Article

A study on green practice infusion of the SMES in the context of circular economy

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Abstract: Sustainable development has attracted widespread attention worldwide, and the circular economy has become one of the essential policies of many countries. Small and medium-sized enterprises are important drivers of world economic growth and can significantly impact the environment. Therefore, SMEs are critical players in implementing a circular economy as the basis for creating a sustainable society. Although a wealth of research on SME environmental management issues can be found in the literature, more must be known about the infusion of green practices in SMEs. The primary purpose of this study is to explore the green practice infusion of Taiwanese SMEs, a context that is particularly relevant due to Taiwan's strong focus on environmental sustainability and its circular economy industrial development policy. Through a questionnaire survey, this study examined the factors that influence green practice infusion behavior in Taiwanese SMEs and the impact of green practice infusion on circular economy performance. The findings show that the relative advantages and compatibility of the circular economy, organizational support, human resource quality, regulatory pressure, and government support significantly impact the green practice infusion of Taiwanese SMEs. The effects of complexity, customer pressure, and environmental uncertainty on SMEs' infusion of green practices are not statistically significant. Circular economy performance is positively correlated with green practice infusion. This study can broaden the research scope of SMEs' environmental management and contribute to a deeper understanding of SMEs' green practice infusion and circular economy.

Keywords: small and medium-sized enterprises; circular economy; green practice infusion; determinant factors; circular economy performance

1. Introduction

The urgent issue of climate change has triggered a global response to environmental protection. This response is driven by the existential threat to life posed by the worldwide deterioration of ecosystems and the increasingly stringent government policies and regulations. As the environmental crisis poses a significant risk to society and economic sustainability, governments worldwide are making concerted efforts to address environmental issues within the framework of economic development. In a testament to its unwavering commitment to environmental issues, the Taiwan government has launched a circular economy industrial development policy. This policy envisions a future where pollution and waste treatment align with economic output, aiming for zero emissions, zero waste, and zero accidents. The circular economy is gaining momentum as a viable solution to a host of challenges,

including waste generation, resource scarcity, and sustainable economic benefits. The Taiwan government's circular economy industrial development policy stands as a beacon of hope, demonstrating the potential for significant change and inspiring other nations to follow suit.

The globally recognized solution to the problem of climate change is the circular economy, a new model aimed at protecting the environment, preventing pollution, and promoting economic prosperity (Apostu et al., 2023; Prieto-Sandoval et al., 2018). The circular economy has received widespread attention around the world. A great deal of literature has focused on the circular economy, especially since it started becoming increasingly important in the legislation of many countries (Arsawan et al., 2023; Ghosh et al., 2023; Yosep et al., 2024). However, less attention has been paid to small and medium-sized enterprises (SMEs) (Min et al., 2021).

Government demands and increasingly conscientious consumers demand that companies, regardless of size, pay more attention to environmental issues; however, the literature on environmental management naturally focuses on large companies with significant influence. Small and medium enterprises constitute an essential part of Taiwan's industrial sector. They represent approximately 98% of Taiwanese companies; therefore, they can significantly impact the environment. Although the individual impact of SMEs on environmental harm is negligible, their collective impact is enormous, estimated to account for approximately two-thirds of global industrial waste pollution (Leonidou et al., 2014; Revell et al., 2009). SMEs are responsible for addressing pollution prevention and aligning their business strategies with environmental management (Caldera et al., 2019). They are increasingly expected to develop strategies to accommodate global sustainability requirements and actively address environmental issues (Lewis et al., 2014). Although some research on implementing environmental management in SMEs has been carried out in recent years, there is still much to learn on this issue (Aykol and Leonidou, 2014; Ferenhof et al., 2014; Garcés-Ayerbe et al., 2019; Pacheco et al., 2017).

Environmental management of SMEs is likely to achieve sustainable success through research to identify necessary adjustments to the environmental impact of SMEs (Atanase and Visan, 2011; Graafland and Smid, 2015; Henriques and Catarino, 2015). For example, some SMEs have attempted to reuse or recycle materials or utilize biological waste or waste heat to save energy (Maher et al., 2023). The transition to a circular economy by SMEs is urgent, as they are responsible for a significant portion of the world's resource use and waste generation. SMEs are critical players in implementing a circular economy as a basis for creating a sustainable society (Prieto-Sandoval et al., 2019). Studying the environmental management of Taiwan's small and medium-sized enterprises is necessary to promote the development of Taiwan's circular economy. Therefore, this paper will examine the environmental management implementation of Taiwanese SMEs in the circular economy context.

Companies need a pragmatic approach that aligns corporate goals with environmental needs in a way that appeals to the business community. Many researchers have put forward various explanations for the environmental management of enterprises by using different theories. However, after initial

adoption, they may not achieve deep usage (Ali et al., 2024; Füssel and Georg, 2000). Like innovation diffusion, which includes adoption and infusion phases (Damanpour and Schneider, 2006; Rogers, 2003; Zhu et al., 2006), infusion is the degree to which an innovative technology is fully and widely used (Fichman, 2001; Yan and Fiorito, 2007). Green practice infusion refers to integrating green practices into organizational operations. Corporate greening begins with senior executives' recognition of the need for companies to address environmental issues, leading to policy commitments and, ultimately, full implementation in the company (Winn and Angell, 2000). Understanding the infusion of green practices within companies is an important issue.

Many researchers have proposed various analyses and explanations on the implementation of corporate green practices and the factors that influence corporate adoption of green practices. However, only a few studies have explored the infusion of circular economy technologies within firms to understand the extent to which these practices are adopted (Füssel and Georg, 2000; Ho et al., 2014; Steadet al., 1998; Winn and Angell, 2000). Furthermore, while various publications discuss different approaches and potential barriers to environmental management for SMEs, less is known about the green practice infusion of SMEs in the context of the circular economy (Johnson and Schaltegger, 2015). To fill the research gap, this study aims to explore the green practice infusion of SMEs in Taiwan in the context of the circular economy. The research objectives of this study include: (1) to analyze the factors affecting green practice infusion of the SMEs in Taiwan in the context of circular economy and (2) to study the influence of green practice infusion on circular economy performance for the SMEs.

2. Research hypotheses

The meaning of green practices might be relatively intuitive, especially in the context of the circular economy. A number of researchers have addressed green practices. Practically, they have been defined based on their implementation objectives. Because environmental issues are multidisciplinary phenomena and should be viewed from technical, managerial, and social perspectives, it may not be easy to address a clear and uncontested definition of green practices (Etzion, 2007). Many studies tend to place greater emphasis on green practices related to products and processes, including product and process planning and improvement, operational integration, material/waste reduction, recycling, reuse, and remanufacturing. Green practices are also broadly defined as new ideas, behaviors, products, and processes that help reduce environmental burdens or achieve sustainability goals. They consist of improved or new technologies, processes, or systems that reduce harm to the environment (Abbas and Khan, 2022; Lin and Ho, 2010). Implementing environmental management practices can be regarded as technological innovation (Ho et al., 2014; Lin and Ho, 2010).

The circular economy has attracted the attention of many researchers because it can not only contribute to environmental protection but also promote economic and social well-being (Franklin-Johnson et al., 2016; Govindan and Hasanagic, 2018). It has been developed and defined in a variety of ways (Carissimi et al., 2023; Khan

and Haleem, 2021; Khan et al., 2022; Kirchherr et al., 2017; Negri et al., 2021). Circular economic activity includes eco-design, recycling, reuse, repair, sustainable supply, and responsible consumption (Ellen MacArthur Foundation and Grata Design, 2015; Ormazabal et al., 2018; Stahel, 2016). The Ellen MacArthur Foundation (2013) provides structure to the circular economy activities with five fundamental traits: "(1) design out waste, (2) build resilience through diversity, (3) work toward energy from renewable sources, (4) think in systems, and (5) think in cascades". Some scholars (Govindan and Hasanagic, 2018; Mura et al., 2020; Rincón-Moreno et al., 2021) have proposed that circular economy practices can be classified into categories according to their meanings and similarities.

2.1. Factors affecting green practice infusion in the SMEs

Implementing green practices involves using new or improved technologies to reduce harm to the environment, sometimes requiring the development of new resource combinations or the arrangement of existing resources in new ways (Hart, 1995; Rothenberg and Zyglidopoulos, 2006). The implementation of green practices is also an innovation process (Ho et al., 2014; Lin and Ho, 2010). Adopting innovations is a multiphase process and can be grouped into three phases: initiation, adoption decision, and infusion (Damanpour and Schneider, 2006; Rogers, 2003; Zhu et al., 2006). Infusion refers to using innovations in an organization in an integrated way to realize their full potential to support the operation of the organization (Fichman, 2001; Yan and Fiorito, 2007). Similarly, utilizing environmental management practices is also a multiphase process consisting of initiation awareness, the decision to adopt environmental management, and the infusion of green practices in the organization. Green practice infusion is the integration of environmental management practices into the organizational operating structure. The infusion stage is a post-adoption behavior and the final stage of green practice implementation, which means embedding and routinizing green practices in the organization (Ho et al., 2014). Although several factors influencing green practice adoption have been investigated in several studies, less attention was paid to exploring organizational infusion behavior in terms of green practices (Ho et al., 2014). Much remains to be learned about the green practice infusion of SMEs in the context of the circular economy.

The technological, organizational, and environmental (TOE) framework (Tornatzky and Fleischer, 1990) has been widely used in studying innovation adoption and has also been used to explore the decision to adopt green practices (Lin and Ho, 2010). The TOE framework suggests three aspects of the firm's context that influence innovation diffusion. Drawing on the TOE framework, Ho et al. (2014) The determinant factors influencing green practice infusion were also grouped into three dimensions. They empirically explored the influences of these factors on the organizational infusion of green practices in Chinese logistics companies. Therefore, this paper also attempts to employ the TOE framework to explore the factors influencing the infusion of green practices in SMEs in the context of the circular economy.

2.1.1. Technological factors

The technological characteristics of an innovation refer to cognitive beliefs reflected in an attitude toward the innovation itself (Jeyaraj et al., 2006; Tornatzky and Klein, 1982). The characteristics of green technologies are relevant to environmental management (Boiral, 2002). Although a number of innovation characteristics can affect its diffusion, this study only takes relative advantage, complexity, and compatibility into consideration because they are considered to be more important in influencing innovation adoption behavior than the other technological characteristics (Lin and Ho, 2010; Sia et al., 2004; Taylor and McAdam, 2004; Zhu et al., 2006).

Relative advantage is the perception of whether a new technology is more advantageous than its alternative ideas. The perceived advantage of the technology can be measured in both economic and social terms, such as performance, benefits, or convenience. That is, companies are more likely to achieve better performance and higher economic benefits by implementing that new technology than other technologies. Relative advantage has a positive impact on the diffusion of innovations (Rogers, 2003; Tornatzky and Klein, 1982). Potential benefits of green practices for companies include reduced natural resource and energy consumption, reduced pollutant emissions, improved environmental and business performance, and superior responsiveness to social expectations (Etzion, 2007; Hart, 1995). According to the Del Rio Gonzalez (2005) study, relative advantages are essential factors that affect the adoption of green technologies. Ho et al. (2014) found that the relative advantage had a positive influence on green practice infusion for logistics companies in China. The perceived relative advantage brought by environmental management will become the driving force for firms to implement green practices. As a result, this study proposes the following hypothesis:

H1: The relative advantage of the circular economy practices positively influences green practice infusion for SMEs.

Complexity refers to the degree to which a new technology is considered difficult to understand and use. Because the complexity of technology increases the difficulty of knowledge transfer and innovation diffusion (Rogers, 2003), it is generally considered to hinder the diffusion of technology in organizations (Tornatzky and Klein, 1982). Green practices often contain some tacit knowledge, such as how to identify pollution sources, how to respond quickly to accidental leaks, etc. (Boiral, 2002), which leads to ambiguity in the implementation of green practices and thus hinders the transfer and diffusion of this technology within the company (Szulanski, 1996). When technological knowledge cannot be easily shared within the organization, companies tend not to implement that technological innovation. Therefore, when the complexity of green practices is high, a large amount of tacit knowledge needs to be laboriously learned and transmitted, making it relatively tricky to infuse green practices. Ho et al. (2014) found that the complexity had a negative effect on the infusion of green practices for logistics companies in China. As a result, this study proposes the following hypothesis:

H2: The complexity of the circular economy practices negatively influences green practice infusion for SMEs.

Compatibility refers to the degree to which a new technology is consistent with a company's existing operating processes, needs, and experiences (Rogers, 2003). Green practices will be integrated with the company's current operation processes and systems. Therefore, the implementation of green practices is a process of integration into green operations. When the compatibility of a green practice with the firm's current technologies and systems is high, the green practice will be more likely to spread within the organization. According to Dupuy (1997), innovations to existing technologies are most likely to be adopted earlier than those that are more difficult to integrate into existing technologies. Ho et al. (2014) found that compatibility had a positive effect on the infusion of green practices for logistics companies in China. To reduce possible barriers to the introduction of green practices, firms are likely to use green practices that are compatible with the firm's current operating system. As a result, this study proposes the following hypothesis:

H3: The compatibility of the circular economy practices positively influences green practice infusion for SMEs.

2.1.2. Organizational factors

Organizational characteristics imply resources and processes that facilitate or constrain innovation. Although there have been many studies examining the impact of various organizational characteristics on innovation diffusion, this study only considers the impact of organizational support and human resource quality on the infusion of green practices because they are organizational resource-related variables that have been extensively analyzed in the literature (Damanpour and Schneider, 2006; Etzion, 2007; Taylor and McAdam, 2004). Adequate organizational capabilities are one critical organizational characteristic that promotes innovation (Damanpour, 1991; Jeyaraj et al., 2006). Management support, resource availability, human resources, and organizational learning capabilities affect the adoption of environmental management practices (Álvarez-Gil et al., 2007; Lee, 2008; Lin and Ho, 2010).

Organizational support refers to the extent to which a company supports and assists employees in taking advantage of innovations and has a positive impact on the adoption of innovation (Damanpour and Schneider, 2006; Jeyaraj et al., 2006; Lee et al., 2005). Organizational support is essential for promoting environmental stewardship as it makes it easier for employees to access the resources they need to adopt green practices and motivates employees to implement green behaviors. In addition, many green practices require coordination and collaboration between different departments during their implementation. To ensure successful implementation, top management must recognize and encourage green initiatives. The main task of top management is to assist each department in acquiring resources and integrating them into organizational operations so that the business can implement environmental management practices and thereby gain an environmental competitive advantage (Judge and Elenkov, 2005; Zhu et al., 2008). Ho et al. (2014) found that organizational support had a positive effect on the infusion of green practices for logistics companies in China. As a result, this study proposes the following hypothesis:

H4: Organizational support for the circular economy positively influences green

practice infusion for SMEs.

Good human resource quality contributes to the diffusion of innovation due to its strong learning ability and is a critical factor affecting the implementation of innovation (Fichman and Kemerer, 1999; Tornatzky and Fleischer, 1990). Utilizing green practices is a complex process that often requires significant changes to existing operating procedures, as well as inter-discipline and cross-departmental coordination and collaboration (Russo and Fouts, 1997). Therefore, the implementation of green practices must rely on developing tacit skills through employee participation, which is a human resource-intensive process (Del Brio and Junquera, 2003; Hart, 1995). Ho et al. (2014) found that human resource quality had a positive influence on the infusion of green practices for logistics companies in China. Companies with higher employee learning abilities are more likely to implement advanced environmental management practices (Christmann, 2000; Judge and Elenkov, 2005) successfully. Employees' lack of learning abilities is one of the significant obstacles to the transfer of innovative knowledge for SMEs (Szulanski, 1996). Employees with good learning abilities will quickly improve their ability to implement green practices through various training programs. To reduce the barriers to infusing green practices, employees need professional training to learn the concepts behind green practices. As a result, this study proposes the following hypothesis:

H5: Human resource quality positively influences green practice infusion for SMEs.

2.1.3. Environmental factors

Environmental factors refer to the external business environment in which the company operates and are a vital issue influencing innovation adoption. Although many environmental factors have been discussed in the innovation diffusion literature (Damanpour and Schneider, 2006; Frambach and Schillewaert, 2002), this study only focuses on the effects of stakeholder pressure, governmental support, and environmental uncertainty on green practice infusion for SMEs. Stakeholder pressure is an essential external environmental factor that affects companies' green management (Buysse and Verbeke, 2002; Sharma and Henriques, 2004). Availability of external resources and environmental uncertainty are two main external environmental factors that have been considered to affect innovation diffusion and environmental strategies (Aragón-Correa and Sharma, 2003; Jeyaraj et al., 2006; Rothenberg and Zyglidopoulos, 2006).

Stakeholders are individuals or groups that affect and are influenced by the firm's business activities. Drawing on the stakeholder theory, companies carry out activities to satisfy the needs of their primary stakeholders. Stakeholder pressure has been considered the most critical factor affecting a firm's environmental strategy (Buysse and Verbeke, 2002; González-Benito and González-Benito, 2006; Sharma and Henriques, 2004). Among various stakeholder groups, regulators and customers are arguably regarded as the most critical stakeholders of a company (Christmann, 2004; Etzion, 2007). Many studies indicate that regulator and customer pressures have significant impacts on a firm's environmental activities (Christmann, 2004; Lee, 2008; Wong and Fryxell, 2004). Ho et al. (2014) argued that regulator and customer

pressures had a positive effect on the infusion of green practices for logistics companies in China. As a result, this study proposes the following hypotheses:

H6: Regulator pressure on the circular economy positively influences green practice infusion for SMEs.

H7: Customer pressure on the circular economy positively influences green practice infusion for SMEs.

Adopting environmental management green practices also depends on the availability of external resources. In addition to regulatory pressure, the government can also promote technological innovation through a number of support policies, such as offering technical resources and financial incentives, providing pilot projects, and issuing tax exemptions. Government support is also an important external environmental factor that affects technological innovation (Scupola, 2003; Tornatzky and Fleischer, 1990). The resource richness of the external operating environment can increase the extent to which a company invests in environmental management (Aragón-Correa and Sharma, 2003; Rothenberg and Zyglidopoulos, 2006). The government can help companies implement green practices in various ways, such as providing governmental subsidies or tax incentives, providing bank financing with lower interest rates for green practices, and providing lower insurance premiums to reduce environmental risks (Aragón-Correa and Sharma, 2003). Lee (2008) found that governmental support for environmental measures has a positive impact on the willingness of SMEs to engage in green supply chains. Ho et al. (2014) found that governmental support had a positive effect on the infusion of green practices for logistics companies in China. As a result, this study proposes the following hypothesis:

H8: Governmental support for the circular economy positively influences green practice infusion for SMEs.

Environmental uncertainty refers to unpredictable and frequent changes in technological developments, competitive behavior, and customer preferences that firms perceive. It is regarded as one relevant external environmental factor that affects corporate decisions (Li and Atuahene-Gima, 2002). Compared with companies in a stable environment, companies facing an uncertain business environment are often more willing to try and use more innovative strategies. In situations of high environmental uncertainty, firms may try to collect and deal with information quickly and frequently to cope with environmental changes (Gupta and Govindarajan, 1991) and tend to invest more resources in innovation. to maintain competitive advantage (Damanpour, 1991; Kimberly and Evanisko, 1981; Zhu and Weyant, 2003). Since the implementation of environmental management practices can be regarded as a technological innovation that can advance environmental performance in an uncertain operating environment, firms are more likely to invest resources in environmental innovation and maintain competitive advantages by implementing green practices (Aragón-Correa and Sharma, 2003; Rothenberg and Zyglidopoulos, 2006). Ho et al. (2014) argued that environmental uncertainty had a positive effect on the infusion of green practices for logistics companies in China. As a result, this study proposes the following hypothesis:

H9: Environmental uncertainty positively influences green practice infusion for SMEs.

2.2. Green practice infusion and circular economy performance for the SMEs

The circular economy aims to prevent pollution, protect the environment, and generate economic prosperity. Regarding the assessment of circular economy performance, several studies have proposed indicators for assessing and evaluating circular economy implementation. Sassanelli et al. (2019) have made a systematic review of circular economy performance assessment methods. This study expects firms' circular economy performance to be positively related to green practice infusion. It is believed that better environmental performance can be achieved when environmental practices are systematically identified and managed. The main goal of implementing green management practices is to improve environmental performance. Many studies have pointed out that the implementation of environmental management can positively improve environmental benefits (Etzion, 2007; González-Benito and González-Benito, 2006). As a result, this study expects that green practice infusion will be positively related to firms' circular economy performance and proposes the following hypothesis:

H10: Green practice infusion has positive influences on circular economy performance for SMEs.

3. Research methods

3.1. Samples and data collection

To test the proposed research hypotheses, this study took small and medium-sized enterprises in Taiwan as research subjects. The SMEs constitute a significant portion of the entire industrial sector in Taiwan. They may generate relevant impacts on the environment. Taiwan's government has begun to take the circular economy as an essential industrial development policy. This study collected data by mailing questionnaires to SMEs in Taiwan. The questionnaire was developed initially according to a review of research analyzing similar theoretical constructs and was modified by accommodating the opinions of some experts in environmental management and circular economy to ensure that each item was interpreted as expected.

In Taiwan, SMEs are defined as enterprises that have completed company registration or business registration in accordance with relevant laws and whose paid-in capital is no more than NT$100 million or who hire fewer than 200 regular employees. There are about 1.6 million SMEs in Taiwan. Because it is difficult to collect data from all SMEs, this study used the stratified random sampling method to select sampled SMEs according to the categories of company size and industrial types. Samples were drawn from the directory of small and medium-sized enterprises provided by the governmental department. The sampled companies were contacted via telephone and e-mail to confirm the names of respondents and their mailing addresses. Questionnaires were mailed to the owners or senior managers of these sampled companies who were familiar with the company's environmental activities. One thousand questionnaires were delivered to the sampled SMEs. Two weeks after the questionnaires were mailed, a follow-up was conducted to remind the sampled

companies of the importance of their responses. In total, 296 questionnaires were returned. Of these respondents, 28 unusable questionnaires were excluded. The overall response rate is 26.8 percent. **Table 1** shows the sample information.

Because a questionnaire survey was used in the study, it may suffer from non-response bias. This study used wave analysis to check the non-response bias. Comparing respondents who replied readily to the survey with those who replied after the follow-up step revealed that there are no significant differences between the two groups in the level of variables. As a result, the non-response bias is not an issue in the study (Armstrong and Overton, 1977). Furthermore, this also implies that the respondents were able to be representative of the whole population.

Table 1. Basic information of the sample.

	Category	Number	Percentage (%)
Number of employees	Below 20	53	19.8
	21–50	71	26.5
	51–100	82	30.6
	101–151	43	16.0
	151–200	19	7.1
Company history (Years)	0–5	47	17.5
	6–10	79	29.5
	11–20	89	33.2
	Above 20	53	19.8
Capital (Million, NTD)	Below 1	13	4.9
	1–5	31	11.6
	5–10	66	24.6
	10–50	84	31.3
	51–100	74	27.6
Industry	Manufacture	183	68.3
	Service	85	31.7

3.2. Measures

Green practice infusion is measured by the extent to which green practices in terms of circular economy (Esposito et al., 2018; Khan and Haleem, 2021; Zhu et al., 2010) are implemented in a complete and sophisticated way in a company, including the number of business operations in which a company has applied green practices and the extent to which primary business operations have integrated with green practices (Ho et al., 2014; Yan and Fiorito, 2007; Yu et al., 2009; Zhu et al., 2006). The assessment of circular economy performance was adopted from the circular economy performance measurements proposed in the literature (Mura et al., 2020; Negri et al., 2021; Rincón-Moreno et al., 2021) which were used in the study.

Measurement of the factors affecting green practice infusion of the SMEs was adopted from innovation diffusion literature (Ho et al., 2014; Lin and Ho, 2010). Complexity was measured by whether the environmental management practices in terms of the circular economy could be learned and used effectively and efficiently

(Ho et al., 2014; Lin and Ho, 2010; Sia et al., 2004). Compatibility was measured according to the degrees of the company's existing operation processes and perceived fitness between the environmental management practices in terms of circular economy (Chau and Tam, 1997; Ho et al., 2014; Lin and Ho, 2010; Sia et al., 2004). The relative advantage was measured according to whether the green practice could advance environmental and business performance (Ho et al., 2014; Lin and Ho, 2010). Organizational support was measured according to the degrees of managers' attitudes toward circular economy issues and the firm's resource support (Ho et al., 2014; Lee et al., 2005; Lin and Ho, 2010). The human resource quality was measured according to employees' learning capabilities in terms of circular economy (Ho et al., 2014; Lin and Ho, 2010; Scupola, 2003). Regulatory pressure and customer pressure were measured by scoring the circular economy pressure exerted respectively by regulators and customers (Álvarez-Gil et al., 2007; Ho et al., 2014; Lin and Ho, 2010). Governmental support was measured according to whether the government promotes technical or financial support for implementing a circular economy (Ho et al., 2014; Lee et al., 2005; Lin and Ho, 2010). Environmental uncertainty was measured based on the degrees of changes in the development of new technologies, customers' requirements, and competitors' innovative activities (Ho et al., 2014; Lin and Ho, 2010; Zhu and Weyant, 2003).

The survey items have been translated from English to Chinese and back-translated to check the accuracy of the translation. Some experts and business managers have also reviewed the questionnaire. To be suitable for the environmental management situation in SMEs, the instrument has been modified according to a series of discussions with some managers in SMEs and some experts in environmental management as well as circular economy. The questionnaire contains six parts: the company's basic information, green practice infusion, technological factors, organizational factors, environmental factors, and circular economy performance. In addition to the company's basic information, the other items measuring participants' perceptions of determinant factors, the extent of green practice infusion, and circular economy performance were measured using 5-point Likert scales anchored by "strongly disagree" and "strongly agree." The participants were asked to what extent they agreed or disagreed with the statement of each item.

According to the reliability coefficients, the smallest value of Cronbach's alpha for this study is 0.7981, as shown in **Table 2**, which implies that the sampling results are reliable (Nunnally, 1978). To evaluate the construct validity of this study, the TOE measurement items were submitted to factor analysis. **Table 2** summarizes the factors with eigenvalues greater than 1.0 and confirms the construct validity.

Because a single informant technique was used in data collection, this study may be subjected to the common method bias. Harman's single-factor test was used to check for potential bias (Podsakoff et al., 2003). The results revealed that the common method bias was not an issue in the study because more than one factor with eigenvalues greater than 1.0 was obtained, and the first factor took only about 32 percent of the variance.

Table 2. Measurement items for the TOE factors.

TOE Factors	Factor Loading	Cronbach's α
Technological Factors (Total explained variance = 73.68%; Cronbach's α = 0.8716)		
Relative advantage		
The circular economy practices can provide better environmental performance.	0.835	
The circular economy practices can provide higher economic benefits.	0.784	
The circular economy practices can enhance our company's reputation.	0.698	0.8803
Complexity		
Understanding the circular economy practices is difficult.	0.828	
Learning the circular economy practices is difficult.	0.793	
Sharing the knowledge of circular economy practices is difficult.	0.732	
Using circular economy practices requires many experiences.	0.681	0.8657
Compatibility		
The circular economy practices are compatible with our existing business operations.	0.789	
The circular economy practices are consistent with our company's values.	0.738	
Integrating the circular economy practices with the company's existing system is easy.	0.682	0.8710
Organizational Factors (Total explained variance = 72.74%; Cronbach's α = 0.8942)		
Organizational support		
Top management encourages employees to learn circular economy knowledge.	0.826	
Our company provides rewards for employees' green behavior.	0.784	
Our company provides resources for employees to learn circular economy knowledge.	0.705	
Top management can help employees deal with circular economy issues.	0.676	0.8935
Quality of human resources		
Employees are capable of learning new technologies quickly.	0.847	
Employees are capable of sharing knowledge.	0.802	
Employees are capable of using new technologies to solve problems quickly.	0.732	
Employees are capable of providing new ideas for our company.	0.681	0.9038
Environmental Factors (Total explained variance = 68.59%; Cronbach's α = 0.8163)		
Regulatory pressure		
The government sets environmental regulations for business operations.	0.834	
Industrial associations require us to conform to environmental regulations.	0.748	0.8418
Customer pressure		
Our customers require us to improve environmental performance.	0.826	
Caring for the environment is an essential consideration for our customers.	0.735	0.8032
Governmental support		
The government provides financial support for adopting green practices.	0.841	
The government provides technical assistance for adopting green practices.	0.803	
The government helps train the workforce with green business skills.	0.729	0.7981
Environmental uncertainty		
Predicting customers' preferences is difficult.	0.815	
Predicting competitors' behavior is complex.	0.784	
The advance in new logistics service modes is quick.	0.724	
Customers' preferences vary frequently.	0.657	0.8036
Total Cronbach's α = 0.8635		

4. Results and discussions

4.1. Hypothesis testing results

To test the proposed research hypotheses regarding the effects of technological, organizational, and environmental factors on green practice infusion in the context of circular economy, as well as the relationship between green practice infusion and circular economy performance for SMEs, the regression analysis is used in the study. In the present regression analysis, the regression assumptions of homoscedasticity, linearity, normality, independence of residuals, and the absence of multicollinearity are all satisfied. The number of employees, company history, capital size, and industry are taken as control variables in the regression analysis.

Table 3. Standardized regression result for the influences of TOE factors.

Dependent variable: Green Practice Infusion		
Predictors	**Standardized Coefficient β**	**t**
Technological factors		
Relative advantage	0.194	3.998**
Complexity	−0.103	−1.586
Compatibility	0.138	2.574*
Organizational factors		
Organizational support	0.211	4.637**
Quality of human resources	0.157	2.845**
Environmental factors		
Regulatory pressure	0.188	3.962**
Customer pressure	0.085	1.176
Governmental support	0.181	3.329**
Environmental uncertainty	−0.096	−1.271
Control variables		
Number of employees	0.036	0.834
Company history	0.041	0.893
Capital size	0.048	0.945
Industry	0.042	0.902
R^2	0.582	
adj R^2	0.569	
F	44.87**	
Durbin-Watson value	1.709	

$^*p < 0.05$, $^{**}p < 0.01$.

Table 3 shows the standardized results of the regression analysis. The results reveal that, except for hypotheses H2, H7, and *H9*, all the other hypotheses are supported. Relative advantage ($\beta = 0.194$, $p < 0.01$), compatibility of circular economy ($\beta = 0.138$, $p < 0.05$), organizational support ($\beta = 0.211$, $p < 0.01$), quality of human resources ($\beta = 0.157$, $p < 0.01$), regulatory pressure ($\beta = 0.188$, $p < 0.01$), and governmental support ($\beta = 0.181$, $p < 0.01$) exhibit significant influences on

green practice infusion for SMEs in Taiwan. The influences of complexity ($\beta =$ -0.103, $p > 0.05$), customer pressure ($\beta = 0.085$, $p > 0.1$), and environmental uncertainty ($\beta = -0.096$, $p > 0.1$) on the SMEs' green practice infusion are not significant. In a study of Chinese logistics companies, Ho et al. (2014) found that the complexity of technology, compatibility of technology, the relative advantage of technology, quality of human resources, organizational support, governmental support, and regular pressure have significant influences on the infusion of green practices for research respondents.

Table 4 shows a regression analysis of the relationship between green practice infusion and circular economy performance. It can be found that circular economy performance is positively associated with green practice infusion ($\beta = 0.203$, $p<0.01$). This means that hypothesis H10 is accepted that there is a positive relationship between green practice infusion and circular economy performance. The SMEs with a more excellent infusion of green practices will attain better circular economy performance.

Table 4. Regression result for green practice infusion and circular economy performance.

Dependent variable: Circular economy performance		
Predictors	**Standardized Coefficient β**	**t**
Green practice infusion	0.203	3.647**
Control variables		
Number of employees	0.032	0.735
Company history	0.028	0.684
Capital size	0.051	0.996
Industry	0.049	0.951
R^2	0.314	
adj R^2	0.257	
F	15.638**	

$^+ p < 0.1$, $^* p < 0.05$, $^{**} p < 0.01$.

4.2. Discussions

According to hypothesis testing results, the relative advantages and compatibility of the circular economy, organizational support, human resource quality, regulatory pressure, and government support significantly impact the green practice infusion of Taiwanese SMEs. Circular economy performance is positively correlated with green practice infusion. These findings provide meaningful implications for research and managerial practices.

4.2.1. Theoretical implications

This study can broaden the research scope of the circular economy by providing some explanations of the determinants and benefits of green practice infusion in SMEs. The organizational infusion perspective can provide insight into how firms make sense of green practice adoption and implementation. Furthermore, although the organizational infusion concept has been discussed in the literature, there is still

much to be conducted in the empirical study on environmental management for SMEs. This study can equip research on organizational infusion theory and circular economy implementation with some empirical evidence. A better understanding of the mechanisms supporting green practice infusion advances the development in improving circular economy implementation in SMEs.

While the circular economy has received considerable attention all over the world, SMEs may not see the circular economy as one priority because they are not aware of the benefits of the circular economy, and they usually have limited technical and financial resources. However, the circular economy offers a number of opportunities for SMEs, such as cost reduction, an increase in prestige, financial profitability, sustainability of the company in the long term, or recovery of the local environment. A circular economy should be the SMEs' strategy for building a competitive advantage by providing value for their customers with green products and services. Environmental management in SMEs has attracted limited research efforts compared to large companies. SMEs may have a significant impact on the environment. Increasingly conscientious consumers and market requests have demanded that businesses exhibit more significant concern for environmental management issues, regardless of their size. The SMEs are critical actors in the implementation of a circular economy as a basis for creating sustainable societies. The transition from a linear to circular economy is essential for SMEs because they are responsible for a large part of the world's generation of waste, emission of greenhouse gases, and use of resources. Therefore, it is necessary to study environmental management in the SMEs. Although several studies about the implementation of environmental management in SMEs have been performed around the world in recent years, much remains to be learned on this issue. None of them examined green practice infusion behavior for SMEs in the context of the circular economy. As a result, this study can contribute to the literature as an empirical study on the determinants and benefits of green practice infusion of SMEs in a circular economy context.

4.2.2. Practical implications

Company size has been regarded as one of the structural variables that most seem to influence the implementation of environmental management practices. A number of empirical studies reveal a significant relationship between company size and the implementation of green practices (Hörisch et al., 2014). However, various obstacles are preventing the SMEs from engaging in green business practices. Environmental management in SMEs may lead to sustainable success through the identification of necessary adjustments to their environmental impacts. The recognition of the importance of the SMEs' green practice infusion would be valuable for both managerial and academic contributions. The primary purpose of this study is to explore green practice infusion behavior for SMEs in Taiwan. While implementing green practices is of great significance to the sustainable development of the social economy and the sustainable improvement of the quality of human life, the significance of this study is to sketch a map for guiding Taiwanese SMEs to increase their green competitive advantage in the context of the circular economy. Understanding the relationships between green practice infusion and circular

economy performance, as well as the factors influencing green practice infusion in the context of circular economy, is essential for practitioners to implement environmental management best and for researchers to understand best the green issues that need to be addressed for SMEs. As the implementation of environmental management not only relates to the firms themselves but also needs the attention of the government, exploring SMEs' green practice infusion behavior can help the SMEs themselves appreciate the incentives and barriers to environmental management and give the government suggestions in designing environmental policies for the SMEs in the context of the circular economy. This study can help the government lay down guidelines for improving circular economy implementation for the SMEs. Because both governmental support and regulatory pressure have significant effects on green practice infusion for SMEs, in addition to setting up environmental regulations, the government can develop environmental support policies that can offer financial incentives and provide required resources and training for the SMEs.

Several SMEs are unaware of the influences of their business operations on the environment and the development of relevant environmental legislation (Burke and Gaughran, 2006). The SMEs are generally considered to lack a sense of commitment to the environment and are sometimes labeled as environmentally irresponsible. They may take environmental action only in response to sanctions and threats from the government and put less effort into the implementation of environmental practices and policies (Rao et al., 2006). However, according to the research results, the present study argues that some SMEs have shown themselves to have a green conscience and have made their business operations aligned with the trend of the circular economy. Those SMEs that have engaged in green practice infusion will have better circular economy performance.

5. Conclusions

The circular economy has received considerable attention worldwide because it is regarded as a solution to climate change and natural environmental problems. It offers an opportunity to optimize and promote sustainable production and consumption through new models based on continuous growth and limitless resources. Taiwan has recently also been promoting an industrial development policy about the circular economy, with which pollution and waste treatment will follow a model of economic output that aims to achieve zero emissions, zero waste, and zero accidents. SMEs play an essential driving force in Taiwan's economic growth and employment. They represent about 98% of Taiwanese firms and constitute a relevant part of the entire industrial sector in Taiwan. Many SMEs may generate a great deal of environmental contamination. The SMEs are critical actors in the implementation of a circular economy as a basis for creating sustainable societies in Taiwan. The prevalence of the circular economy concept derives from the need for implementing green practices in SMEs. It is necessary to explore the SME's peculiarities in their determination to face environmental management problems as well as to suggest applicable mechanisms for their engagement in circular economy.

Drawing the TOE model, this study shows that the relative advantages and

compatibility of the circular economy, organizational support, human resource quality, regulatory pressure, and government support significantly impact the green practice infusion of Taiwanese SMEs. The effects of complexity, customer pressure, and environmental uncertainty on SMEs' infusion of green practices are not statistically significant. Circular economy performance is positively correlated with green practice infusion. This study can broaden the research scope of SMEs' environmental management and contribute to a deeper understanding of SMEs' green practice infusion and circular economy.

There are some limitations to the present study. Because the SMEs cover a wide range of industrial categories. In the study, we did not consider the influences of industrial categories of SMEs on the infusion of circular economy practices. Different industrial categories might lead to different effects of technological, organizational, and environmental factors on the infusion of circular economy practices for SMEs. It is worthwhile to conduct further studies on the moderating effect of industrial categories on the infusion of circular economy practices in organizations. In addition, this paper only explored the organizational infusion of circular economy practices for SMEs in Taiwan. The current study may be limited in its generalizability. It will be worthwhile to advance a cross-national comparative study on the infusion of circular economy practices among SMEs in Taiwan and other countries. Moreover, the present study only considers the factors that have been widely used in the literature of organizational innovation and environmental management. Other possible factors that influence SMEs' circular economy infusion behavior can also be taken into consideration in future studies.

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