as financial performance. The study findings provide implications and contribution to environmental-based operations management. First, we examine a list of practices related to EPR for the reference of manufacturing enterprises to evaluate the different aspects of EPR practices implementation in their operations. The list of practices provides useful references for manufacturers to plan implementation actions and better prepare themselves for environmental regulatory compliance particularly in those countries strict in EPR related regulations. Second, this study lays an important ground for the contingency theoretic perspective of EPR for environmental-based operations management by providing empirical evidence that customer integration influence the relationship between EPR practices and the market and financial performance outcomes. Although it is often implicitly assumed that customer integration is valuable to bring performance for environmental management efforts, involving customers for EPR practices is important for Chinese manufacturers to gain market performance. This study contributes to the contingency theory by providing empirical evidence on the moderating role of customer integration on the performance outcomes of EPR practices of manufacturing enterprises. Such customer integration in EPR practices enables manufacturers to develop an environmentally responsible corporate image, and increases opportunities of accessing international markets. The study results indicate the benefits of integrating with customers in the implementation of EPR practices. Manufacturers seeking to establish market position with their EPR practices need to strengthen customer integration in their environmental initiatives. Towards this end, manufacturers may consider to reinforce customer awareness on their responsibility to retrieve usable products from the markets. A more proactive way is to invite customers as part of their environmental audits and product return program to strengthen their support in the EPR program. This study provides insights into the role and importance of customers in EPR implementation. The participation and involvement of customers enable manufacturers to market their products internationally by addressing overseas environmental regulations. In addition, taking back used or end-of-life products allow manufacturers to gain information regarding usage pattern and design flaws of their products, which are helpful for improving product design, significantly shortening the lead time for new product development.

On the other hand, we found that EPR practices implementation by Chinese manufacturers characterized with lower level of customer participation are associated with better financial performance. This dark side of customer integration for EPR practices implementation implies that firms need to develop a mechanism to better coordinate EPR practices with customers for reducing inventory investment and the costs in handling returned products. This is in line with the prior literature that firms may not be able to achieve financial performance at the outset of their environmental management efforts (Zhu et al., 2010). It requires organizational effort to develop a coordination system with their supply chain partners to streamline cross-firm processes in order to reduce costs (Zhu et al., 2011). Managers need to control the cost of coordinating product returns from customers in order not to compromise the financial performance gains from the EPR practices implementation. In doing so, they may consider a collection mechanism for product returns by customers to reduce the uncertainties of returned resources and hence the buffer inventory investment. It is also useful to establish a network along the supply chain to improve the effectiveness in handling the returned products and lower the expenses related to customer enquiries and efforts duplication in the handling of returned resources. Manufacturers that have implemented or intend to implement ERP practices should pay attention to the coordination aspects of the implementation with customer integration to achieve both the market and financial performance.

6. Limitations and Future Research Directions

This study has a number of limitations that require caution in interpretation which are left for future research. First, this study is conducted in China, which is a major global manufacturer causing environmental concerns due to its rapid industrial development while it emerges as a key economy. Although China represents one of the major manufacturing countries and provides insights into the value of EPR practices for manufacturing enterprises, future research may consider extending to other emerging countries, such as India, Vietnam, and Brazil, to improve the generalizability of the findings. Second, the data collected for this research is cross-sectional. Future studies may consider applying longitudinal research design to ascertain the causal direction of the associations between EPR, market performance, financial performance, and customer integration and in other industrial contexts such as retailing and transport logistics (Hilmola, 2011; Lai, Cheng, & Tang, 2010; Lai, Lun, Wong, & Cheng, 2013; Wong, Lai, Lun, & Cheng, 2012). Third, in addition to customer integration, it is possible that there are other operational and relational characteristics in a supply chain that may affect the performance results of EPR (Wong, Lai, & Ngai, 2009; Yang, Wang, Wong, & Lai, 2008; Yang, Wong, Lai, & Ntoko, 2009). This study lays ground for future research to explore contingencies that may affect the EPR implementation outcomes. Future studies may consider factors such as buyer-supplier relationship and information technologies use in facilitating EPR practices to achieve desired performance. The motivators and readiness driving sustainability development via EPR practices also warrants further research investigation (Gunasekaran & Spalanzani, 2012; Law & Gunasekaran, 2012). In addition to the contingency factors, it is also worthwhile to examine how the competitive capabilities of organizations including quality, cost, flexibility, delivery, and innovativeness mediate the EPR practices-performance link. Further research in this direction will advance knowledge on whether EPR practices can help nurture competitive capabilities of organizations and the indirect performance effects of EPR practices through developing such capabilities. It is also possible that environmental management practices such as EPR practices will lead to environmental performance first before the market and financial outcomes can be realized (Yang, Hong, & Modi, 2011). Examining how environmental performance improvement due to EPR practices influences the bottom-line outcomes and the strength of the performance effect will deepen our understanding on the environmental value of implementing EPR practices. Fourth, while this study examines the EPR practices of export-oriented manufacturers, this study did not take account of differences in regulations and market expectations of different exporting countries. There is also a strong research need to understand the implications of EPR-related regulations in different countries from an operations perspective (Atasu & Van Wassenhove, 2012). Future research may consider such differences to gain understanding on how these may affect the performance results of EPR practices.

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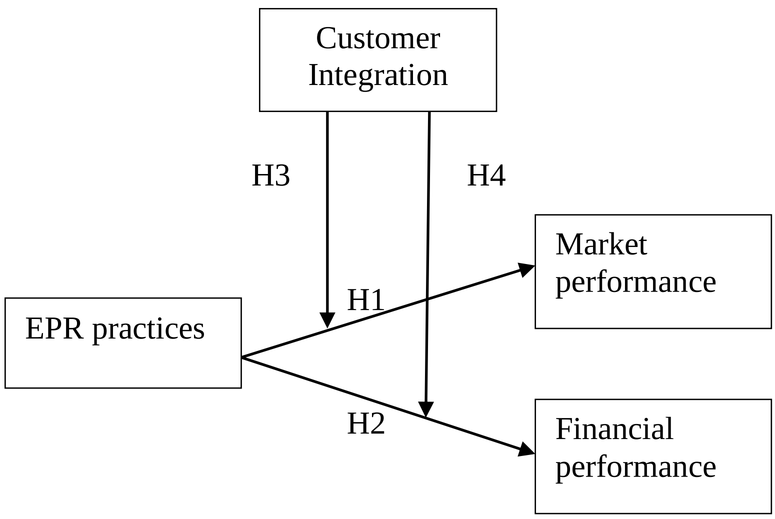

Figure 1 Research Framework

Table 1 Correlation, Cronbach's alpha, composite reliability, average variance extracted, and common method bias analysis

	EPR Practices	Market Performance	Financial Performance	Customer Integration
EPR Practices	**0.87**[a] **0.89**[b] **0.50**[c]			
Market Performance	0.28[d] 0.28[e]	**0.79** **0.81** **0.54**		
Financial Performance	0.36 0.36	0.64 0.64	**0.90** **0.90** **0.59**	
Customer Integration	0.38 0.36	0.26 0.27	0.19 0.20	**0.84** **0.84** **0.57**
Type of Ownership (marker variable)	*0.12*	*-0.05*	*0.01*	*0.18*

All correlations are significant at $p < 0.05$, except values in italics.

[a]Cronbach's alpha

[b]Composite reliability

[c]Average variance extracted

[d]Correlation between the constructs

[e]Correlation corrected for common method bias

Table 2 Structural Equation Modeling Results of Hypotheses1 and 2

Structural Model: H1-H2						
Paths	Standardized Estimate	SE	t-value	*p*	Hypothesis	Conclusion
EPR practices → Market performance	0.29	0.07	2.77	.01	H1	Supported
EPR practices →Financial performance	0.21	0.07	2.47	.01	H2	Supported

***$p<0.001$, **$p<0.01$, * $p< 0.05$

Table 3 Multi-group Analysis Results of Hypotheses 3 and 4

High vs. Low Customer Integration							
Models	χ^2	df	χ^2/df	IFI	TLI	CFI	χ^2difference test
1. Baseline Model	292.89	198	1.48	0.91	0.90	0.91	
2. Constrained Model	316.99	217	1.46	0.90	0.89	0.80	$\Delta\chi^2$ = 24.10, Δdf = 19 $p < 0.05$
3. Constrained Paths:							
3a. EPR practices → Market performance	301.08	199	1.51	0.90	0.90	0.90	$\Delta\chi^2$ = 8.19, Δdf = 1 $p < 0.05$
3b. EPR practices→Financial performance	297.67	199	1.50	0.91	0.90	0.91	$\Delta\chi^2$ = 4.78, Δdf = 1 $p < 0.05$

Path Coefficients				
Paths	High customer integration (n = 63)	Low customer integration (n = 65)	Hypothesis	Conclusion
EPR practices→ Market performance	0.36[a] (2.09)*	0.19 (1.34)	H3	Supported
EPR practices→Financial performance	0.17 (1.32)	0.25 (2.04)*	H4	Supported

[a]Path coefficients

t-values are in brackets

***$p<0.001$, **$p<0.01$, * $p< 0.05$

Appendix A Measurement constructs and items

Construct Name	**Measurement Items**	**Standard Loadings** (p < 0.05)
Extended Producer Responsibility Practices (Goodness-of-fit indices: χ^2 = 36.6, df = 14 p < 0.001; CFI = 0.94; IFI = 0.94; TLI = 0.91)	Please indicate the extent to which your firms performs the following practices to your products (1 = not at all, 5 = to a great extent): • Adoption of modular design • Inspection of disassembled parts • Separation of re-usable parts • Recycle • Reprocess • Reuse • Cannibalization – recover reusable parts and reuse them in repairing, refurbishing, or remanufacturing of other products	.64 .68 .68 .75 .79 .75 .64
Market Performance (Goodness-of-fit indices: χ^2 = 6.5, df = 2, p < 0.05; CFI = 0.98; IFI = 0.98; TLI = 0.93)	Please indicate the extent to which you agree or disagree with the following statements on performance impacts after adopting the practices (1 = strongly disagree, 5= strongly agree) • Significantly improved lead time • Improved position in marketplace • Improved chances of selling products in international markets • Improved our corporate image	.43 .68 .92 .80
Financial Performance (Goodness-of-fit indices: χ^2 = 30.9, df = 5, p < 0.001; CFI = 0.93; IFI = 0.94; TLI = 0.90)	Please indicate the extent to which you agree or disagree with the following statements on performance impacts after adopting the practices (1 = strongly disagree, 5= strongly agree) • Decrease in disposal costs • Increase in revenue from resale • Effectiveness in handling recovery of assets related to our returned products • Effectiveness in handling cost containment related to our returned products • Reduction in inventory investment	.78 .75 .82 .82 .86
Customer Integration (Goodness-of-fit indices: n/a)	Please indicate the extent to which you agree or disagree with the following statements that describe the customers of your company (1 = strongly disagree, 5= strongly agree) • Customers consider that it is our responsibility to retrieve usable products from the markets	.78 .65

	• Our customers carry out environmental audits of our firm • Our customers take part in our product return program	.86