The following publication Geng, D., Lai, K. H., & Zhu, Q. (2021). Eco-innovation and its role for performance improvement among Chinese small and medium-sized manufacturing enterprises. International Journal of Production Economics, 231, 107869 is available at https://doi.org/10.1016/j.ijpe.2020.107869

Eco-innovation and its role for performance improvement among Chinese small and medium-sized manufacturing enterprises

Abstract: Due to the growing public quest for environmental protection, small and medium-sized manufacturing enterprises (SMMEs) are under pressure to adopt eco-innovation to improve their operations. So far, it remains unclear how eco-innovation efforts are implemented among SMMEs and if such efforts are worthy of their investment for performance improvement. Drawing on the contingency theory, this paper develops and empirically tests a model which proposes the existence of different types of SMMEs based on their eco-innovation implementation levels and that the performance improvement is contingent with traditional environmental management (TEM) practices (i.e., internal source reduction, external compliance and communication, and internal management and control) adopted in their operations. Using survey data collected from 382 SMMEs in China, our cluster analytic results reveal two types of SMMEs characterized with three types of eco-innovation (technology, management, and marketing) implementation. From the results, we observed eco-innovation adopters involving 225 SMMEs (58.9% of the sample). The rest of 157 SMMEs (41.1% of the sample) are regarded as eco-innovation planners. Results from hierarchical regression analyses further show that implementing certain eco-innovation practices jointly with TEM practices is beneficial for performance improvements. External compliance and communication is helpful for management innovation to bring environmental performance among eco-innovation planners, but it can be detrimental to environmental image together with marketing innovation. For eco-innovation adopters, internal source reduction is helpful for both technology and management innovation to deliver environmental performance. Technology innovation and internal source reduction can jointly bring economic performance among eco-innovation planners, but such joint efforts can weaken the economic performance outcome. Our paper contributes knowledge on the role of eco-innovation to bring performance gains among

SMMEs in China, a major manufacturing hub in Asia servicing global production demands. We also examine the performance contingencies of eco-innovation with TEM practices in the SMMEs, providing practical implications for them to improve operations as well as policy insights for government to promote the performance benefits of eco-innovation particularly targeting for the smaller-sized manufacturers in the industry.

Keywords: eco-innovation; performance; manufacturing; SMMEs; contingency theory.

1. Introduction

Traditionally, stakeholders including governments, general public, and non-governmental organizations (NGOs) exerted pressure on large enterprises for environmental protection. However, small and medium-sized manufacturing enterprises (SMMEs) contribute substantially to economy and at the same time cause damages to the environment. With stricter environmental regulations, SMMEs have struggled to implement traditional environmental management (TEM) practices such as internal emission reduction and control as well as external communication with related stakeholders to alleviate their caused problems (Zhu et al., 2017; Zhu et al., 2018). Nevertheless, it is not uncommon for SMMEs worldwide lacking the capabilities or resources to implement green management practices (Nunes et al., 2019; Zhu and Lai, 2019). In hope of balancing and improving environmental and economic performance in their operations, SMMEs in UK implement innovative environmental management practices, i.e., eco-innovation (Brammer et al., 2012). Compared to larger manufacturing enterprises, SMMEs such as those in the Austrian medical device sector are not aware of the eco-innovation concept (Auer and Jarmai, 2018). Meanwhile, large enterprises face the risk of supply chain disruptions due to violations of environmental regulations by their suppliers, especially those SMMEs operating in developing countries (Plambeck et al., 2012; Tong et al., 2018). To gain business from large customers, SMMEs have been motivated to implement eco-innovation practices (Damert et al., 2018; Dou et al., 2018; Rennings, 2000), while TEM practices become their basic management actions to comply with environmental regulations (Ndubisi et al., 2019).

Chinese SMMEs[1] account for 99.7% of manufacturing enterprises, and these SMMEs

[1]The Chinese government released a definition of Chinese SMMEs in 2003, and the definition was updated in 2017. In 2003, manufacturing enterprises with less than 300 employees, less than 30 million RMB for annual sales, and less than 40 million RMB for total assets were defined as small ones. Medium sized manufacturing enterprises have employees between 300 and 2,000 while annual sales and total assets are 30-300 million RMB and 40-400 million RMB, respectively. In 2017, manufacturing enterprises with less than 20 employees and less than 3 million RMB for annual sales have been defined as micro-ones. Small manufacturing enterprises have 20-300 employees and annual sales of 3-20 million RMB. Medium-sized

implement environmental practices mainly due to pressure from customers and the government (Huang et al., 2015). In the early of the 21st century, Chinese SMMEs were motivated for environmental management practices mainly at the request of their international customers (Zhu et al., 2005). In recent years, due to increasingly stringent regulations that punish enterprises for environmental violations (Yang et al., 2015), Chinese SMMEs are mandated for operating with TEM practices. At the same time, the Chinese government has launched “carrot” programs to motivate the adoption of eco-innovation practices among SMMEs with the help of larger manufacturing enterprises in their supply chains. One remarkable example is that the Ministry of Industry and Information Technology of China initiated a program called the Green Manufacturing System in 2016, which promotes three types of proactive environmental management practices: 1) green process, 2) green product design, and 3) green supply chain management[2]. The latest on green supply chain management encourages large enterprises to collaborate with SMMEs along a supply chain to jointly improve resources utilization efficiency and environmental performance.

An increasing number of studies have examined the value of environmental management practices among SMMEs analyzing the cost and benefits of the practices adoption. ISO 14001 certification can facilitate SMMEs to gain associated ecological benefits (Graafland, 2018; Zhu, Q. et al., 2012). Environmental best practices can be appealing to the market (D'Souza and Taghian, 2018). However, with limited organizational resources, SMMEs need an innovative management approach to improve their performance (Jha et al., 2018; Zhu, Q. et al., 2012). Dey et al. (2018) find that the implementation levels of environmental management practices differ among SMMEs and such differences are related to SMMEs’ characteristics such as size (employee number, sales, and turn over) and geographical location. In view of scant research

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manufacturing enterprises have 300-1000 employees and annual sales of 20-400 million RMB.

[2] The program includes pilot and demonstration projects. For pilot projects, the government annually provides financial support of 2 billion RMB (approximately 290 million US dollars) to about 100 pilot projects for three years (2016-2018). For demonstration projects, experiences of recognized firms have been summarized for the development of standards.

examining how eco-innovation can effectively bring performance improvement among SMMEs, this study aims to reveal contingency factors (e.g. firm clusters in terms of their eco-innovation implementation levels, TEM practices) that can affect the relationship between eco-innovation practices and performance improvement in their operations. Specifically, we first explore if different firm clusters exist among SMMEs in terms of their eco-innovation practice implementation levels, and determine if TEM practices and performance vary among these clusters. We further examine if and how eco-innovation and TEM practices jointly affect performance of the SMMEs.

2. Literature review and hypotheses development

In operations management, researchers have advanced from studies on practices to examine contextual conditions for explaining success among enterprises (Sousa and Voss, 2008). Thus, contingency factors have been studied for environmental management practices to achieve performance gains (Alves et al., 2017; Wiengarten et al., 2012). For SMMEs, exploring contingency factors of operations management can be more effective than that of the best practice approach (McAdam et al., 2019). The contingency theory suggests that "organisational effectiveness results from fitting characteristics of the organisation…to contingencies that reflect the situation of the organisation" (Donaldson, 2001). Using this definition, two steps are indicated to explore organizational effectiveness of certain practices, they are, identifying types of organizations based on the practices, and exploring fits of the practices with contingency factors (Tenhiala, 2011).

Similar to other environmental management practices (Dey et al., 2018), SMMEs may adopt eco-innovation practices at different implementation levels. Drawing on the contingency theory, we first explore if different firm clusters of SMMEs exist considering their extent of implementing eco-innovation. Some previous studies reveal that eco-innovation can bring both environmental and economic performance (Terziovski, 2010; Zhou et al., 2019), which is similar to those of TEM practices. We further examine if and how eco-innovation and TEM practices can interactively improve performance for the SMMEs. A research model guiding this study is shown in Figure 1, which examine three types of internal and external TEM practices as well as two performance dimensions with the length of company establishment modelled as a control variable for analyzing the performance outcomes.

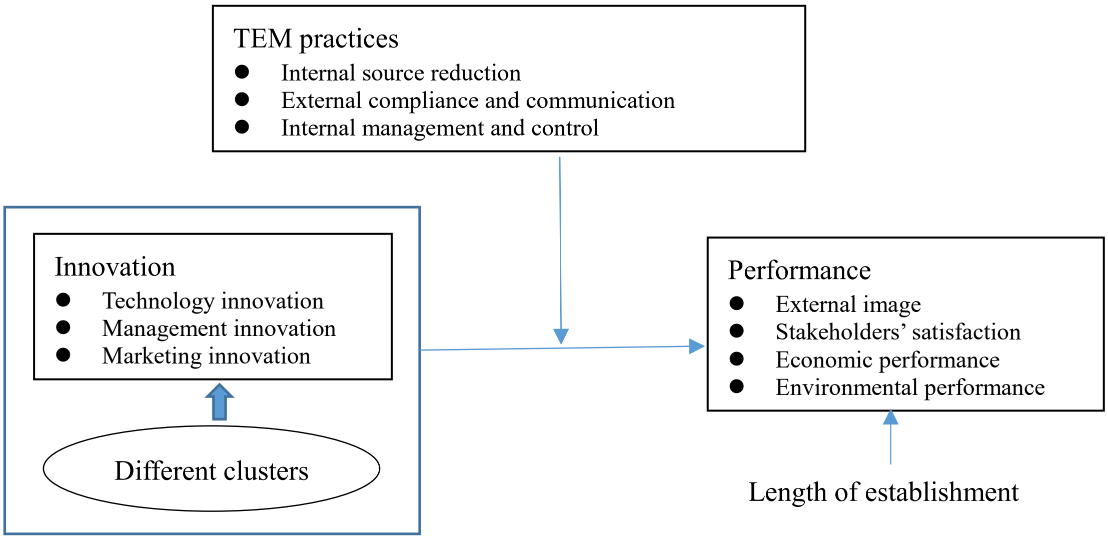

Figure 1 A model on the role of eco-innovation for performance improvement considering the performance contingency of firm clusters on innovation with TEM practices

According to Reger (2003) and Hwang (2004), innovation includes three implementation dimensions covering technology, management, and marketing. Most studies on eco-innovation focus on technological innovation (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013). In addition to technology and design, eco-innovation also needs to consider other implementation dimensions including users, product service, and governance (Carrillo-Hermosilla et al., 2010). Cheng and Shiu (2012) developed three dimensions of implementing eco-innovation at the organizational, product, and process levels. Zubeltzu-Jaka et al. (2018) carried out meta-analysis on eco-innovation related publications between years of 2006 and 2017, and summarized with four drivers of implementing eco-innovation, they are, technology push, market pull, regulatory push-pull, and firm specific factors. Thus, learning from the innovation studies and previous research on eco-innovation, this paper also includes the three eco-innovation implementation dimensions.

There are strategic sustainability behaviors in SMMEs, ranging from resistant, reactive, anticipatory, and innovation-based to sustainability-rooted behaviors (Klewitz and Hansen, 2014). SMMEs may adopt eco-innovation at different implementation levels (Daddi et al., 2012) and the underlying reasons include different organizational size and geographical location (Dey et al., 2018), as well as different cultures, supply chain networks, and regulations in the sector (Pacheco et al., 2018). By investigating 5,135 SMMEs operating in 27 European countries, Triguero et al. (2015) found enterprises with different organizational sizes implement eco-innovation differently. SMMEs have different strategic orientation, market or entrepreneurial orientation in their pursuit of sustainability development, which can be associated with different levels of eco-innovation implementation (Jansson et al., 2017). Sustainability-related capability and resources such as human capital and communication capability vary among SMMEs, resulting in different firm clusters for eco-innovation implementation (Aboelmaged and Hashem, 2019).

Hypothesis 1: Different types exist among SMMEs in terms of three eco-innovation practices implementation.

Many studies show that eco-innovation practices can bring performance improvement, but most are concerned with larger enterprises (Fernando et al., 2019a). Technological eco-innovation can promote energy saving, pollution prevention or waste recycling, hence bringing both environmental benefits and economic gains (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013). Empirical study in the Italian home-furnishing industry show that enterprises adopting eco-innovation under green strategies can reduce their caused environmental harms and gain economic benefits. By learning from larger enterprises, SMMEs can improve their environmental and economic performance by developing a formal strategy and structure (Terziovski, 2010).

Eco-innovation has been increasingly prominent among all enterprises. So far, even for TEMs, Chinese SMMEs are lagging in related practices as compared to larger enterprises (Zhu and Sarkis, 2004a; Zhu et al., 2019). Eco-innovation needs TEM practices for support to bring performance (Arnold, 2017). In other words, an eco-innovation practice can benefit performance only when certain TEM practices are in place. Cases among Italian and Canadian enterprises show that innovation and sustainability should be integrated and collectively implemented (Dangelico and Pujari, 2010). Process innovations interact with traditional green and lean practices, which play a crucial role for performance improvement (Cherrafi et al., 2018). Eco-innovation related to marketing on product development should be implemented with traditional practices of new product development to improve performance (Jugend et al., 2017). Eco-innovation in supply chain management needs to be concurrently implemented with traditional internal environmental management to bring performance (Jabbour et al., 2015).

Hypothesis 2: Eco-innovation practices need TEM practices for support to bring performance improvement for different types of SMMEs.

3. Methodology

3.1 Items development and data collection

Different eco-innovation practices exist (Kiefer et al., 2019). Learning from Reger (2003) who introduced innovation for strategic competence and a previous study on innovation for firms' competitiveness (Hwang, 2004), we include three implementation dimensions for measuring innovation implementation in enterprises, they are, technology (Bocquet et al., 2017), management (Bamber et al., 2017), and marketing (Rahman et al., 2017). Thus, we develop measurement items for evaluating eco-innovation by considering the three implementation dimensions, which are summarized in Table 1. For TEM practices, we consider internal and external ones while we include two internal ones conercing source reduction and management & control. Details are shown in Table 2. We consider both environmental and economic performance with the measurement items shown in Table 3.

Five-point scales were used for measuring all the items. For items on eco-innovation and TEM practices, the measurement scale points are: 1=has never considered; 2=has considered; 3=has considered and worked on plan development; 4=has organized implementation; and 5=has implemented successfully. For items on both environmental and economic performance improvement, the measurement scale points are: 1=none; 2=not significant; 3= some; 4=significant; and 5=very significant.

In China, SMMEs are mainly located in the Southeastern area of the country. Wenzhou, a municipal city in Zhejiang Province is famous for the presence of SMMEs in operations and we chose to collect data in this city. Using the standard of Organization for Economic Co-operation and Development, we define SMMEs as those operating with less than 249 employees. After developing a pilot questionnaire for survey, we interviewed 10 SMMEs to test if we missed key measurement items for evaluating the theoretical constructs and if these items are well understood by our target respondents. With the help of local municipal industrial association, we administered 500 questionnaires and 456 of them were returned. We deleted those completed questionnaires having more than 10 unanswered questions or 10 continuous questions having been responded with the same scale points, and these steps left a total of 382 usable questionnaires for our subsequent data analyses. Among these 382 useful responses, 38 are micro enterprises operating with employees between 1 and 9, 154 are small enterprises operating with employees between 10 and 49, and 190 are medium-sized enterprises operating with employees between 50 and 249. In sum, 362 SMMEs reported their ownership, including the majority of 294 private SMMEs as well as 19 state-owned, 11 foreign, and 38 joint-stock SMMEs.

3.2 Factor analysis

As an initial study of eco-innovation among SMMEs, we applied exploratory factor analysis (EFA) with maximum likelihood and a varimax rotation to explore the dimensions for implementing eco-innovation practices, TEM practices, and performance. Both the scree test and the initial eigenvalue test indicate three factors for eco-innovation practices, explaining 74.02% of the inherent variation. Loadings for items of eco-innovation practices are shown in Table 1. Each item has a high loading (over 0.60) for one factor while having low loadings (less than 0.40) for rest of the factors with one exception. Such results generally demonstrate the properties for validity of the identified factors. Based on the factor analytic test results, three factors were labeled as technology eco-innovation, management eco-innovation, and marketing eco-innovation, respectively. One item with cross high loadings is "The company pays close attention to new challenges and needs environmental and social development to stimulate innovation on technology, product, and service", which has a high loading of 0.676 on Factor 1 (labelled as technology eco-innovation) and a relatively high loading of 0.469 on Factor 2 (labelled as management eco-innovation). One possible reason is that we asked not only about technology, but also about product and service for this item. To further test if items in the same factor can be grouped together, especially for this exceptional item, we performed reliability test with the benchmark value of 0.70 to determine their acceptance (Nunnally and Bernstein, 1994). The reliability for three factors of eco-innovation practices was confirmed with the high coefficient alpha values of 0.876, 0.881, and 0.717 respectively for technology, management, and marketing eco-innovation factors.

We employed the same procedures to explore factors of TEM practices and performance. Loadings are shown in Tables 2 and 3, respectively. Three TEM practice factors explain 75.5% of the inherent variation, labelled as internal source reduction, external compliance & communication, and internal management & control with the reliability coefficient alpha values of 0.888, 0.811, and 0.851, respectively. Two performance factors explain 70.9% of the inherent variation, respectively labelled as environmental performance, and economic performance improvement with the reliability coefficient alpha values of 0.932 and 0.915.

Table 1 Rotated Component Matrix[a] on eco-innovation

	Factors		
	1	2	3
The company has a self or jointly established R&D institution with consideration of eco-innovation	.658	.174	.444
The company establishes an incentive mechanism for technical personnel on eco-innovation	.704	.129	.517
The company established an mechanism to promote R&D achievements on eco-innovation to be transformed as productive forces	.749	.312	.282
The company protect R&D achievements by the legal system on intellectual property related to eco-innovation	.758	.329	.091
The company pays close attention to new challenges and needs environmental and social development to stimulate innovation on technology, product and service	.676	.469	.118
The company introduced new or improved product or service to reduce environmental impact in past three years	.270	.779	.313
The company introduced innovation and improvement in production, logistics or distribution to reduce environmental impact	.272	.817	.285
The company introduced innovation on information and communication technology systems to reduce environmental impact	.344	.769	.272
The company introduced innovation on green marketing through product design, channels, promotion and marketing policies	.173	.370	.771
The company sufficiently understands importance of eco-innovation for its survival and growth	.325	.327	.695

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 8 iterations.

Table 2 Rotated Component Matrix[a] on traditional environmental management practices

	Factors		
Items	1	2	3
Try best to reduce consumption of production consumable	.711	.337	.268
Minimize consumption of toxic material	.757	.402	.243
Adopt measures to reduce consumption of electricity and gas	.777	.329	.273
Gradually improve the ratio of suppliers that implement cleaner production technologies	.746	.250	.320
Communicate with the local community about existing and potential pollution	.343	.701	.295
Avoid use of chemicals forbidden by regulations	.351	.769	.217
Adopt ways to reuse or recycle industrial wastes	.268	.756	.275
Can identify pollution produced by operational activities of our company	.260	.319	.784
Can measure, record and report important pollution sources	.267	.271	.821
Adopt measures to reduce types of pollution including light and noise pollution	.551	.206	.656

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 6 iterations.

3.3 Tests for method biases

We carried out several procedural remedies for method biases according to seven suggestions by a previous study (Podsakoff et al., 2012). For items development, we used the neutral scale point of "3" in the five-point scales for measurement of eco-innovation practices, TEM practices, and performance. During the questionnaire development process, we separated the survey questions on eco-innovation practices, TEM practices, and performance into three different parts of the questionnaire. For data collection, we guaranteed that both the respondents and the SMMEs at which the former work were treated in confidential manner and the data are only analyzed and reported in aggregate without disclosing their identity. To further check if common method bias exists, we conducted the Harman's one factor test using confirmatory factor analysis for eco-innovation and TEM practices. Results of this one-factor model are χ^2(df)= 1614.768 (170), p=0.000, CFI=0.709, NFI=0.687, RFI=0.650, IFI=0.710, RMSEA=0.262, suggesting a poor model fit. Thus, common method bias should not be a problem in this study.

Table 3 Rotated Component Matrix[a] on performance

	Factors	
	1	2
Exhaust gas is decreased	.799	.244
Industrial waste water is decreased	.846	.262
Industrial solid waste is decreased	.830	.249
Noise pollution is decreased	.802	.238
Use of hazardous/toxic/harmful materials is decreased	.797	.244
Frequency of environmental accidents is decreased	.806	.159
Enterprise's environmental conditions are improved	.783	.255
The net profit is increased in the past year compared to enterprises in the same sector	.191	.783
The rate of sales is increased in the past year compared to enterprises in the same sector	.221	.825
The market share is increased in the past year compared to enterprises in the same sector	.233	.840
The employee income is increased compared to enterprises in the same sector	.261	.793
The average profit is increased compared to enterprises in the same sector	.263	.782
Innovation areas on management or business modes are increased compared to enterprises in the same sector	.235	.814

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 3 iterations.

To examine non-response bias issue, we separated the 382 usable questionnaires into two groups. Among these 382 questionnaires, 125 of them were directly returned within one month. Then, we contacted SMMEs that did not respond, and additional 257 questionnaires were collected through one or two phone calls to these respondents. We applied t-tests to compare mean values of all the underlying factors of eco-innovation practices, TEM practices, and performance. No significant differences were found for all those factors at the $p<0.05$ level, suggesting that non-response bias is not an issue for this study.

4. Results

4.1 Cluster analysis and results

A cluster analysis using both hierarchical and non-hierarchical methods (Hair et al., 2010) was applied to test if firm clusters exist among SMMEs in terms of implementing eco-innovation. The hierarchical analysis using Ward's method reveals two clusters of SMMEs concerning their eco-innovation implementation. To compare differences between the two firm clusters, a K-mean cluster analysis (a non-hierarchical clustering technique) of the three eco-innovation factors was performed. T-tests were further used to examine if the clustered SMMEs vary in their eco-innovation as well as in TEM practices and associated performance outcomes (see Table 4).

Table 4 Results of descriptive analysis and comparison between two clusters

		Total (n=382)		Cluster 1 (n=157)		Cluster 2 (n=225)		T-tests (Clusters 2 vs.1)
		Means	S.D.	Means	S.D.	Means	S.D.	
Eco-innovation	Technology	3.97	.93	3.14	.75	4.54	.53	20.09***
	Management	3.88	1.00	2.98	.80	4.51	.53	20.76***
	Marketing	4.01	.92	3.16	.71	4.59	.51	21.74***
Traditional environmental management practices	Internal Source reduction	4.12	.98	3.52	1.07	4.53	.63	10.70***
	External compliance and communication	4.16	.94	3.62	1.04	4.54	.64	9.87***
	Internal management and control	4.04	1.03	3.51	1.09	4.42	.78	9.00***
Performance	Environmental	3.61	.97	3.24	.84	3.90	.95	7. 43***
	Economic	3.33	.94	2.95	.81	3.60	.94	7. 11***

4.2 Regression analysis and results

Previous studies (Hayes, 2009; MacKinnon et al., 2004; Preacher and Hayes, 2008) suggested that hierarchical regression analysis with four steps can help to explore interaction (moderation effect) between eco-innovation and TEM practices for performance improvements. Results are summarized in Tables 5 and 6 for environmental and economic performance, respectively. Learning from previous studies (Zhu et al., 2013; Zhu and Sarkis, 2004b), we used the mean value of all items for developing each factor. First, we entered the control variable, the length of establishment, as the first block (See Step 1). Then independent factors of three eco-innovation practices were entered as the second block (see Step 2). For the third step, we included potential moderators of three TEM factors. Finally, we entered nine interaction variables of three independent factors and three TEM factors as the fourth block (see Step 4).

To address the multicollinearity issue, we used the 'centering' method for analyzing all eco-innovation and TEM factors in Step 4. All variance inflation factors are close to 1.00, and thus multicollinearity should not be a problem for this study. Either an individual interaction variable with a significant beta value or the significant collectively incremental F for the step reveals the moderation effect (Zhu and Sarkis, 2004b).

5. Discussion and implications

5.1 Discussion

5.1.1 Discussion on cluster analysis

According to the contingency theory (Donaldson, 2001), the first step to explore organizational effectiveness of certain practices is to identify types of organizations based on the practices (Tenhiala, 2011). Table 4 shows that Clusters 1 and 2 have 157 and 225 SMMEs, respectively. The mean values of Cluster 1 for all eco-innovation practices are around 3.00 (3=has considered and worked on plan development), and we can label SMMEs in this cluster as eco-innovation planners. The mean values of Cluster 2 for all three eco-innovation practices are over 4.50 (4=has organized implementation; and 5=has implemented successfully). Thus, we can label this cluster as eco-innovation adopters. SMMEs in Cluster 1 lag in all eco-innovation practices as compared to those in Cluster 2. More than the half (225 among 382, 58.9%) are clustered as eco-innovation adopters, which may result from the increasingly stricter environmental regulations in China. However, still 157 SMMEs (41.1%) in our sample only plan for eco-innovation without implementation. Hypothesis 1 is supported.

Table 4 further shows that SMMEs in Cluster 1 implement TEM practices at the similar level as that for eco-innovation practices. TEM practices in Cluster 2 have significantly higher implementation levels that those in Cluster 1. However, eco-innovation planners in Cluster 1 initiate implementation of TEM practices with all three mean values over 3.50 (3=has considered and worked on plan development; 4=has organized implementation), which are higher than those for eco-innovation practices with all three mean values of around 3.00.

Both environmental and economic performance improvements are higher for eco-innovation adopters in Cluster 2 than those for eco-innovation planners in Cluster 1. Such a result indicates that the cluster to which SMMEs belong with respect to eco-innovation is a contingency factor influencing performance improvement. T-tests show that such differences between two clusters are clearly lower than those for eco-innovation practices. Moreover, difference for environmental performance with the t-test value of 7.43 is higher than that for economic performance (t-test value of 7.11), which shows that the contingency factor of cluster has stronger effect on environmental performance than that on economic performance.

5.1.2 Discussion on hierarchical regression analysis

Table 5 shows the role of eco-innovation on environmental performance as well as the moderating effect of TEM practices. For eco-innovation planners in Cluster 1, management innovation shows significant and direct effect for all the three steps (Steps 2-4), marketing innovation shows direct effect in Steps 2 and 3, while technology innovation shows no direct effect. For eco-innovation adopters, only marketing innovation shows direct effect in Steps 2 and 3.

Two significant betas of interaction coefficients for eco-innovation planners in Cluster 1 are both related to one TEM practice, i.e., external compliance and communication (ECC). Such result indicates that ECC is a contingency factor for certain eco-innovation practices to bring environmental performance. However, one beta is positive while the other is negative. The positive beta of interaction effect indicates that management eco-innovation and ECC can jointly bring environmental performance. Hypothesis 2 is supported. Nevertheless, the negative beta of interaction effect shows that ECC can be detrimental to environmental performance improvement through market eco-innovation. Hypothesis 2 is rejected. Such a result is attributable to the low level of implementing both ECC and market eco-innovation.

For eco-innovation adopters in Cluster 2, only marketing innovation show direct effect in Steps 2 and 3. Two positive significant betas of interaction effects exist, and both are related to internal management and control (IMC). Technology and management eco-innovation practices can jointly improve environmental performance with a TEM practice of IMC. Hypothesis 2 is supported and IMC is a contingency factor explaining the performance impact of eco-innovation.

Table 6 shows the role of eco-innovation on economic performance as well as the moderating effect of TEM practices on performance. For eco-innovation planners in Cluster 1, both management and marketing eco-innovation practices show significant effect. One positive interaction beta shows that technology eco-innovation and internal source reduction (ISR) can jointly improve economic performance. Hypothesis 2 is supported for a technology-based eco-innovation with a specific contingency factor. However, for eco-innovation adopters in Cluster 2, one negative and significant beta of interaction effect indicates that ISR can weaken economic gains through technology innovation. This result provides no support for Hypothesis 2, which is attributable to the high level of implementing both ISR and technology innovation. Such a result indicates that when ISR and technology innovation are implemented at a certain high level, marginal benefit can be trivial to cover the marginal cost incurred resulting in negative economic gain. .

Table 5 Effects of eco-innovation and environmental management practices on environmental performance

		Cluster 1				Cluster 2			
		Step1	Step2	Step3	Step4	Step1	Step2	Step3	Step4
Length of establishment (years)		.044	.059	0.070		-.014	-.023	-.026	-.018
Eco-innovation	Technology (Tech)		.013	-.044	-.097		-.013	-.061	-.006
	Management (Mana)		.251**	.243**	.332**		.004	-.042	.009
	Marketing (Mark)		.167*	.133+	.063		.120+	.125+	.078
Traditional environmental management practices	Internal Source reduction (ISR)			-.168	-.419			-.007	.379
	External compliance and communication (ECC)			.434***	.521+			.160	-.003
	Internal management and control (IMC)			-.045	.078			.034	-.155
Interaction effects	Tech* ISR				.012				-.318
	Tech*ECC				-.134				-.066
	Tech*IMC				.033				.267*
	Mana*ISR				-.514				-.387
	Mana*ECC				.571*				.245
	Mana*IMC				.115				.304+
	Mark*ISR				.270				.013
	Mark*ECC				-.439*				.017
	Mark*IMC				.005				-.053
	F for the step	.292	6.091***	5.047**	1.384	.046	1.019	1.934	1.639
	F for the regression	.292	4.648***	5.034***	3.033***	.046	.776	1.278	1.496
	Adjusted R^2	-.005	.087	.155	.174	-.004	-.004	.009	.034

Notes: ***p<0.001, **p<0.01, *p<0.05, +p<0.1

Table 6 Effects of eco-innovation and environmental management practices on economic performance

		Cluster 1				Cluster 2			
		Step1	Step2	Step3	Step4	Step1	Step2	Step3	Step4
Length of establishment (years)		.076	.093	.100	.108	-.083	-.109	-.107	-.126+
Eco-innovation	Technology (Tech)		-.015	-.032	.000		.111+	.109	.173+
	Management (Mana)		.255**	.257**	.304**		.037	.045	.130
	Marketing (Mark)		.219**	.212**	.147		.118+	.127+	.112
Traditional environmental management practices	Internal Source reduction (ISR)			-.105	-.084			-.099	.246
	External compliance and communication (ECC)			.141	.342			.012	-.170
	Internal management and control (IMC)			.006	-.252			.057	.068
Interaction effects	Tech* ISR				.424**				-.460+
	Tech*ECC				-.286				.228
	Tech*IMC				-.039				-.028
	Mana*ISR				.100				-.199
	Mana*ECC				.321				.080
	Mana*IMC				-.335				.146
	Mark*ISR				-.327				-.080
	Mark*ECC				.141				.183
	Mark*IMC				-.025				-.144
F for the step		.896	7.341***	0.420	1.224	1.491	3.115*	.381	1.392
F for the regression		.896	5.758***	3.432**	2.211**	1.491	2.720*	1.704	1.541+
Adjusted R^2		-.001	.110	.100	.112	.002	.031	.022	.038

Notes: ***p<0.001, **p<0.01, *p<0.05, +p<0.1

5.2 Implications

Our study results reveal that over half of SMMEs implement eco-innovation practices while still over 40% of SMMEs only plan or consider eco-innovation in their operations. Significant differences exist among the adopters for all of their eco-innovation practices, TEM practices, and associated performance outcomes. Eco-innovation adopters among SMMEs reported higher mean values for all TEM practices and two performance factors, which demonstrates that they usually implement TEM practices at the higher level, and they can get more environmental and economic performance. The Chinese government can develop standards or even regulations to require eco-innovation planner to implement similar eco-innovation practices.

Technology innovation can promote environmental performance only for eco-innovation adopters. Moreover, such improvement can be achieved only jointly with internal management and control. For economic performance, technology innovation and internal source reduction jointly show effect, but in an opposite way for the two firm clusters of SMMEs. When eco-innovation and TEM practices are both implemented at a low level, internal source reduction can be helpful to gain economic performance through technology innovation. However, when eco-innovation and TEM practices are both implemented at a high level, interaction effect of technology and internal source reduction is negative for economic performance improvement. Thus, for eco-innovation planners, they can gain economic performance by joint efforts of technology innovation and internal source reduction. For eco-innovation adopters, they can improve environmental performance through technology innovation together with internal management and control. However, economic performance improvement becomes difficult to be achieved probably due to high investment inputs for technology. Government support such as subsidy for high technology development can be helpful or even needed.

Management innovation can promote environmental performance for both eco-innovation planners and adopters, but different TEM practices are needed to complement the implementation. For eco-innovation planners, external compliance and communication can be helpful for management innovation to improve environmental performance. For eco-innovation adopters, internal management and control can facilitate management innovation for improved environmental performance. In terms of economic performance, management innovation has significant and positive direct effect for eco-innovation planners. Thus, management innovation seems to be more important for eco-innovation planners. When such an eco-innovation practice is implemented at a relatively low level among SMMEs, neither environmental nor economic performance improvement can be achieved.

For marketing innovation, SMMEs mainly introduce innovative ways for product design, channels development, and promotion. Two positive betas in Steps 2 and 3 indicate that marketing innovation can improve environmental performance for eco-innovation planners. However, one negative interaction effect with external compliance and communication is shown in Step 4, which indicates that the effect is weakened by this TEM practice. One plausible explanation of this result is the low level of implementing the TEM practice of external compliance and communication with the mean value of 3.62 (3=has considered and worked on plan development; 4=has organized implementation). No effect exists for eco-innovation adopters for environmental performance. For economic performance, only direct effect and no interaction effect exist for both firm clusters of SMMEs while the direct effect is more significant among eco-innovation planners. Thus, eco-innovation planners can market their eco-innovation efforts, which can bring economic gains. However, they need be careful not to overstate their efforts during external communication.

6. Conclusions

This study contributes knowledge by revealing two different firm clusters among SMMEs based on their eco-innovation implementation levels, labelled in this study as eco-innovation adopters and eco-innovation planners. Empirical results further show that eco-innovation adopters implement TEM practices at the higher level and that their associated performance (environmental and economic) are better. Further, this study analyzes the interaction effect of eco-innovation and traditional environmental practices on their performance improvements. Such effects are found to vary different among two firm clusters of SMMEs.

Our empirical results can provide decision support for SMMEs and the government. Leading SMMEs of eco-innovation adopters are informed with evidence that their efforts are associated with performance improvement. Eco-innovation planners need to understand that they have leading competitors (eco-innovation adopters in this study). They can learn from these benchmark SMMEs and then more proactively implement eco-innovation practices. Moreover, our results from hierarchical analysis reveal some interaction effects of eco-innovation and TEM practices for both clusters of SMMEs. Eco-innovation adopters and planners can identify reasonable eco-innovation practices to effectively improve their environmental and economic performance at the current stage. For policy makers, they can develop more reasonable rules and regulations to promote eco-innovation by understanding characteristics of the clusters as well as their eco-innovation implementation levels and percentage of leading SMMEs. With the majority of leading SMMEs that collectively implement both eco-innovation and TEM practices in operations, government officials can develop stricter standards mandating SMMEs to pursue their implementation. It is also helpful to guide laggards of eco-innovation planners to learn from leading SMMEs by developing the diffusion mechanism with feasible channels.

There are several limitations that can affect the interpretation of results for this study. First, due to the difficulty of data collection, our sample SMMEs are only confined to one typical geographical area where they contribute much to the local economic development. Samples from other industrial location areas than Wenzhou or countries can help to generalize results.

Second, we identify some interaction effects of eco-innovation and TEM practices and reveal implementation differences between two clusters of SMMEs. Further research efforts are need to explain the existence of these interactions with multiple sources of evidences, e.g., longitudinal panel data. Third, we only examined eco-innovation practices and TEM practices for performance improvement among manufacturing enterprises. Similar theoretical development, data collection and analysis can be replicated in other industrial sectors, e.g., logistics and shipping services (Fernando et al., 2019b).

Acknowledgements: This work is also supported by National Natural Science Foundation of China (71632007 and 71690241), and Program of Shanghai Academic/Technology Research Leader (18XD1402100)

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