Regulatory policy awareness and environmental supply chain cooperation in China: A regulatory exchange theoretic perspective[1]

Key words: environmental awareness; environmental supply chain cooperation; exchange theory; information acquisition; manufacturers; China

Abstract: Some developed countries have enacted extended producer responsibility regulations that facilitate the diffusion of environmental supply chain cooperation (ESCC) practices amongst manufacturers. Developing countries, such as China, have adopted similar, but generally flexible and voluntary regulations and policies. Using exchange theory with a focus on regulatory aspects as the theoretical lens, this paper develops propositions to examine if awareness of voluntary environmental regulatory policies is different among manufacturers as well as the relationship to ESCC practices adoption. Results from cluster analysis and multivariate analysis of variance (MANOVA) for 308 responses identify three categories of Chinese manufacturers with respect to their awareness of environmental regulatory policies. These three categories include savvy, attentive, and nescient manufacturers. It was found that manufacturers characterized with higher environmental regulatory awareness tend to implement ESCC practices more intensively. Hierarchical regression analysis was further used to examine the relationship between awareness of regulatory policies and ESCC practices. Awareness of domestic regulatory policies has positive effects on green purchasing only for savvy manufacturers. Regression results show a non-linear relationship between awareness of domestic regulatory policies and customer cooperation with environmental concerns, from slightly positive for nescient manufacturers,

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slightly negative for attentive manufacturers, to significantly positive for savvy manufacturers.

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1. Introduction

Policy makers have long recognized the need for regulatory policy as an effective tool for greening business [1]. Originally, regulations and policies mainly required manufacturers to make internal organizational environmental improvements. In the past decade, policy makers have realized the value of extended producer responsibility regulations for profound ecological improvements in operations [2]. This trend is observed in developed countries enacting regulations such as the Restriction of Hazardous Substances (RoHS) that need manufacturers to control all suppliers through their supply chains to avoid use of six hazardous substances. Additionally, Waste Electrical and Electronic Equipment (WEEE) directives mandate the extension of environmental management efforts by manufacturers to include their consumers for treatment of end-of-life products. Energy savings have been also extended to supply chain management, either through control of a key energy-intensive supplier [3] or through eco-design for energy-efficient products [4].

In response to these regulatory policies, environmentally friendly organizations and their supply chains have started to globally diffuse their green practices [5]. Manufacturers have implemented environmental supply chain cooperation (ESCC) to extend their environmental management efforts across organizational and geopolitical boundaries [6-8]. With the increasing capability and willingness of more manufacturers to foresee and correct specific chronic/repetitive environmental problems, regulations continue to evolve. Given that leading manufacturers tend to develop alternative materials with fewer environmental burdens due to regulatory policy, they need awareness of regulations such as RoHS which may become stricter resulting greater restrictions on the use of certain materials. WEEE regulations also evolve to mandate monitoring for operations and production capabilities of a larger set of products governed by these regulations. Regulations related to energy savings also require continuous vigilance with the evolution of regulatory requirements. As an example, some of

these efforts on energy saving may be linked to evolving and emerging greenhouse gas and carbon markets and taxing regulatory developments.

Developing countries are at relatively early stages of environmental regulatory policy implementation. Although, developing countries have introduced advanced environmental regulations and policies such as China's RoHS and WEEE [9]. However, most of these regulations are generally voluntary and flexible [10]. Due to poor information diffusion from government to industry, such voluntary regulatory policies may not be known to manufacturers with lower knowledge acquisition abilities [11]. As a result, environmental regulations fail to motivate ESCC practices among manufacturers [12]. Even leading manufacturers may be unaware of some regulatory policies, especially voluntary measures where fines and liabilities are not elements of the enforcement structure. Manufacturers may also be unaware of international regulatory policies that require environmental management adjustments by their supply chain partners and that permeate their supply chain governance. China represents a typical but large manufacturing-based economy. Lack of ESCC practices among Chinese manufacturers not only cause international trade barriers for Chinese manufacturers [13], but also makes it difficult for leading foreign multinational corporations to manage their Chinese suppliers [14].

Manufacturers in developing countries such as China have encountered many of these awareness issues for voluntary environmental regulations, which can be a reason explaining their limited implementation of ESCC practices [15]. Unlike manufacturers in developed countries where "ignorance of the law is no excuse", it is not uncommon for many Chinese manufacturer to use such ignorance argumentation to defend violations. These voluntary regulations can become required, coercive, as their development and diffusion evolve. Thus, lagging manufacturers can encounter trade barriers in the form of environmental regulatory compliance which have been experienced by their counterparts exporting products to

developed countries [13]. This scenario leads to two timely and important research questions. Is there an awareness heterogeneity (difference) in environmental regulations and policies among Chinese manufacturers? If these differences do exist, does this awareness heterogeneity relate to their implementation of ESCC practices? Answers to these questions can be helpful for Chinese policy makers to develop effective ways for information dissemination, communication, or training to promote ESCC even with voluntary regulations and policies. It is also helpful for Chinese manufacturers to seek operational benefits as early adopters of innovative ESCC practices. In addition, this study can provide practical implications for companies on how to better manage Chinese manufacturers in their global supply chains.

There is a lack of insight and investigation into the awareness and information dissemination issues of regulations and policies in general and specifically among Chinese manufacturers. The influence of these regulations on organizational operations and operations strategies has also not seen systematic investigation. One particularly important theoretical lens to investigate this relationship is exchange theory. This theory is used to examine the effect of regulations on industrial practices [16, 17]. Using this theoretical underpinning with a focus on regulatory aspects of exchange theory, this study contributes to the body of knowledge by investigating a research framework with two propositions examining the link between awareness of environmental regulatory policies and ESCC practices implementation among Chinese manufacturers.

2. Theoretical background

2.1 Exchange theory and research framework

Exchange theory [18] helps us to further understand the framing of issues related to awareness of environmental regulations and policies. Exchange theory posits that different

organizations can effectively improve various corporate responsibility practices through various forms of non-economic exchange, especially information and communication [19]. One dimension of exchange theory is regulatory exchange which focuses on the relationship between government and industry [16, 17]. Regulatory exchange refers to communication and information exchange based on regulations, as developed by government for industry. The most fundamental aspect of effective regulatory exchange is that industry needs to be aware of governmental regulations and policies.

According to exchange theory, part of governments' role is to develop regulations and policies and raise awareness for proactive practices in the industry [20, 21]. Some regulatory policies facing industry are mandatory, 'command-and-control', which will require changes in operational strategy and practices. For example, recent regulations in the U.S. that influence supply chain operations and information management are the Dodd-Frank act and conflict minerals that require organizations to trace the origin of four specific regulated minerals in their supply chains [22].

In this study, the regulatory communication concerns voluntary regulations. These voluntary and flexible regulatory initiatives are meant to help and guide organizations address environmental concerns in their own and supply chain activities [23]. Thus, the exchange is with information and communication, and sometimes incentives, from governmental agencies and regulators. In return, the return exchange, for the public good, is for manufacturers to improve their and their supply chain's environmental performance by building capacities and capabilities such as ESCC practices.

Overall, greening and environmental sustainability is one area where theoretical developments related to environmental regulations are critical for advancing operations and sustainability research [24]. Globally, supply chain and operational practices have also been influenced through environmental regulatory practices, which can operationally benefit or

disadvantage organizations. To promote energy saving and pollution reduction, central as well as regional and local Chinese governments have introduced regulations and policies over the past decade, but most of them are generally flexible and voluntary providing subsidies to incentivize manufacturers to implement innovative environmental management practices such as ESCC [15, 25]. Regulatory policies in other international locales such as the European Union's WEEE and RoHS have caused China and Chinese manufacturing enterprises to work with their suppliers and customers to address environmental issues [26, 27]. Although not mandatory in China, these regulatory policies need to be met for the license to operate and do commerce in the EU. However, whether non-exporting Chinese manufacturers notice and respond to these international regulations is unknown. Overall, this lack of awareness of environmental regulations and implications to operations practices adoption also requires investigation.

Typically, governmental and community awareness raising efforts from policy makers' perspectives are more important for voluntary regulatory measures where coercive fines and penalties are not aspects of the regulations. Increasing awareness of voluntary regulations can result in greater corporate social responsibility practices adoption, especially environmentally-oriented dimensions. Governments and communities should seek to promote regulatory awareness with the understanding that further knowledge and awareness of regulatory policies will lead to greater adoption of environmental management practices among manufacturers [28-31]. Using exchange theory with a focus on regulatory aspects that identifies a role for communications and awareness of regulations, especially voluntary regulations, a research framework to examine the two research questions is introduced. The first step is to identify whether different manufacturer clusters exist in terms of voluntary environmental regulations and policy awareness. The second step will determine whether varying environmental regulatory awareness levels are associated with ESCC practices

implementation level.

2.2 Awareness of environmental regulations and policies

Regulatory exchange can be effective if information dissemination of regulatory policies is efficient, especially for voluntary regulations. The awareness level of regulatory policies among manufacturers can be a measure for information dissemination efficiency. That is, when there are equal awareness levels across organizations, or awareness level is homogeneous across organizations and industries, then information dissemination efficiencies are assumed to exist.

As previously stated, both direct voluntary and indirect mandatory international regulatory policies can affect ESCC related operational practices adoption amongst Chinese manufacturers [15]. We group non-voluntary international regulations alongside voluntary domestic regulations as these international regulations are not mandatory for organizations operating in China, but can influence them if they should decide to do business in global regions covered by these regulations. Thus, international regulations do not have the direct coercive characteristics of mandatory (non-voluntary) domestic regulations, especially for companies or industries that are not part of an international supply chain. Awareness of these regulations and responses to them through ESCC related operational practices implementation is important from domestic and global perspectives. An interesting implication is that awareness of voluntary or indirect voluntary policy mechanisms could result in improved environmental performance along supply chains and with manufacturers. Whether awareness results in and is related to greater adoption of ESCC practices can imply a need for more voluntary measures. Alternatively, a lack of relationships may mean that fewer voluntary and more mandatory measures are needed to motivate or make manufacturers and their supply chains become less environmentally burdensome.

There are factors and situations that work against regulatory information dissemination efficiencies [32]. Part of these inefficiencies may be due to the lack of policy maker knowledge on why some industries or organizations are motivated to acquire related information, while other industries and organizations may not proactively seek such information [33]. Thus, a standard, one-size-fits-all level of information dissemination by policy makers may cause varying, inefficient, information awareness levels.

Manufactures with different organizational capabilities may also result in this regulatory awareness heterogeneity. Awareness and knowledge acquisition are closely related and are fundamental for companies to understand, implement, and meet regulations [21]. Varying knowledge acquisition capabilities will result in differing organizational awareness of environmental regulatory policies and can be influenced by manufacturer organizational types and characteristics. Previous studies show that organizational size and visibility play a significant role in knowledge acquisition and awareness. Larger manufacturers in the US were found to more likely participate in voluntary pollution abatement programs [34]. Larger manufacturers subject to greater public scrutiny are generally the main targets for governmental intervention [35]. As a result, these manufacturers may allocate more resources for information collection and thus pay more attention to environmental regulations and policies, even flexible or voluntary policies due to this scrutiny. The amount of regulatory exchange is expected to be greater with these more visible and larger organizations.

These situations above and characteristics lead us to raise the first proposition:

Proposition 1: Given that inefficient regulatory exchange and different knowledge acquisition abilities are present, Chinese manufacturers may be clustered into various groups based on their environmental regulations awareness levels.

2.3 Awareness of environmental regulatory policies and ESCC practices

Exchange theory states that government and industry can work together through regulatory policies to aid and encourage organizations in adopting responsible practices. Governmental regulations and policies are important mechanisms to promote ESCC practices [36], where these can be exemplary valuable organizational resources for performance gains and building competitive strength [37]. Thus, manufacturers whose awareness levels of voluntary regulatory policies are higher tend to adopt more innovative strategies and undertake proactive actions [38-40]

One theoretical finding about the 'ineffectiveness' of voluntary regulatory programs actually provides us with insight on why differences may or may not exist in adoption of environmental management practices. It has been argued that efficient information dissemination of voluntary environmental regulations will cause homogeneous (less heterogeneous) adoption of proactive environmental management practices across manufacturers [41]. If awareness level is the same across industries and companies, there will be efficient regulatory exchange and information dissemination of voluntary regulatory practices. In this situation, there should be no difference between those who are involved in voluntary regulatory programs and those who are not (e.g. the 33/50 program in the United States).

The corollary of this conjecture is inefficient information dissemination, through poor regulatory exchange, of these voluntary programs will result in variations of awareness and thus heterogeneous adoption practices. Without high awareness of voluntary regulatory policies, even leading manufacturers may delay implementation of proactive environmental management practices such as ESCC [42]. Smaller manufacturers are generally more reluctant in responding to flexible regulatory policies [43], but manufacturers with stronger environmental commitment are more proactive in implementing environmental management

practices [44]. In addition, manufacturers encountering greater pressures from government agencies are normally characterized by higher awareness of voluntary regulatory policies, and thus are more likely to adopt voluntary environmental practices and measures [45].

Manufacturers varying in awareness of related policies can differ in strategies and decision processes for environmental innovation. In some cases, these manufacturers may withdraw from affected markets or postpone investment decisions due to uncertainties especially with respect to regulatory requirements [46]. The lack of awareness of environmental regulatory policies can cause doubts for Chinese manufacturers delaying investment in environmental innovations. Their increased awareness of environmental regulatory policies allow them to determine more accurately whether ESCC practices are worthy of investment. Examination of the second research proposition below will provide insights on the extent to which lower environmental regulatory awareness impedes corporate environmental innovation to greening in Chinese manufacturing.

Based on the above discussions, we posit the second proposition.

Proposition 2: Heterogeneity of environmental regulatory awareness among Chinese manufacturers is positively associated with their variations in ESCC implementation. Specifically, Chinese manufacturers with higher environmental regulatory awareness implement ESCC more intensively.

3 Methodology

3.1 Items development and samples

3.1.1 Items development

Measurement items for evaluating environmental awareness include both domestic and international environmental regulations and policies (see details in Table 1). Chinese

regulations and policies were reviewed and those that related to ESCC are included. For international regulations and policies, we include two items on pollution control that are closely related to ESCC, they are, regulations on waste control such as WEEE from the downstream supply chain side and restriction for use of hazardous substances from the upstream supply chain side. Additionally, carbon emissions control is a major global environmental concern. Thus, a measurement item concerning knowledge of the Kyoto Protocol is also included. These measurement items were identified and evaluated by two academic experts within the environmental policy domain. To avoid missing any major regulations and policies, these items were further reviewed by four government officials, including two from the Shenyang Municipal Development and Reform Commission who are responsible for implementation and monitoring of circular economy and energy savings regulatory policies, and two from the Shenyang Environmental Protection Bureau who are responsible for pollution control regulatory policy.

In targeting a variety of industries, we include Chinese voluntary regulations and policies related to energy savings and pollution reduction that are applicable to many industries. These measures are listed as eight items for evaluating the domestic dimension. Economic globalization and international environmental regulations and policies have greatly influenced Chinese manufacturing practice. Thus, we include three items for measuring awareness of international regulations and policies. The first item (Kyoto) is a general one which affects manufacturers in a variety of industries, where the clean development mechanism element of the Kyoto protocol can be for developing country improvements, even within organizational supply chains, on greenhouse gas emissions. Developed countries have enacted specific regulations related to ESCC in different industries that can influence Chinese manufacturers, where WEEE and RoHS regulations are examples. These two directives are related to ESCC in the electronic & electrical and other industries, which can influence many

industries that belong to various industrial supply chains. Thus, we include two broad international regulations/policies influencing customer and supplier considerations, i.e., WEEE and RoHS. These items request responses on a five-point scale, that is, 1= never heard of it; 5= know it well with initiation related practices due to the regulation.

ESCC practices include cooperation with suppliers and customers. Thus, two ESCC factors, green purchasing (GP) and customer cooperation with environmental concerns (CC) are considered in this context. The measurement items for the two ESCC practices factors are based on previous studies investigating Chinese manufacturers (see details in Table 3) [1, 15, 47] and from suggestions by 12 senior managers who provided feedback during a pilot study of the questionnaire. These sixteen items used a five-point scale, from 1=not considering it; to 5=implementing successfully.

The pilot test for the survey questionnaire completed with 12 senior managers was also used to determine if any key items were missed and if the items were clear. No serious issues for the questionnaire were found as a result of the pilot test, only minor word refinements were undertaken to improve content validity of the questionnaire items.

3.1.2 Samples and non-response bias test

A major heavily industrialized city within China, Shenyang, was the chosen location for administering the survey instrument. Surveys were completed in two main industrial zones in Shenyang[2], namely the Shenyang Economic & Technological Development Zone (SETDZ) and the Shenyang Hi-tech Industrial Development Zone (SHTIDZ). The local environmental protection bureau provided a support letter together with contact information for conducting

[2] Shenyang is one of the largest industrial cities in China. In China, two main industrial zones have been supported to promote industrial development including Economic & Technological Development Zones (ETDZ) and Hi-tech Industrial Development Zones (HTIDZ). Shenyang represents a prototypical microcosm of industrial development throughout China represented by these two industrial zones. The State Council of China approved the first round of 14 national ETDZs in 12 coastal cities between 1984 and 1988, with one of these in Shenyang. The State Council of China approved the first national HTIDZ in 1988, and it approved two rounds of 26 HTIDZs between 1991 and 1992, respectively. The Shenyang HTIDZ was established in May 1988, and was formally approved by the State Council in 1991. Thus, Shenyang is a good representation of Chinese industrial development and variety, representing some of the most mature commercial industrial zones in China.

the survey. We randomly distributed 500 surveys in the two industrial districts in Shenyang. A total of 376 surveys were returned with 308 of these returned survey questionnaires considered complete and valid. Distribution of samples in terms of industries, ownership and size is shown in Table 1.

<Insert Table 1 about here>

Non-response bias can be a threat to the representativeness of our study samples. To test potential non-response bias, we compared responses from early respondents to those responded in the later stage. Initially, the survey instrument was administered through emails or postal mail. The target respondents were asked to return the questionnaires within two weeks. These early respondents represented 208 usable questionnaires. All non-respondents were then followed-up with telephone calls and encouraged to complete their questionnaires. These late respondents represented an additional 100 usable questionnaires. T-tests were used to compare the mean values of all items and factors between the early and late respondents. No significant differences were found at the $p > 0.05$ significance level. The results provide us with confidence that non-response bias is not a concern in this study [48].

Common method bias can be another issue. Following seven suggestions by a previous study [49], we took several procedural remedies during the items development and questionnaire delivery process. In addition, we completed a statistical evaluation using Harman's one factor test through confirmatory factor analysis for a post-hoc statistical analysis. No serious issues were identified.

3.2 Statistical Analysis

To examine the two propositions, four phases are completed for the statistical analysis. Details are shown in Figure 1.

<Insert Figure 1 about here>

The first phase is to identify both awareness of regulations/policies and ESCC practices factors. Two factors for awareness of regulations/policies were explored in our previous study [15] while two ESCC factors were developed and confirmed by several previous studies [1, 50]. Thus, confirmatory factor analysis rather than exploratory factor analysis is used to examine the theoretical dimensions of the study constructs. The fit statistics for the two awareness factors are χ^2(df)=489.03(43), p=0.000; CFI=0.93; NFI=0.92; IFI=0.93; RMR=0.08. Standardized factor loadings for awareness of domestic regulations/policies are between 0.65 and 0.88 while those for awareness for international regulations/policies are between 0.78 and 0.95. The fit statistics for the two practice factors are χ^2(df)=944.83(103), p=0.000; CFI=0.90; NFI=0.89; IFI=0.90; RMR=0.06. Standardized factor loadings for green purchasing are between 0.78 and 0.88 while those for customer cooperation with environmental concerns are between 0.78 and 0.90. These results show that these factors have valid and reliable measure properties.

The second phase is to identify clusters. To determine if there are different Chinese manufacturer clusters in awareness of environmental regulations/policies, a cluster analysis is performed using both hierarchical and non-hierarchical methods [51]. The hierarchical analysis using Ward's method is first applied to determine the number of clusters. Specifically, the agglomeration coefficients which reveal the squared Euclidean distance between two combined clusters are examined in the process of deriving the clusters. Results from the hierarchical procedure show that the agglomeration coefficients significantly increase for

both one and two-cluster solutions while the coefficient increase is less for a three-cluster solution. Thus, it can be concluded that three clusters exist.

The third phase is to compare differences amongst the clusters. After the hierarchical analysis, a K-mean cluster analysis (a non-hierarchical clustering technique) of the two factors was performed. Similar to a previous study [19], analysis of variance (ANOVA) was used to examine if the clustered manufacturers vary in their awareness of environmental regulations/policies (see Table 2) and ESCC practices (see Table 3). Multivariate analysis of variance (MANOVA) was further employed to examine collective comparisons of the two factors. Moreover, a post-hoc analysis was used to evaluate if pairwise differences exist between each set of two clusters. The results are shown in Table 4.

<Insert Tables 2, 3 and 4 about here>

The fourth phase is to examine relationships between awareness of environmental regulations and ESCC practices implementation for each of the separate manufacturer clusters. To conduct this step, hierarchical regression analysis is performed. Previous research has shown that firm size and ownership characteristics may influence these relationships [52]. Thus, these two control variables are included in the initial hierarchical regression stage. Firm size is operationalized as the log of employees. Ownership is represented by a 0-1 dummy variable, where a value of 1 represents a state-owned manufacturer while a value of 0 is for others. For the second stage, two awareness factors are added to the regression analysis. Since two awareness factors are formative rather than reflective, scores (weighted values from exploratory factor analysis) rather than mean values are used. Results are shown in Table 5.

<Insert Table 5 about here>

4 Results

4.1 Results for the manufacturer cluster analysis

The statistical analyses were used for manufacturer clustering in three clusters. The summary of these results (Table 2) – show three manufacturer clusters with 43 companies in cluster 1, 109 companies in cluster 2, and 156 companies in cluster 3. Significant differences in their environmental awareness are observed (see Table 2). Proposition 1 is strongly supported since three manufacturer clusters varying in their environmental regulatory policy awareness were observed. Results of a post-hoc analysis using the Scheffé tests as summarized in Table 4 show that all six possible combinations for the two awareness factors across the three clusters are significantly different ($p< 0.05$), which provide further support for Proposition 1.

Manufacturers in cluster 1 are knowledgeable of both domestic and international regulations/policies with mean values of 3.86 and 3.73, respectively. Manufacturers in cluster 2 are aware of, but have weak awareness of how environmental regulatory policies are related to their organizations, with a mean value of 2.77 for awareness of domestic regulations/policies and a mean value of 2.14 for awareness of international regulations/policies, respectively. Manufacturers in cluster 3 are relatively unaware of environmental regulations/policies, with a mean value of 1.65 for awareness of domestic regulations/policies and a mean value of 1.33 for awareness of international regulations/policies, respectively.

These three Chinese manufacturer clusters are labeled according to their awareness of environmental regulations and policies. Manufacturers in cluster 1 are quite aware of both domestic and international environmental regulations and policies, and thus are labeled savvy manufacturers. Manufacturers in Cluster 2 have mean values between 2.00 and 3.00 for all

awareness factors, which indicate that they generally know environmental regulations and policies but are unclear about relationships to themselves. Thus, we label them as attentive manufacturers, with slight awareness. Manufacturers in cluster 3 are generally unaware of environmental regulations and policies and are labeled nescient manufacturers.

Manufacturer organizational characteristics in each of the three manufacturer clusters can be made. In terms of organizational size, based on number of employees, savvy manufacturers are primarily larger with the average size of 1403 employees, while attentive and nescient manufacturers in clusters 2 and 3 are significantly smaller with average sizes of 391 and 156 employees, respectively. In terms of ownership, 31 of 43 manufacturers in Cluster 1 reported ownership information. There are sixteen foreign manufacturers, while there are six and nine state-owned and domestic private manufacturers, respectively. In Cluster 2, 74 manufacturers reported ownership. There are 32 foreign manufacturers, 27 domestic private manufacturers, and 15 state-owned manufacturers represented in Cluster 2. For Cluster 3, the majority of manufacturers (39) from the 74 that reported ownership are domestically private ones. The rest of the 35 manufacturers include 19 state owned, and 16 for foreign manufacturers. The organizational characteristics set the stage for a number of implications, including having resources to be able to raise awareness to the targeting larger organizations by environmental regulatory agencies. Some of these issues will be discussed later as well.

4.2 Results of regulatory awareness effect on ESCC practices

Table 3 shows that significant differences exist for ESCC practices across the three manufacturer clusters. Savvy manufacturers in cluster 1 have relatively greater adoption of both green purchasing (GP) and customer collaboration on environmental issues (CC) with mean values of 3.15 and 3.25, respectively. Attentive manufacturers in cluster 2 have

considered these ESCC practices to a lesser extent, with mean values of 2.89 for GP and 2.77 for CC, respectively. Nescient manufacturers in cluster 3 are the least likely manufacturer type to consider and adopt GP and CC with scores below 2.00. The results point to lessened efforts on implementing ESCC practices particularly when the awareness of the manufacturer clusters on related regulations and policies is low, and thus Proposition 2 is supported. Table 4 shows that 5 out of 6 possible combinations for the two ESCC factors across the three clusters are significantly different ($p<0.05$), providing additional support for Proposition 2.

Table 5 shows that, overall, both factors for awareness of domestic and international regulations/policies have significant relationships with two ESCC practices. These results show some consistency with the first cluster, savvy manufacturer, results. Table 5 shows that for the first cluster of savvy manufacturers, awareness of domestic regulations/policies has a significant positive relationship to the two ESCC practices while awareness of environmental international regulations/policies only has an effect on green purchasing. For the second cluster of attentive manufacturers, awareness of international regulations/policies shows no significant relationship to GP while awareness of domestic regulations/policies has a slightly negative relationship to CC. For the third cluster of nescient manufacturers, only awareness of domestic regulations/policies has a slightly positive relationship to CC. The strength of the relationships weakens as the results go from Cluster 1, to 2 to 3. This result occurs even after controlling for size, ownership, and industry sector.

From each cluster and the control variable analysis, firm size and ownership are not significantly related. This result is evident because the clusters are more homogeneous, based on the initial cluster analysis, with respect to size and ownership. A broader regression analysis with all the clusters included in one overall data set conforms to previous studies that show firm size and industry are significantly related to practices adoption.

5 Discussion

5.1 Manufacturer clusters

Chinese manufacturers in our study are clustered by their variations in awareness of environmental regulations. This empirical taxonomy is used to examine differences in awareness of environmental regulations as well as ESCC practices adoption among three clusters of Chinese manufacturers.

Savvy manufacturers are generally more aware of environmental regulations and policies compared to manufacturers in the other two manufacturer clusters. Even for savvy manufacturers, their environmental regulatory awareness levels are not high. Such lack of regulatory awareness can be one result of inefficient regulatory exchange between regulators and manufacturers. Differing levels of awareness among manufacturers are related to various organizational characteristics. Understanding a couple of these important characteristics will be beneficial to policy makers, but also to managers for organizational operations.

To improve awareness of regulations, especially for voluntary and flexible regulatory policy instruments, organizations will need to invest resources in information search. Distribution of organizational characteristics of the respondent manufacturers shows that savvy manufacturers are larger in organizational size. Foreign manufacturers are the largest group within this cluster, with 16 out of 31 manufacturers having this reported ownership, followed by domestic private manufacturers. Larger organizations have higher regulatory awareness and also implement ESCC practices more intensively. Larger organizations typically have additional capabilities and resources, allowing them to acquire knowledge and information [53]. Foreign manufacturers have higher awareness of environmental regulations/policies, which may result from their experiences with related regulations in their home countries. A longer history with their domestic regulations and awareness of dynamic

and flexible regulations in their developed country situations may cause them to seek out or anticipate voluntary policies. Also, since they are foreign companies, being cognizant of all types of regulatory policies will help them overcome some liability of foreignness [54, 55].

Alternatively, governments may need to adjust their information dissemination efforts taking into consideration heterogeneous organizational and industry characteristics. Sometimes the amount of information search required is well beyond the economic or resource capabilities of organizations. This marginal economic (cost) threshold on when information search should cease is lower for smaller firms due to lack of resources and expertise. Thus, building awareness for smaller firms will require that the marginal cost of information search is lowered. This marginal cost can be lessened through better government support or supply chain partner support.

These findings are not surprising given the inefficient regulatory information dissemination effort within China for generally voluntary regulations that influence adoption of ESCC practices. But these results do provide support that with greater awareness, higher levels of implementing innovative environmental management programs can occur. There is also support for the proposition that greater awareness boosts the confidence of manufacturers to dedicate resources and commit investment in environmentally sound practices.

Similar to previous studies, smaller manufacturers are lagging in awareness of regulatory policies and form the preponderance of nescient cluster members [56-58]. Evidence of the theoretical principle of “vulnerable compliance” is evident in these results. Vulnerable compliance is a reactive approach to compliance and effective utilization of voluntary measures. Awareness raising may weaken this vulnerable compliance, which is the most evident in smaller manufacturers [57]. Improving governmental-side regulatory exchange through these efforts with smaller firms, whose resources are limited, is necessary in the Chinese context.

Larger manufacturers usually experience greater pressure from governments and allocate more resources to collect information on voluntary regulatory policies, and thus implement ESCC practices more proactively to improve their environmental performance [59]. In addition, larger manufacturers have greater involvement in regulatory policy setting and more effective expertise at their disposal. For many smaller manufacturers, the preponderance of raising awareness may come from external sources, for example, professional organizations, special (usually local) government agencies, and (in Western nations) even insurance and liability agencies. These external sources are not as easily accessible to smaller organizations, resulting in greater information dissemination inefficiencies.

Low awareness of environmental regulations and policies among lagging manufacturers mainly result from limited knowledge acquisition [44]. This conclusion is partly confirmed by our study. The results show savvy manufacturers are larger organizations. Larger organizational size typically means more resources, capabilities, and channels to acquire information and knowledge on voluntary environmental regulations. However, our study also reveals that state-owned manufacturers, with the least number represented in the savvy manufacturer type and the largest number represented in the nescient manufacturer type, tend to have the lowest regulatory awareness and implementation of ESCC practices. Although the expectation is that state-owned manufacturers should be well informed of state developed environmental regulations, they tend to be ignorant of voluntary environmental regulations. It would seem that the government would want to have its own manufacturing firms to be aware of the regulations, and these organizations may be the “low-hanging fruit” for helping to further diffuse ESCC practices.

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5.2 Discussions of regulatory awareness effect on ESCC practices

For savvy manufacturers, awareness of environmental regulatory policies can significantly affect ESCC practices but they still tend to be hesitant in implementing innovative environmental management practices, although not as much as the other two manufacturer clusters. It has been shown that regulations are one of the most important factors motivating organizational implementation of environmental management practices [61]. Environmental regulatory policies such as environmental taxes or subsidies (non-coercive measures) can influence the intention of manufacturers on whether to implement innovative practices [62].

Regulatory policies tend to evolve in the early phases of implementation. Even savvy manufacturers may hesitate to invest in and implement innovative environmental

management practices such as ESCC due to regulatory flexibility [42]. If there are significant and continuously occurring regulatory changes, many organizations may not seek information until there is greater stability in these policies. Greater varieties of regulatory instruments, government bodies (local, national, supranational), and enforcement levels all add to this variance. Governments should establish relatively stable environmental policies, at least in the short term. Governments can also publicize the trend of stricter enforcement of policies, e.g., through targeted and publicly visible enforcement. Even more importantly for stability is to maintain consistency of environmental policies in spite of change in key regulatory administrations. These examples of regulatory uncertainty measures will reduce the hesitation of manufacturers to invest in environmental innovation, and continue to improve regulatory exchange relationships with manufacturing firms.

It is surprising that awareness of domestic environmental regulatory policies has only a slight effect on CC practice adoption for nescient manufacturers, and more interestingly, there is a slightly negative relationship for attentive manufacturers. For savvy manufacturers with the highest awareness level, the relationship is significantly positive. These results indicate that a little regulatory awareness as for the attentive manufacturer cluster can be a bad thing for CC practices adoption. While increasing the regulatory information exchange will likely change the minds of savvy manufacturers to develop stronger relationships with customers.

In this study, most of the environmental regulatory policies and schemes are generally voluntary. The voluntary measures may include some form of subsidy or programmatic aid to manufacturers needing financial resources to pursue environmental initiatives. Manufacturers with a little knowledge about them may consider these policies as not beneficial for them. Savvy manufacturers' greater awareness of the regulations can build up their knowledge and understanding due to greater exchange through such efforts as involvement in demonstration projects, early adoption of recommendations, developing stronger governmental relationships

or lobbying for additional incentives. Thus, these savvy manufacturers may have used these regulations, many of which have incentives built in, to develop customers and supply chain environmental management practices.

It is interesting to note that the regression results between awareness and ESCC practices when all three manufacturer clusters are grouped as one set are generally consistent with the savvy manufacturer cluster. That is, stronger positive awareness relates to adoption of ESCC practices for the complete set of manufacturers also occurs for the savvy manufacturer cluster. This result is interesting because savvy manufacturers have the smallest number of manufacturers in their cluster. This relationship may be more evident because the strength of the relationship for the savvy manufacturer helps to overcome weaker, less significant relationships amongst the other clusters. A previous study demonstrated that regulatory awareness is associated with ESCC practices, but that awareness needed to be transformed into an actual concern or pressure, for example, competitive pressures [15]. This result supports previous studies finding this relationship. Higher awareness levels, given greater manufacturer pressure experience, can lead to a stronger relationship between awareness and ESCC practices adoption.

Our study findings provide empirical support to the relational exchange theory argument that firms with lower information acquisition capability, and lessened regulatory exchange, may be unaware of such regulations. This lack of awareness can result in lagged adoption of environmental innovation practices such as ESCC, as evidenced in the Chinese manufacturers found in this study. While exchange theory suggests that firms can respond to environmental regulations for their own performance benefits, our results show there is varying ESCC adoption among the Chinese manufacturers reflecting heterogeneous responses due to their variations in awareness of environmental regulatory policies.

6 Conclusions

Under increased environmental and resource conservation pressure, Chinese governmental agencies at all levels realize the benefits and risks associated with energy conservation, resource scarcity, and general environmental protection. In response to these social and environmental pressures, environmental regulations and policies targeted at motivating manufacturers to implement innovative environmental management practices such as ESCC have been introduced. Many of the most recent environmental regulations within China, such as cleaner production and circular economy promotion laws, as well as policies such as the development and support of eco-industrial parks and circular economy demonstration projects, are flexible and voluntary.

Cluster analysis reveals that different clusters representing awareness of voluntary environmental regulations and policies exist. MANOVA analysis together with a post-hoc analysis show that manufacturers in the three clusters have differing levels of awareness for voluntary environmental regulations/policies. Also, results show that ESCC practices implementation levels differ. The hierarchical regression results further indicate that there is a positive relationship between regulatory awareness and ESCC practices, and that the significance varies across the three manufacturer clusters.

Savvy manufacturers in China generally understand the needs for these regulations and policies and their awareness has significant positive effect on implementing ESCC practices. But these manufacturers have not really been motivated to implement innovative environmental management practices such as ESCC. In fact, awareness of domestic environmental regulations and policies has slightly negative effect on ESCC practices adoption for some, attentive, manufacturers. Nescient manufacturers, especially smaller organizations, are not even aware of these flexible and voluntary regulations and policies, let alone implement ESCC practices.

Voluntary regulatory policies may not effectively instill corporate environmental management within organizations [21]. However, voluntary regulations can be helpful for strengthening managerial perceptions and inducing proactive environmental management practices [63]. The role of raising awareness of voluntary measures, especially for nescient manufacturers, is a necessary way for organizations to fully realize advantages of these systems and reduce the occurrence of vulnerable compliance by these organizations.

Attentive manufacturers also need to understand how their responses to voluntary measures can be beneficial for improving operations and expanding markets. For savvy manufacturers, improving the regulatory exchange relationship by, for example, maintaining an information awareness network for emergent legislation and becoming involved in the legislative process, will allow them to reap the competitive benefits of introducing innovative environmental practices. In addition, proactive savvy manufacturers can prove quite helpful to policy makers as regulatory exchange mechanisms by diffusing information on environmental management practices as role models for gaining benefits from implementing innovative environmental practices. Savvy manufacturers, many of whom are larger manufacturers, may also help in regulatory exchange by diffusing regulatory information through their supply chains and partner organizations. They may serve as intermediaries of regulatory exchange for those organizations who lack capabilities and resources.

Developing and identifying awareness limitations (inefficiencies) in regulatory exchange on environmental regulations and policies can be a policy tool to green Chinese manufacturing sectors. The findings here also have implications for other countries as well. Chinese governments, in order to maintain or raise awareness, should try to maintain consistency as these regulations and policies evolve. At the same time, proactive environmental management practices such as ESCC among leading manufacturers can also be benchmarks for other lagging manufacturers, which is further reason for governments to

develop more definitive environmental regulations and policies.

In summary, we find that increasing environmental regulatory awareness can support implementing innovative environmental management practices in organizations. This study sets the stage for further identification and investigation for how information acquisition abilities of regulatory policies relate to pursuit and implications of environmental innovation by manufacturers, and potentially other corporate social responsibility behaviors. However, several limitations exist, some of which provide directions for investigation in future studies. First, data collection was only collected from two industrial zones in Shenyang. A broader sampling plan and sample size can be helpful to further enhance generalization of study results. Second, exchange theory with a focus on regulatory aspects is limited in prediction power to unravel some of the nuanced underlying causes of awareness heterogeneity. Low environmental regulatory awareness may occur from a number of factors: inefficient regulatory exchange such as poor governmental policy dissemination; industry's relative inactivity in policy development; and the need for greater policy implementation (enforcement). Third, manufacturer motivation for their ESCC practices adoption in different clusters requires additional in-depth study. Manufacturers need to be aware if voluntary environmental regulations exist, but they may tend to implement ESCC practices only when they feel additional pressures or can gain performance improvements. This investigation of more complex potential relationships amongst awareness and ESCC practices adoption is suggested to extend this line of research. Fourth, the measurement scale used in this study may have an interpretive limitation. The highest awareness response for certain regulations is to implement practices due to the regulation. But in some cases, manufacturers may be highly aware of a regulation but may not take any actions due to lack of resources and/or capabilities.

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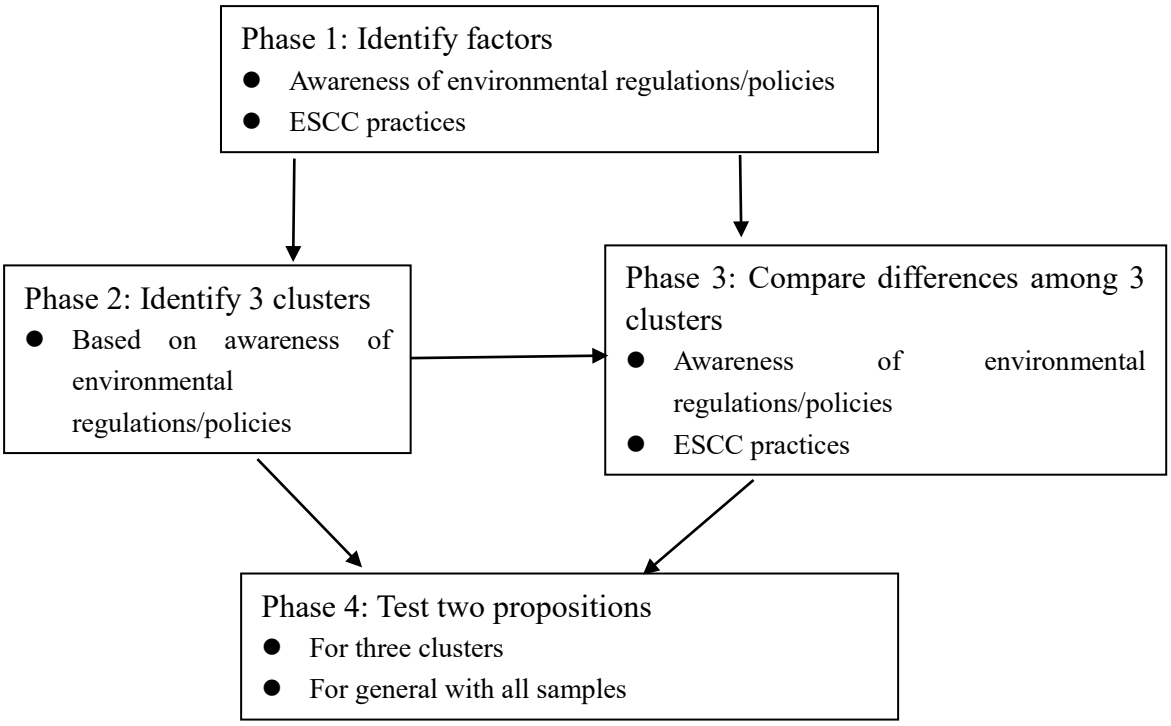

Figure 1 A flow chart showing the four-phase research methodology of this study

Table 1 Distribution of samples in terms of industries, ownership and size

	Total	Percentage
Industry		
Mechanical	102	33.1%
Chemical/petro-chemical	62	20.1%
Electronic/electrical	55	17.9%
Food/drinking	36	11.7%
Automobile	32	10.4%
Furniture/construction	21	6.8%
Total	308	100%
Ownership		
State-owned	67	21.8%
Private Chinese	127	41.2%
Foreign	114	37.0%
Total	308	100%
Size		
Small with less than 300 employees	230	74.7%
Medium-sized with employees between 300 and 1000	54	17.5%
Large with employees over 1000	24	7.8
Total	308	100%

Table 2 Descriptive statistics and MANOVA results for awareness of environmental regulations and policies

Factors/Items	Means[1]	Std. Deviations	Means[1]			F[2]
			Cluster1 (N=43)	Cluster 2(N=109)	Cluster 3(N=156)	
F1: Awareness of domestic regulations/policies	***2.35***	***.94***	***3.86***	***2.77***	***1.65***	***379.3***
"Saving Energy Law" enacted in 2008	2.51	1.17	4.05	2.83	1.86	114.1
"Cleaner Production Promotion Law" enacted in 2003	2.36	1.11	4.09	2.57	1.73	164.8
"Circular Economy Promotion Law" publicized in 2009	2.32	1.11	3.91	2.74	1.59	193.6
EIP demonstration projects by the MEP	2.26	1.06	3.72	2.60	1.62	146.5
National Management Measures EIP demonstration projects (tentative)	2.25	1.07	3.65	2.71	1.54	166.6
CE demonstration projects by NDRC	2.32	1.11	3.88	2.81	1.55	218.3
Articles on CE promotion by State Council	2.37	1.12	3.74	2.94	1.60	187.4
Notification of action plan on energy saving and pollution reduction by State council	2.42	1.09	3.81	2.94	1.67	183.7
F2: Awareness of international regulations/policies	***1.95***	***0.96***	***3.73***	***2.14***	***1.33***	***358.7***
Kyoto Protocol	1.98	1.03	3.67	2.17	1.39	195.2
Foreign countries regulations for used products such as WEEE in Europe	1.93	1.05	3.79	2.13	1.28	285.2
Foreign countries regulations that avoid the use of hazardous substances such as RoHS in Europe	1.94	1.03	3.72	2.12	1.32	241.6

Tests	Value	F	Between groups d.f.	Within groups d.f.	Significance of statistic, p
Pillai's Trace	0.85	49.9	4	272	0.000***
Wilks' Lambda	0.17	98.5	4	270	0.000***

Awareness	Sum of square	d.f.	Mean square	*F*	Significance of statistic, p
Domestic	86.3	5	17.3	65.4	0.000***
International	100.7	5	20.1	74.0	0.000***

Note:
1=never heard of it; 2=heard about it but do not know detail contents; 3=know it but do not know the relationship with own enterprise; 4= know it with consideration to initiate practices to meet the regulation; 5=know it well with initiation related practices due to the regulation.
2 $p<0.001$

Table 3 Descriptive statistics and MANOVA tests for ESCC practices

Factors/Items	Means[1]	Std. Deviations	Means[1]			F[2]
			Cluster1 (N=43)	Cluster 2 (N=109)	Cluster 3 (N=156)	
F1: Green purchasing	***2.44***	***1.02***	***3.15***	***2.89***	***1.94***	***48.9***
Providing design specification to suppliers that include ESPR requirements for purchased items	2.57	1.11	3.36	2.97	2.07	41.3
Cooperation with suppliers for ESPR objectives	2.48	1.17	3.26	2.83	2.01	32.5
Environmental audit for suppliers' inner management	2.35	1.18	3.19	2.72	1.85	36.3
Suppliers' ISO14000 certification	2.35	1.26	3.14	2.78	1.82	34.3
Second-tier supplier ESPR practice evaluation	2.40	1.09	3.00	2.78	1.96	29.8
Adopting just-in-time logistics system	2.37	1.15	3.00	2.82	1.88	34.1
Suppliers are selected using ESPR criteria	2.42	1.11	3.13	2.86	1.93	39.6
Cooperating with suppliers to reduce packaging	2.47	1.18	3.29	2.96	1.91	47.3
Require suppliers to use environmental packaging (degradable and non-hazardous)	2.54	*1.22*	3.31	3.02	1.99	40.4
F2: Customer cooperation with environmental concerns	***2.38***	***1.06***	***3.25***	***2.77***	***1.90***	***42.4***
Cooperation with customers for eco-design	2.33	1.14	3.10	2.60	1.93	24.3
Cooperation with customers for cleaner production	2.41	1.08	3.37	2.69	1.97	38.1
Cooperation with customers for green packaging	2.32	1.21	3.15	2.62	1.88	26.3
Cooperation with customers for using less energy during product transportation	2.42	1.23	3.35	2.83	1.89	37.9
Adopting third-party-logistics	2.42	1.25	3.16	2.93	1.88	35.9
Cooperation with customers for product take back	2.36	1.19	3.06	2.77	1.90	28.2
Cooperation with customers for reverse logistics relationships	2.32	1.23	3.14	2.77	1.81	33.6

Tests			Between groups d.f.	Within groups d.f.	Significance of statistic, p
	Value	F			
Pillai's Trace	0.20	6.35	4	234	0.000***
Wilks' Lambda	0.81	6.59	4	234	0.000***

Awareness	Sum of square	d.f.	Mean square	*F*	Significance of statistic, p
Domestic	24.44	5	5.69	7.06	0.000***
International	34.77	5	6.95	7.77	0.000***

Note: 1=not considering it; 2=planning to consider it, which means in the early phases of discussion and consideration and may not be considered for final implementation; 3=considering it currently, which means that the ESCC practice has been planned for and is on the way to being implemented but not carried out yet; 4=initiating implementation; 5=implementing successfully

2 $p<0.001$

Table 4 Scheff multiple comparison test results for awareness of environmental regulations and ESCC practices

Factors	Clusters	Level of significance	
		2	3
Awareness of domestic regulations/policies	1	1.09***	2.21***
	2		1.12***
Awareness of international regulations/policies	1	1.59***	2.39***
	2		0.81***
Green purchasing	1	0.26	1.21***
	2		0.95***
	3		
Customer cooperation with environmental concerns	1	0.48*	1.35***
	2		0.87***
	3		

Note: ***p<0.001, *p<0.05

Table 5 Effects of awareness of environmental supply chain cooperation among three clusters of manufacturers

		Green purchasing								Customer cooperation with environmental concern							
		General		Cluster1 (N=43)		Cluster 2 (N=109)		Cluster 3 (N=156)		General		Cluster1 (N=43)		Cluster 2 (N=109)		Cluster 3 (N=156)	
		Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2
Independent factors	Awareness of domestic regulations/policies		0.27**		.60**		-.15		.09		0.29***		.41*		-.19^{+}		.14^{+}
	Awareness of international regulations/policies		0.32***		.65**		.07		.06		0.22**		.27		.11		.03
Control variables	Firm size	0.31	0.14	-.17	-.29	.16	.19	.14	.14	0.13	0.03	-.28	-.39	-.01	.01	.20	.20
	Ownership	-0.37	-0.28	.10	.30	-.18	-.20	-.13	-.11	-0.12	-0.10	.24	.27	-.06	-.07	-.24	-.23

Note: ***p<0.001, **p<0.01, *p<0.05, $^{+}$p<0.1