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Factors for implementing end-of-life product recycling operations in Chinese manufacturing sector

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This study aims to prioritise various end-of-life product recycling factors in reverse supply chains from firms' perspective in Chinese manufacturing sector. Using case study method and analytic hierarchy process this study prioritises factors in five manufacturing companies. Comparative analysis is carried out to understand influencing factors in the five companies.

Keywords: Reverse logistics, factors, end-of-life, manufacturing sector

1.0 Introduction

Waste generated in various industries within Chinese manufacturing sector is enormous due to rapid industrialization and presence of 22% of world population. Industrialisation and population resulted in economic benefits and simultaneously yielded serious environmental pollution and waste generation more than developed countries (Fang et al., 2007). Recent statistics states that 5 million tons of waste steel, 200,000 tons of non-ferrous metal, 14 million tons of waste paper, large amount of waste plastics and glasses which has been never recycled. Beyond this it is also interesting to note that China is second in the world after the USA in landfilling and incineration of e-waste residues (Ma, 2004; Zoeteman et al., 2010). These statistics reveals that there is a huge scope to recover valuable materials through implementing reverse supply chain or reverse logistics in Chinese manufacturing sector. Reverse logistics is a process by which a manufacturer systematically accepts previously shipped products or component from the point of consumption for possible reuse, remanufacturing, recycling or disposal. Thus reverse logistics is an important process to protect environment and reclaim valuable resources from end of life products or waste. It is essential to implement reverse logistics process to achieve several benefits and this has been already done in developed countries whereas it is at an infancy stage in China. Several external and internal factors govern the successful implementation of reverse logistics and mostly it has been addressed by numerous researchers in developed country context. Few external and internal factors suggested by researchers are government regulations, customer demand, policy entrepreneurs, support of top management, stakeholder commitment, incentive systems, quality of inputs and vertical integration (Rahman and Subramanian, 2011; Dowlatshahi, 2005; Carter and Ellram, 1998). It is also stated that reverse logistics literature is dominated by studies on location-allocation modelling and has not been broadly researched

or developed with respect to implementation (Kumar and Putnam, 2008; Ilgin and Gupta, 2010). Zhu et al. (2008) studied the green aspects of reverse supply chain in few Chinese industries suggested future researchers to explore motivations and barriers on why organizations do or do not implement typical green reverse supply chains. Our intention in this study is to identify important internal and external factors through literature review and to examine what factors motivates the Chinese manufacturers if they want to implement reverse logistics. Case study has been carried out in five manufacturing companies to understand their views with respect to reverse logistics. Analytic hierarchy process (AHP) has been employed in this study to prioritise governing factors for successful implementation of reverse logistics in Chinese manufacturing sector.

2.0 Reverse logistics implementation factors

Few studies in the past suggested conceptual models in general to design and implement reverse logistics. Carter and Ellram (1998) classified reverse logistics implementation factors into external and internal and they are regulations, customer demand and policy entrepreneurs. Subsequently few researchers attempted to customise the general model with additional factors such as strategic cost benefit, strategic quality, customer service and environmental concern to specific products such as End-of-Life computers, E-waste, automotive etc. (Dowlatshahi, 2005; Knemeyer et al., 2002; Ravi et al., 2005; Kumar and Putnam, 2008; Rahman and Subramanian, 2011). Table 1 summarises the reverse logistics factors considered by researchers which has been applied in different sectors and in different country context. It is interesting to note two important gaps from the review and they are only limited sector have been focused and it is hard to find plastics, footwear industry etc. and difficult to find reverse logistics implementation factors in Chinese context. It is obvious from the review that only one study carried out by Zhu et al. (2008) discusses Chinese context. But their objective is to study the implication of green supply chain management on performance of four different industries such as automotive, power generation, petroleum/chemical and electrical/electronic. Furthermore they indicated to explore factors (motivations and barriers) on why organizations do or do not implement typical green reverse supply chains. There are enormous studies in Chinese context in terms of waste management, E-waste handling and recent development of environmental regulations (Chung and Zang, 2011; Zhou et al., 2007; Lau and Wang, 2009).

Table 1: Summary of RL implantation factors in various countries and sectors

Factors	Implication	Sector	Country	Source
Legislation	Regulations or Acts passed by government agencies to ensure firms take back and reuse the products they produce	E-waste, Automotive, Appliances, health care, cosmetics, food retailer, Chemical and power generation	Turkey, Australia, US, UK, China, Thailand, India	Yuksel (2009); Kumar and Putnam, 2008; Rahman and Subramanian, 2011; Frota Neto et al., 2008; Walker et al. (2008); Zhu et al. (2008); Tan and Kumar (2006);
Customer demand	Customer demand for green products	E-waste, Automotive, Appliances, health care, cosmetics, food retailer, Chemical and power generation	Australia, US, UK, China, Thailand, India	Dowlatshahi (2005), Ninlawan et al., (2010); Ravi et al. (2005); Liu (2006)
Incentive	Benefits derived by returning products	E-waste	Australia,	
Strategic Cost/Benefits	non-recurring costs incurred by manufacturer for the design and implementation of a reverse supply chain system	E-waste, paper based products, health care, cosmetics, food retailer	Turkey, Australia, Europe, UK, US, India	
Environmental Concern	Proactive consideration of green and sustainable issues by manufacturers	E-waste, Automotive, Appliances, paper based products, health care, cosmetics, food retailer	Turkey, Australia, Europe, UK	
Resource	Possibility of using existing resources for reverse logistics or need of additional resources	E-waste	Australia	
Integration & Coordination	Communication, effective use of information systems	Automotive, E-Waste, Appliances	US, Australia	
Volume and Quality	Emphasis on quantity and nature of returned product	E-waste, paper and paper based products, health care and Automotive	Australia, Europe, US	

3.0 Chinese manufacturing sector

Manufacturing has successfully transformed China's economy from that which was primarily agriculture based to becoming the world's manufacturing factory. Aided by relatively cheap, dedicated and skilled workforce, everything from toys, to cars to some of the most sophisticated electronic goods thinkable on the planet are made in China. The significance of the manufacturing sector in China can be comprehended by the statistics reported by Pinto (2005) and they are: continual increasing manufacturing prowess, significant cost advantage (beyond just labor cost), worldwide market-share – 5% of cameras, 30% of air conditioners and television, 25% of washing machines, 20% of refrigerators. Pinto (2005) also noted that a single private Chinese company makes 40% of all microwave ovens sold in Europe. China for example is now the largest automobile producer in the world and a key market for global players in the automobile industry. The country now supplies world's leading automotive manufactures with high quality parts and components. China's vehicle production scale reached 18.26 million vehicles in 2010, an over 30% increase from 2009's 13.79 million units (FOURIN China Automotive Intelligence). China's local automotive companies are increasingly working as part of joint ventures with leading global brands; and important trends that are likely to dominate the development of the global automotive industry over the next decade will all have China playing a key role. Similarly the China's plastics manufacturing sector employs 2.6 million workers and generate a total export value of US \$14.40 billion in 2009. China's packaging market is the largest in the world and is predicted to grow to \$97bn per annum by 2012 (Wood, 2010). Food packaging alone accounts for 50% of the total demand for packaging with volume growth of more than 20% being common in most food sectors. It is a similar story for China's footwear industry with the total export value hitting US\$24b in 2009. These motivated our selection of five firms in China's key manufacturing industry such as automotive, electronics, food packaging, plastics and footwear for a case study to identify the importance of reverse logistics implementation factors and to know how best the firms are aware about those issues.

4.0 Research methodology

Case study has been carried out in five companies in different manufacturing sectors such as automotive, electronics, food, plastics and leather to identify the importance of reverse logistics implementation factors and to know how best the firms are aware about those issues. The case study used quantitative data to investigate few aspects related to external

(legislation, customer demand and incentive) and internal factors (Strategic cost benefit, environmental concern, resource, integration and coordination, volume and quality) of reverse logistics implementation. The case data were gathered mainly through interviews and authors on-site observations. Data collection took place during September – October 2011. Interviews were semi-structured and conducted at the respective companies'. We had a questionnaire with two parts. Part A consists of questions related to influence of external and internal factors with respect to successful implementation of reverse logistics. We requested the respondent to give their importance of factors for a pairwise comparison using Saaty's 9 point scale (Saaty, 1980). Part B had questions related to profile of respondent and the organization. Additional questions were asked by phone, email and follow-up interview was conducted with their respondents.

Respondent characteristics and organizational characteristics are shown in Table 2.

Table 2: Case companies profile

Organization sector	Respondent and company profile						
	Position in organisation	Years of Experience in Reverse logistics & Return management	Age	Type of organisation	No. of staff in logistics & SCM	No. of staff in in Reverse logistics & Return management	Type of certification
Automotive company ABC	Senior manager	4-7	30-40	Joint venture	11-15	11-15	ISO 1400/1/2
Electronics company DEF	Senior manager	4-7	41-50	Private	11-15	11-15	ISO 9000/01/02
Food packaging company GHI	Head of Unit	0-3	30-40	Joint venture	> 21	> 21	ISO 9000/01/02
Plastics company JKL	Assistant manager	0-3	20-29	Joint venture	1-5	1-5	ISO 9000/01/02
Footwear company MNO	Director	4-7	20-29	MNC	6-10	6-10	ISO 9000/01/02

4.1 Case companies' profile

Automotive Company ABC: The Company is a leading manufacturer of tools sets, tools kit, spark plug wrench, oil filter wrench, ratchet wrench and other accessories for automotive sector and located at Zhe Jiang Province. The company started its business operation in 2003. It is a joint venture wholly locally owned with nearly 40 years' of manufacturing experience. The company currently has about 15 dedicated supply chain management and reverse logistics management employees and annual revenue of USD 5,000,001. The company is an ISO 14001/2 standard.

Electronics Company DEF: The Company is a leading manufacturer and exporter of various lighting sensor electronic in Ningbo, in Zhejiang Province, China. The products include: PIR sensor switch, M/W sensor switch, wireless remote control door bell, smoke alarm and multifunctional wireless home security alarm systems, amongst others. The company currently has about 15 dedicated supply chain management and reverse logistics management employees. The company has over 20 years' experience as an exporter of specialized sensor electronic systems. It currently employs over 300 lighting specialists. The company is an ISO 9000/01/02 standard and products are manufactured under quality standard of Most products have CE, GS, UL, BSI, VDS, approval.

Food packaging Company GHI: The Company is a leading manufacturer food and drug packaging products in Ningbo, in Zhejiang Province, China. The company specializes in food packaging pouch, medical disposable co-extrusion film, vacuum seal storage bag, films, amongst others. The company has international first-class co-extrusion film blowing production lines in a 1,900-square-meter workshop that meets the GMP standard. It is a joint venture company with more than 10 years of international business experience. The company currently has more than 21 dedicated supply chain management and reverse logistics management employees with about 3 years of experience in logistics, SCM and return management. The company is an ISO 9000/01/02 standard.

Plastic Company JKL: The Company is established in 1997 and it specializes in designing and manufacturing molds for companies local and international clients and it is located Ninghai in Zhejiang Province, China. The company has a total staff strength of 128 of which 8 are senior engineers, 16 - designers, 37 - molding technicians and 65 high-skilled molding workers. This joint venture company currently has about 5 dedicated supply chain management and reverse logistics management employees. The company is an ISO 9000/01/02 standard and moldings are manufactured to high quality English, American, HASCO, and D-M-E standards.

Footwear Company MNO: The Company specializes in the manufacturing and exporter of various beach slippers, flip flops, indoor slippers, children slippers, amongst others in Ningbo, in Zhejiang Province, China. The company is an ISO 9000/01/02 standard and about 60% of its products are exported mainly to Europe and USA. It has a total annual sales volume of US\$10 – 50 million. The company is a MNC and currently has about 10 dedicated supply chain management and reverse logistics management employees with between 4-7 years of experience in logistics and SCM.

4.2 AHP methodology

The Analytic Hierarchy Process (AHP) proposed by Saaty (1980) is very popular and has been applied in wide variety of areas including prioritizing criteria, planning, selecting a best alternative, resource allocation and resolving conflicts. The application of AHP to a decision problem involves four steps (Zahedi, 1986; Ramanathan 2006).

STEP 1: Structuring of the Decision Problem into a Hierarchical Model

It includes decomposition of the decision problem into elements according to their common characteristics and the formation of a hierarchical model having different levels. Our AHP model (Figure 1) has three levels (goal, criteria and sub criteria) though more complex models with more levels could be formulated.

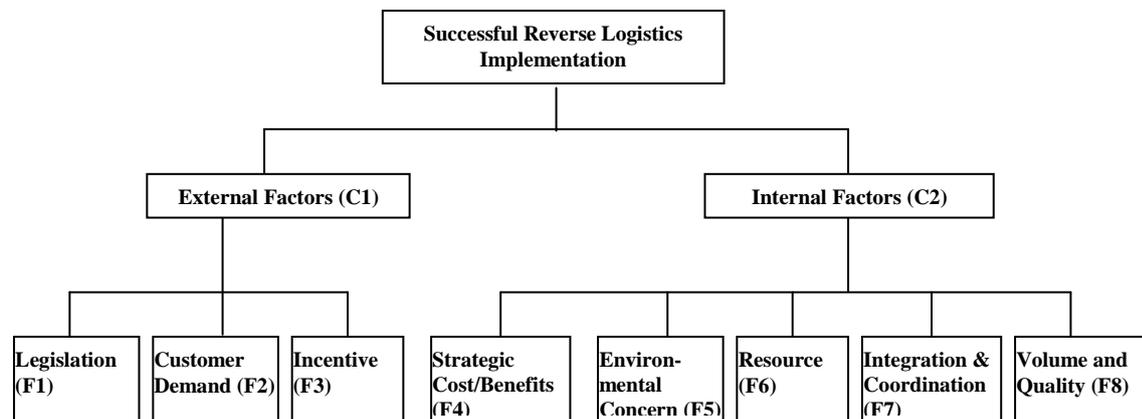


Figure 1: AHP model for successful reverse logistics implementation

STEP 2: Making Pair-wise Comparisons and Obtaining the Judgmental Matrix

In this step, the elements of a particular level are compared with respect to a specific element in the immediate upper level. The resulting weights of the elements may be called the local weights (to be contrasted with final weights, defined later).

The opinion of a decision-maker (DM) is elicited for comparing the elements. Elements are compared pair-wise and judgments on comparative attractiveness of elements are captured using a rating scale (1-9 scale in traditional AHP). Usually, an element receiving higher rating is viewed as superior (or more attractive) compared to another one that receives a lower rating. Each entry a_{ij} of the judgmental matrix are governed by the three rules: $a_{ij} > 0$; $a_{ij} = 1/a_{ji}$; and $a_{ii} = 1$ for all i . If the transitivity property holds, i.e., the $a_{ij} = a_{ik} * a_{kj}$, for all the entries of the matrix, then the matrix is said to be consistent. If the property does not hold for all the entries, the level of inconsistency can be captured by a measure called Consistency Ratio (Saaty, 1980). A value of CR less than 0.1 is considered acceptable because human judgments need not be always consistent, and there may be inconsistencies introduced because of the nature of scale used.

STEP 3: Local weights and Consistency of Comparisons

In this step, local weights of the elements are calculated using the eigenvector method (EVM). The normalised eigenvector corresponding to the principal eigenvalue of the judgmental matrix provides the weights of the corresponding elements. Though EVM is followed widely in traditional AHP computations When EVM is used, Consistency Ratio (CR) can be computed. For a consistent matrix $CR = 0$, and if CR for a matrix is more than 0.1, then judgments should be elicited once again from the decision-maker till he gives more consistent judgments.

STEP 4: Aggregation of Weights across Various Levels to obtain the final weights of alternatives

Once the local weights of elements of different levels are obtained as outlined in Step 3, they are aggregated to obtain final weights of the decision alternatives (elements at the lowest level). For example, the final weight of alternative F_1 is computed using the following hierarchical (arithmetic) aggregation rule.

$$\text{Final Weight of } F_1 = \sum_j \left[\left(\begin{array}{c} \text{Weight of } F_1 \text{ with} \\ \text{respect to Criterion } C_j \end{array} \right) \times \left(\begin{array}{c} \text{Importance of} \\ \text{Criterion } C_j \end{array} \right) \right]$$

By definition, the weights of alternatives and importances of criteria are normalized so that they sum to unity.

5.0 Results and Discussion

The final weight obtained by AHP method for the five companies selected for our study is shown in Table 3. Invariably all the companies feel that reverse logistics implementation will be successful only due to external factors. Among the external factors legislation tops the list. They believe if there is a strong regulation and monitoring from Chinese government then reverse logistics would be successful in all industries in manufacturing sector. They also believe that informal recycling could be curbed if there is a strict monitoring mechanism in place. Companies also agree both domestic and foreign customers are demanding for green products. Chinese companies are ready to adapt this as a business strategy to increase its profit. All the companies give due importance to incentive which they accept it as a vital tool to encourage customers to return end-of-life products. Among the external factors except Footwear Company all others consider incentive as an influencing factor than customer demand. When compared with external factors internal factors are not too significant to companies. Among the internal factors companies are more concerned with strategic cost/benefits. They are eager to invest in reverse logistics if they are able to gain substantially. Due to extensive awareness about environment they are also paying attention to it. They give weightage to environmental concern next to strategic cost and benefit. Since all the companies studied are not fully into reverse logistics they didn't really value the other factors such as resource, integration and coordination and volume and quality. Hence all the factors are relatively weighed very less compared to others.

Table 3: Final weight of reverse logistics implementation factors

Factor	Final weight				
	Automotive company ABC	Electronics company DEF	Food packaging company GHI	Plastics company JKL	Foot wear company MNO
Legislation	0.59	0.62	0.60	0.50	0.50
Customer Demand	0.12	0.11	0.12	0.17	0.14
Incentive	0.16	0.15	0.12	0.17	0.09
Strategic Cost/Benefits	0.07	0.08	0.07	0.07	0.08
Environmental Concern	0.03	0.02	0.03	0.03	0.08
Resource	0.01	0.02	0.02	0.03	0.04
Integration & Coordination	0.01	0.01	0.02	0.02	0.03
Volume and Quality	0.00	0.00	0.03	0.02	0.03

6.0 Conclusion

We attempted to prioritise factors which govern end-of-life product reverse logistics implementation among five Chinese manufacturing companies. Based on literature we grouped reverse logistics implementation factors into external and internal. We also identified the influencing factors in Chinese companies which motivates them to implement reverse logistics. Our study considered few industries such as plastics and footwear industry which has not been taken into account. We used AHP method to prioritise the external and internal factors. Interesting finding from our study is that all companies agree external factors are important and they feel strong legislation is important for successful reverse logistics implementation. Majority of them accept incentive factor is most important than customer demand factor for reverse logistics to take place. We didn't see due importance to internal factors since reverse logistics implementation is at an infancy stage in Chinese companies. In future the above study could be extended to analyse the inter relationship among the factors considered and to generalise the findings through empirical analysis. This study considers manufacturing sector since it is a major sector in China. In future possibility is there to study other sectors.

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