What Hinders Hotels' Adoption of Environmental Technologies: A Quantitative Study

Abstract

In response to our planet's severe environmental problems, many businesses use environmental technologies to strengthen their environmental performance. However, the adoption rate of using such technologies in hotels is still slow, and very few quantitative studies have examined the reasons why. This study examined the barriers to environmental technology adoption in the Hong Kong hotel industry. We sent 648 questionnaires to the target sample and eventually received 102 completed responses. Seven barriers were identified: (1) monopolised after-sales service; (2) human resource limitations; (3) government and initial support; (4) financial performance; (5) lack of green knowledge and green network; (6) customer experience; and (7) environmental feasibility. An independent samples *t*-test and analysis of variance (ANOVA) were conducted to investigate the relative significance of the seven barriers for different hotel demographic variables. This study offers specific theoretical and practical implications. Recommendations for the industry are also provided.

Key words: Environmental technologies, hotels, quantitative study, barriers

1. Introduction

In 2016, the American billionaire Bill Gates, co-founder of Microsoft, responded to the world's growing environmental problems by partnering with international business leaders including Virgin Group founder Richard Branson, Amazon founder Jeff Bezos, Chairman of Alibaba Jack Ma, and Bloomberg LP founder and former New York City mayor Michael Bloomberg to invest US$1 billion in clean energy technologies to fight climate change (South China Morning Post, 2016). This action illustrates the importance of technological solutions to various environmental problems. Many hotels have implemented environmental management systems (EMSs) and formed green committees to improve their environmental performance due to pressure from external stakeholders such as hotel guests (green travellers), business partners (e.g., event organisers and travel agents), environmental groups and shareholders in their holding companies. For instance, about 71% of TripAdvisor members who participated in the travel site's 2012 survey indicated that they would make eco-friendly choices when travelling (TripAdvisor, 2012).

In parallel with the implementation of EMSs, many hotel companies have adopted environmental technologies to help meet their environmental goals. According to Chan et al.

(2005), about 80% of hotels realise the advantages of using environmental facilities and technologies to optimise their environmental performance. These technologies include light-emitting diode lights, fluorescent tubes, occupancy detectors, in-room smart key systems for controlling electricity use, water-cooled chillers and food decomposers (Chan et al., 2017). Some upscale hotels in Hong Kong have implemented building management techniques that control the hotels' air conditioning systems and use occupancy sensors to turn off lights and other electrical appliances when rooms or corridors are vacant. For instance, the Holiday Inn Express Hong Kong SoHo, with the expectation of increasing profit margin and financial return, installed innovative environmental technologies such as Peltier headboard coolers, energy-saving pattern recognition solutions and solar hot water collector systems, and used green materials and environmentally friendly methods in its construction (Business Traveller Asia-Pacific, 2012). Luxury hotel, Mira Hong Kong has used a food decomposer to liquefy leftover food before discharge to reduce food waste (Chan et al., 2017; 2018). Cheung and Fan (2013) illustrated that environmental technologies are normally used in air-conditioning-related control, heat energy generation, lighting, motors, electricity generation and water supply. Notwithstanding these advantages, many hotels remain hesitant to adopt new environmental technologies. This prompted us to comprehensively investigate this important matter to understand what makes some hoteliers 'stop' or 'postpone' when considering adoption of the technologies and to assess whether demographic characteristics of hotels matter.

In the academic world, very few studies of environmental technologies have focused on the hotel industry, although many studies have concentrated on other businesses. For instance, Jaffe et al. (2005) investigated the relationship between technology and environmental policy to help develop strategies for tackling various environmental problems. Brunnermeier and Cohen (2003) examined how green innovation by U.S. manufacturers responded to regulatory alterations. Rutberg (2002) investigated the impact of plasma technologies on environmental protection. Krass et al. (2013) studied the possibility of using environmental taxes to motivate companies to adopt emissions-reducing technologies. Quitzow (2015) developed a comprehensive model for evaluating policies that promote environmental technologies.

In one of the rare studies of the hotel industry, Chan et al. (2017; 2018) investigated the applications of environmental technologies in hotels and the barriers to their adoption. Despite the barriers identified in Chan et al. (2018), this current study focuses on three specific research questions: (1) What barriers will impede hotels the most when they plan to adopt an environmental technology? (2) Do different types of hotels encounter the same barriers? and (3) Will hotels that are currently implementing a formal environmental management system encounter fewer barriers? It is clear that further research on the hotel sector is needed, as hotels are 24/7 operations that consume significant amounts of energy and water and produce various types of waste, such as food waste, empty plastic/glass bottles and partially used soap. Some waste is seemingly inevitable, as hotels must provide personalised, high-quality services to customers, and this priority affects their adoption of environmental initiatives (Chan and Hawkins, 2010). Due to the rapid growth in visitor arrivals (58.47 million in 2017) (Hong Kong Tourism Board, 2017), the number of hotels in Hong Kong is expected to increase from 283

(79,231 rooms) in March 2018 to 327 (90,893 rooms) in 2021 (Hong Kong Tourism Board, 2018). The rising number of hotels will inevitably lead to more energy and water consumption and increased solid waste generation. Environmental technology, which has a great impact on hotel environmental management and performance (Kasim, 2015; Kim, et al., 2017; Pereira-Moliner et al., 2015; Yoon et al., 2016), is thus an important area of research.

This research is also a response to Chan and Hsu's (2016) study of the environmental management literature in the hospitality field, which reviewed 149 hospitality environmental management studies published from 1993 to 2014. Their analysis indicated that previous studies typically focused on environmental policies and practices, EMSs, environmental benchmarking, indicators and reporting, environmental performance, managers' green attitudes and green consumerism and marketing, and suggested that scholars consider examining the application of environmental technologies. In addition, our study is guided by Chan et al.'s (2018) indication that quantitative research is essential for investigating the barriers to environmental technology adoption in the hospitality field. As their qualitative study is only a preliminary step to understanding these barriers, confirmatory research with larger hotel samples is needed to expand on their findings. Therefore, the current study employs a quantitative survey research method to investigate the barriers to adoption and evaluate how different types of hotels, and hotels with or without a systematic environmental programme experience the identified challenges. This method can ease cross-sectional assessments and comparisons across hotels and individual managers. To be specific, building on the barriers identified by Chan et al., this research seeks to (1) examine the barriers to the adoption of environmental technologies using a quantitative approach, (2) assess the relative importance of these barriers, (3) examine whether hotel demographic characteristics affect these barriers and (4) make suggestions for minimising the barriers.

2. Literature review

When studying innovations in the hospitality industry, de la Peña et al. (2016) and Horng et al. (2018) emphasised that hotels should develop innovative activities to improve the efficiency of their operations and make their products and services more attractive to maintain their competitiveness. According to Nieves and Segarra-Ciprés (2015), technology is a common way of improving a company's innovation. In the hotel industry, hoteliers use various technologies to take bookings, check guests in and out, take food and beverage orders, improve security and fire safety, control indoor air quality, save energy and water and reduce waste, among other tasks (Bilgihan et al., 2011; Collins and Cobanoglu, 2008; Cobanoglu et al., 2011; Okumus, 2013; Pesonen and Horster, 2012). The Henn-na Hotel near Nagasaki in Japan has gone one step further and uses high-tech robots to perform front desk, concierge and housekeeping jobs, making it one of the most efficient hotels in the world (The Guardian, 2015).

In terms of environmental protection, many companies have adopted proactive rather than passive methods to improve their environmental efficiency and performance (Fraj et al., 2015).

Proactive, innovative environmental strategies require companies to continuously improve their product, service and operation processes and to adopt new technologies. Shrivastava (1995, p. 187) defined technologies used for environmental protection as those that "limit or reduce the negative effects of products or services on the natural environment." Del Río González (2009) further categorised these technologies as (1) end-of-pipe technologies and (2) cleaner production technologies.

Studies of the reasons for adopting environmental technologies have identified different forces driving adoption. For instance, technological change can be triggered by various needs such as improving efficiency, reducing costs, complying with environmental regulations, demonstrating organisational environmental commitment, fulfilling the requirements of EMS such as ISO 14001 (Balcombe et al., 2013; Demirel and Kesidou, 2011) and heeding the pressure to adopt benign processes and develop greener products (Vachon, 2007). The environmental advantages provided by solar energy are also a motivator for change (Tsoutsos et al., 2005). Blair (2003) further indicated that the primary tangible benefit of environmental technologies is the improvement of heating, ventilation and air conditioning systems, which can significantly reduce the consumption of energy and resulting cost (Chua et al., 2013).

In the hotel industry, Shiming and Burnett (2002) recommended that hotel operators reduce the consumption of electricity by implementing energy management programmes based on high-tech energy-saving equipment. Mehta (2007, p. 421) also argued that energy-saving kitchen equipment and renewable-energy technology could be used in hotels to reduce energy consumption, that low-flow showerheads could be used to save water (Barberán et al., 2013) and that solid waste could be composted to reduce the costs of disposal (Radwan et al., 2010). Solar collectors can be used to produce sanitary hot water, heat swimming pools and provide solar cooling (Zografakis et al., 2011). Chan et al. (2017) confirmed the savings potential of environmental technology applications in hotels.

All of these studies demonstrated the value of environmental technologies. Indeed, hotel customers increasingly demand "green" hotels that incorporate environmental ideas and facilities into their design and even pay more for green products/services (Kang et al., 2012; Leonidas, 2004). From the hotel business perspective, the installation of environmental technologies may please the increasing number of green travellers who select hotels in part based on their environmental facilities and initiatives. In short, by practising green initiatives, hotels and other hospitality businesses can lower their operational costs and improve their image to attract green consumers and contribute to sustainable hotel and tourism development (Farrington et al., 2017; Kim, et al., 2017; Jones et al., 2016; Nicholls and Kang, 2012; Tang and Lam, 2017).

Despite the potential advantages of environmental technologies, some hotel operators remain sceptical because they are doubtful of the return on investment (ROI) and lack sufficient time to manage the adoption and implementation of the new technologies (Sloan et al., 2013). A lack of knowledge and staff availability may also be key obstacles to the adoption of green initiatives in the workplace (Levy and Dilwali, 2000). Chan (2008; 2011) found that the main barriers to green initiatives (e.g., EMS) were insufficient environmental knowledge, skills,

professional advice and resources; management uncertainty about environmental performance; implementation costs; a lack of urgency; ambiguity of some green label standards; quality of the standards of consultants; conflicting guidance; and inconsistent support. According to Richardson and Lynes (2007), who employed a qualitative method to investigate the institutional motivations and barriers to green building construction, priority was often given to construction timelines and budgets rather than the benefits. Additionally, the same authors found that the perception that designing and constructing a green building requires higher initial capital costs negatively affects views on green construction and environmental management.

Studies of other industries have identified some barriers to the adoption and implementation of environmental technologies. For instance, Grover and Goslar (1993) found that a lack of centralised organisational decision-making and formalised operating processes influenced the adoption of innovative technologies such as environmental technologies. Levy and Dilwali (2000) indicated that limited budgets and knowledge, a lack of institutional performance indicators and the difficulty of calculating environmental benefits could prevent directors of university facilities from using technologies to reduce their institutions' environmental impact. Lay et al. (2013), investigating green technology adoption by higher education institutions, identified similar barriers to adoption. Challenges were identified like (1) high technology adoption costs; (2) a lack of environmental knowledge, which could negatively influence the attitudes of individuals towards adoption; (3) a lack of green awareness, which could make company employees unaware of the importance of complying with environmental policies, procedures and benefits; (4) a lack of trust, triggering individual disconfirmation on the adoption and making the decision-making process more complicated and difficult; (5) adoption scepticism, especially when consumers are doubtful about the adoption of a green technology; (6) a low institution adoption rate due to a feeling of inferiority or uncertainty about the environmental technology; and (7) difficulties in switching from an existing system to a new green technology due to loyalty and comfort.

Suppliers also play a contributing role to barriers. Vachon and Klassen (2006) concluded that a lack of knowledge transfer from suppliers was an important obstacle to the use of pollution-prevention technologies in the package printing industry. However, few studies have investigated the obstacles that hinder hotels from adopting environmental technologies. One exception, Chan et al. (2018), used a qualitative approach to identify three categories of barriers to adoption in the hotel industry: (1) product-related, (2) external and (3) internal barriers. Product-related barriers include products' immaturity, which normally results in a very limited performance record but a high purchasing cost; unreliability, which may trigger an unexpected breakdown; a high initial cost that requires a longer payback period; and a costly on-going maintenance service package, which is normally controlled by the sole agency of a new technology.

External barriers result from local governments causing inconvenience in the lengthy application process in cases where the physical environmental must be changed for the technology installation, unpredictable weather that affects the use of such renewable energy as solar energy and the experiences of hotel guests, who may raise complaints against the hotel's green practices as a result of the affected service quality. Meanwhile, internal barriers mainly

result from the hotel's physical limitations that make the installation of environmental technologies impossible; a lack of owner initiative that results in no money for investment; budgetary priorities, as the installation of such technologies is not normally considered a top agenda item; a lack of resources such as time, manpower and budget during the period of environmental technology adoption; the influence of daily operations, which results in an increase in staff workload and customer service deterioration; and management contract durations that force senior management to focus on projects with the fastest ROI. These barriers are likely to reduce the motivation of senior hotel management to adopt the technologies unless they are essential to survival.

In addition to the barriers identified by Chan et al. (2018), another possible barrier is hotel operators' limited knowledge of the technologies. Similarly, Law and Jogaratnam (2005), in their study of hotel IT applications, concluded that hotel managers' reluctance to adopt new technologies was mainly due to poor knowledge of information technologies. Hotel managers may have concerns that a technology will negatively influence personalised services provided to hotel guests, and they may react in the same way to environmental technologies. Our study uses the draft framework for possible barriers to adopting environmental technologies developed by Chan et al. (2018) and investigates whether the same barriers can be identified and generalised from a larger sample size from the hotel industry. It also examines the relative importance of the barriers and differences based on hotels' demographic characteristics.

3. Methods

A research instrument developed in previous studies (Chan et al., 2018) was used. Using a dichotomous-selection test previously used by hospitality scholars (e.g., Chan, 2008; Chan and Kuok, 2011; Wong and Pang, 2003), we pilot-tested the instrument with 11 hotel professionals to validate the items' reliability. The hotel professionals included general managers, resident managers, directors of finance, housekeeping directors, engineering directors and EMS managers, all of whom had been involved in planning their hotel environmental technology adoption. The hotel professionals were asked to choose either 'yes' or 'no' in response to statements about factors hindering the adoption of environmental technologies in hotels. Factors regarded as barriers by fewer than 50% of the respondents were eliminated. The remaining 22 statements were used in the main study. In the final questionnaire, the 22 statements were randomly ordered to minimise response bias. All the respondents were invited to assess the barrier statements on a 5-point Likert-type scale (1 = strongly disagree; 5 = strongly agree) to indicate their level of agreement. Information about their hotels' EMSs, green-certification status, environmental programme auditing history and establishment of green committees was also obtained, in addition to demographic information about the hotels.

The target population comprised employees at Hong Kong hotels listed by the Hong Kong Hotels Association. Six hundred and forty-eight questionnaires were sent to the following employees at 162 hotels: (a) the general manager/resident manager, (b) the director of engineering/chief engineer, (c) the EMS manager and (d) the director of finance. These

executives were chosen because individuals in these positions are usually highly involved in planning and purchasing environmental technologies for their employers. To maximise the response rate and to make the process of returning the completed questionnaire more convenient, each respondent was given a stamped envelope. The response rate was approximately 16%, with 102 responses. As multiple responses were received from some hotels (18 hotels provided 2 responses and 5 hotels provided 3 responses), the actual number of hotels represented was 74.

All 102 of the completed questionnaires were statistically analysed using the Statistical Package for the Social Sciences (SPSS), as informants at the same hotel company may have had different experiences of environmental technology decision-making. Principal component analysis with varimax rotation was used in the exploratory factor analysis to identify the underlying attributes of the hotel industry that could hinder the adoption of environmental technologies. The independent samples *t*-test and analysis of variance (ANOVA) were then used to observe the differences and correlations between barriers and hotel demographic variables such as hotel size, ownership, class, green certification and formal EMS implementation.

4. Results

4.1 Respondents' profiles

Of the 102 respondents, 24.5% were general managers/resident managers, 40.2% were directors/assistant directors of engineering, 10.8% were directors of finance, 4.9% were EMS managers and the rest were IT directors/managers and directors of operations. Respondents working at locally owned hotels made up 83% of the sample, and those working at foreign-owned firms comprised 11%. However, more than 50% of the respondents indicated that their hotels were internationally branded (international hotel chains), whereas only 32% of the respondents worked at locally branded hotels (local hotel chains). Hotels that had previously won a green award employed 48% of the respondents. Most of the respondents (85.3%) worked at four- or five-star hotels; only 8.8% were employed by three-star hotels. Hotels with more than 300 rooms employed 71.6% of the respondents, and 28.4% worked at hotels with 50-300 rooms. None of the respondents worked at hotels with fewer than 50 rooms. More than 50% of the respondents indicated that their hotels employed a specialist responsible for environmental programmes and that these programmes had been/were being audited. Approximately 70% of the respondents stated that their hotels had already established a green committee. Fewer than 30% of the respondents planned to obtain green certification for their hotels within a year, but approximately 50% reported that a formal EMS would be implemented at their hotels within a year.

4.2 Exploratory factor analysis

Using principal component factor analysis of the 22 barrier statements, we identified constructs that hindered hotels' adoption of environmental technologies (Loker and Perdue, 1992). A factor loading of 0.5 was set as the criterion (Hair et al., 1998); statements with loadings lower

than 0.5 on all of the factors, or loadings of 0.5 or higher on more than one factor, were eliminated. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy showed a practical level of common variance (KMO = 0.722), and Bartlett's test of sphericity yielded a value of 873.016 with a 0.000 significance level. These figures indicated that the data were correlated and suitable for factor analysis. The communalities obtained for the statements were quite high, ranging from 0.52 to 0.90, indicating that the variance of the original values was captured fairly well by the seven factors identified. Eigenvalues were used to identify meaningful factors, with the cut-off set at 1.0. As a result, seven barriers measured by 19 barrier statements with eigenvalues greater than 1 were identified and analysed; they were found to account for 69.2% of the variance. The reliability coefficients of the seven factors ranged from 0.57 to 0.91, exceeding the recommended value of 0.50 (Nunnally and Bernstein, 1994), which indicated good internal consistency across the barrier statements within each factor. Table 1 gives the names of the seven factors, reflecting the content of their items.

Factor 1: Monopolised after-sales service

Factor 2: Human resource limitations

Factor 3: Government and initial support

Factor 4: Financial performance

Factor 5: Lack of green knowledge and green network

Factor 6: Customer experience

Factor 7: Environmental feasibility

(Insert Table 1 about here)

4.3 ANOVA and t-test

To examine the varying effects of the seven barrier factors on hotels with different demographic variables, an independent samples *t*-test and ANOVA were carried out. Table 2 shows that the mean value obtained for financial performance was significantly higher for independent hotels (hotels that were not part of a hotel chain) than for locally branded and internationally branded hotels ($p < 0.05$), indicating that independent hotels were more influenced by this barrier than locally or internationally branded hotels. In terms of customer experience, the mean value obtained was significantly higher for independent hotels and internationally branded hotels than for locally branded hotels ($p < 0.05$), indicating that independent and internationally branded hotels gave more weight to customer experience when considering whether to adopt environmental technologies than their locally branded counterparts.

In the *t*-test conducted to compare the effects of all seven barriers on hotels with and without ISO 14000 certification, the mean scores for human resources limitations and financial performance were significantly higher ($p < 0.05$) for the uncertified hotels. In other words, hotels without ISO 14000 certification were more strongly hindered by human resource limitations and financial performance than certified hotels. Similarly, hotels with green awards were less affected by financial performance and a lack of green knowledge and a green network ($p < 0.05$) than hotels without green awards. The same barriers had a greater influence on hotels without an audited environmental programme than on hotels that already had an audited environmental programme. Hotels without green committees or environmental managers were more powerfully influenced by the lack of green knowledge and a green network ($p < 0.05$).

(Insert Table 2 about here)

5. Discussion

Some of the barriers identified are similar to those found in the qualitative study of Chan et al. (2018), such as ongoing maintenance costs and long payback periods (product-related barriers), government interference and negative influence on the customer experience (external barriers) and a lack of human resources (internal barriers). Therefore, this study not only validates some of the barriers mentioned by Chan et al. but also identifies some new factors. The following sections discuss the identified barriers and their relative importance in detail.

5.1 Top three barriers

Analysis of the seven identified barriers' overall mean values shows that Factor 7, environmental feasibility, is the most important barrier to environmental technology adoption in hotels; it has a mean value of 3.70. Environmental feasibility, in terms of technical and cost feasibility, exerts a strong influence on adoption. Hotels have a strong interest in using environmental technologies. However, before specific environmental technologies can be adopted, implemented and maintained, the surrounding environment, weather and orientation must be considered, especially for renewable energy technologies such as solar-powered panels.

Physical environmental constraints are likely to affect management's decision on whether to adopt a technology. For example, a lack of sunny weather or too many surrounding buildings may prevent solar panels from generating sufficient solar energy (Gharakhani Siraki and Pillay, 2012). All of these factors may affect technical feasibility. Furthermore, long payback periods for investment affect cost feasibility, thus preventing hotels from adopting environmental technologies. Due to the structure of management contracts, many hotel management companies prefer that the ROI be as early as possible (Chan et al., 2018; Newell and Seabrook, 2006). A director of finance of an international hotel group stated to the first author that any new projects/facilities that required a ROI period longer than five years would probably go unimplemented. This criterion is understandable, as hotel management companies are normally required to optimise profits for owners within the agreed-upon management period. Any project requiring a long payback period is a big headache for a hotel management company unless it gains the support of the owners.

Despite the difficulties of environmental constraints and long payback periods, hotel managers still have ways of strategically influencing senior management/owners to support the installation of green technologies. For instance, Chan et al. (2018) suggested that hotel managers should start with a relatively "small scale" project (e.g., installation of water restrictors in guest rooms) with immediate and obvious benefits – in this case, water cost savings. To save energy, using lighting with built-in small solar panels to illuminate public outdoor areas (Wu et al., 2009) may also be considered. Once an environmental technology positively contributes to the company's financial statement, senior managers/owners can be encouraged to support the adoption of larger scale environmental technologies that require additional manpower, time and money. Of course, a detailed cost-benefit analysis for adoption is essential. However, to improve technical feasibility, comprehensive analysis of a hotel site's quality, such as its orientation and the surrounding environment, and incorporation of the possible environmental initiatives and technologies into the design phase of the hotel building construction may help.

The second most important barrier is the lack of green knowledge and a green network, which has a mean value of 3.55. It is obvious from the statements listed in this factor that a lack of green knowledge can hinder managers from adopting environmental technologies. It is hard to determine whether a new environmental technology is suitable. Hotel managers hesitate to adopt an environmental technology if they are unsure of the benefits to be obtained. In addition, a lack of trade association/business network support discourages hotels from adopting technologies, especially as most hotels lack knowledgeable specialist staff for environmental initiatives (Chan, 2008; Negro et al., 2012). Without such a network, it is difficult for hotel managers to equip themselves with updated green knowledge and obtain valuable information and examples from the industry and relevant business partners for benchmarking. The *t*-test results also indicate that hotels with no green committee/EMS managers, no green awards and unaudited environmental programmes are more influenced by this barrier, which is in line with the findings of Sroufe (2003) and Chan (2008) and indicates that a lack of operational structure blocks companies from adopting and implementing green initiatives. This finding implies that an audited, well-developed environmental programme can improve hotel employees' knowledge of environmental technologies and access to network support.

A formal structure to promote environmental management (Kim et al., 2015; Yoon et al., 2016) makes it more efficient and effective for a hotel to build a green culture by encouraging managers to learn more through formal training and to establish a network through participation in local hotel associations' green committees or in green associations. Hotel managers may experience benefits once a formal structure/system is established. To keep themselves current on the latest developments and assess the feasibility of adopting technologies, managers must regularly communicate with environmental technology companies. Therefore, hoteliers are strongly encouraged to consider a formal EMS standard to ensure more systematic, effective and efficient environmental management from which better environmental knowledge can be imparted to hotel employees. Meanwhile, a better network with important strategic stakeholders may be established due to the requirements of the standard (e.g., ISO 14001).

Monopolised after-sales service is the third most important barrier, with a mean value of 3.52. Reliable after-sales service is essential to ensuring that the adopted environmental technology functions properly. However, a single contractor often monopolises after-sales service of new technologies for a long period due to the impact of technological change on the skills of a company's in-house maintenance workers (Cooke, 2002). It is risky for a hotel to rely on one service provider when the service may influence hotel guests' experiences. This concern hinders hotels' adoption of environmental technologies. The monopoly further results in high on-going maintenance costs. Therefore, hotels planning to adopt an environmental technology should work closely with different dealers to explore market options for after-sales service and maintenance costs. This information puts them in a better position to negotiate with dealers to achieve a win–win situation. Maintaining close relationships with main service providers to ensure efficient maintenance especially during emergencies is recommended. Hotel managers should treat service providers as their strategic partners. In addition, to increase hoteliers' confidence in environmental technologies, dealers who provide after-sales service should assist hotel companies in implementing the adopted technology, including regular checks of hardware/software setups to optimise efficiency and reduce risk.

5.2 Other barriers

In addition to the aforementioned three major barriers, this study identifies four others. Based on overall mean score, the other barriers, in order of importance, are government and initial support, customer experience, human resource limitations and financial performance. These factors are discussed in this section.

Chan et al. (2018) also identified government and initial support as a barrier to the adoption of environmental technologies. In terms of government support, lengthy and complicated administrative processes for adopting technologies (e.g., the approval process for changing the use of spaces in the hotel for new facilities) may influence hotel managers' decisions. Furthermore, the installation of environmental technologies such as heat pumps, solar panels, computerised energy management systems and occupancy sensors requires significant amounts of money. Some facilities such as food decomposers and heat pumps need a considerable amount of space for installation. Without sufficient space and resources, hotel managers may find it difficult to adopt these technologies successfully. These findings confirm the observation of Zhang et al. (2011) that technical difficulties, a long planning and approval process, a lack of awareness and required knowledge, inefficiency in implementing green building regulations and stakeholder different interests are the major negative influences on green property development. Therefore, streamlining governmental administration processes in addition to providing initial support is vital for successful adoption; users can quickly accept innovative technology if local government provides sufficient support in the form of relevant laws, regulations and information (Tan and Teo, 2000).

Hotel managers may consider working with the local hotel owners' association to lobby local government to improve existing procedures. Chan et al. (2018) suggested that hotel developers

should incorporate green ideas such as the installation of environmental technologies during the design phase of new hotels or major renovations to avoid the complicated governmental administration process that old hotels (in operation for over 10 years) normally encounter when they attempt to change the use of a particular space. The availability of resources for the adoption of environmental technologies relies on the consistent support and commitment of hotel senior management, which is an important success factor (Chan and Wong, 2006; Lutz, 2000). Without this support, hotels may experience delays in adoption.

Customer experience is also a barrier to the adoption of environmental technologies. Despite increasing demand for environmentally friendly products, hotel managers may encounter difficulties in balancing good service provision with environmental performance (Chan and Wong, 2006; Yu et al., 2017). Some hotel guests never accept compromises on quality, performance and convenience when using green products and services (Ginsberg and Bloom, 2004). The ANOVA/*t*-test also indicates that this concern is of greater importance for internationally branded hotels. This result is understandable, as internationally branded hotels are likely to emphasise good and consistent service quality to maintain their brand around the world.

There is no doubt that some environmental initiatives can have a negative effect on guest services. For instance, water flow and pressure can be affected when a water restrictor is installed in the showerhead, or the in-room temperature may be higher (25°C) than hotel customers' expected comfort zone (21°C-23°C). To deal with these issues, hotel managers could educate their customers by developing an effective green marketing plan that promotes the hotel's green facilities, services and other green activities (Chan, 2013; 2014; Wang et al., 2018), in hopes that guests would be more accepting of green hotel initiatives. Furthermore, giving hotel guests such incentives as cash discounts or meal coupons may be an effective way to motivate them to actively participate in those activities. For instance, Hotel Okura Macau, which received the 'Green Hotel – Gold Award 2015' from the Environmental Protection Bureau in collaboration with the Macao Government Tourism Office, established a reward mechanism by providing Macanese Patacas with a $5 discount for guests to motivate them to bring their own reusable food containers for takeaway.

Some hotels may not have the time or manpower required to adopt environmental technologies. Traditionally, making money for owners by providing well-managed lodging and accommodation and ensuring quality guest services is the number one aim of the hotel industry (Chan, 2008; Chan, 2011). Therefore, hotel managers must keep a wary eye on the profitability and services of their hotels; protecting the environment is unlikely to be their priority. It is very common for an executive to wear multiple hats when supervising a hotel's environmental programme. Our findings show that human resource limitations are the greatest barrier for hotels without formal EMS standard certification (e.g., ISO 14000). This finding is logical, as without environmentally knowledgeable people with adequate skills, uncertified hotels are likely to experience delays in the adoption of environmental technologies. Nevertheless, hotels with limited manpower should actively educate themselves by inviting suppliers/companies selling green products and technologies to the hotel to share information with managers, as integrating the technologies to enhance operational efficiency is necessary to maintain

competitiveness. In addition, hotel operators may adopt a top-down decision-making approach to facilitate the adoption of green technologies (Chan and Hawkins, 2010), as internal leadership is a key ingredient of successful environmental projects (Richardson and Lynes, 2007).

Financial performance is the least important barrier to the adoption of environmental technologies, with a mean value of 2.46. The mean score of the factor is slightly skewed toward the negative end of the scale, indicating that some managers feel that adoption hurts a hotel's financial performance or creates a deficit; however, most perceive environmental technologies as ways to improve financial performance by saving energy and water costs and reducing waste. These inconsistent perceptions are likely due to the long payback period and expensive maintenance costs of some technologies. Our findings also indicate that hotels which are independent, lack audited environmental programmes or formal EMS standard certifications and have not received green awards are more influenced by financial barriers, implying that such hotels are less likely to experience the benefits of a well-developed environmental programme. This result echoes Nicholls and Kang's (2012) finding that chain-affiliated hotels have a more positive view of environmental protection than do independent hotels. When considering the purchase of environmental technologies, hotel managers may therefore start with environmental technologies that help to reduce electricity usage, which normally dominates hotel energy consumption (Chan, 2005). In addition, companies selling such technologies can demonstrate the benefits of energy-saving technologies to potential customers.

6. Conclusions

This study lays a foundation for in-depth research into the obstacles to the deployment of environmental technologies in hotels. By offering empirical findings on environmental management and technologies and discussing them in detail, it contributes to the environmental management literature by expanding the horizon of the adoption of technologies through a quantitative approach, which has greater chance to generalise the research results. In addition, this study helps validate some of the findings of the qualitative study conducted by Chan et al. (2018) and introduces new possible barriers to the adoption of environmental technologies, such as monopolised after-sales service and financial performance. Using a quantitative analysis, this study further uncovers which barriers are most important for hindering hotels from adopting the technologies, explains the differences in hotel demographics on the issue and makes an important contribution to any consideration of the changing demography of hotels and therefore the adoption of environmental technologies.

Studies of environmental management have mostly emphasised the driving forces behind implementing environmental systems/programmes, examined the process of implementation, developed eco-labels or proposed an EMS; only a few have attempted to study the adoption of environmental technologies. This research asks what barriers to adoption will bother hoteliers most. The findings reveal that the most common obstacles to adoption, ranked in order from

greatest to least, are (1) environmental feasibility, (2) lack of green knowledge and green network, (3) monopolised after-sales service, (4) government and initial support, (5) customer experience, (6) human resource limitations and (7) financial performance. The barriers identified in this study generalise some of the findings of Chan et al. (2018). They also echo Chan's (2008) finding that internal barriers are the major barrier to adoption of some environmental facilities and programmes. These internal forces are mainly related to hotels' physical structures, money, employee environmental knowledge, hotel green networks and financial performance. Another important research question of this study is whether or not different types of hotels encounter the barriers identified. Findings indicate that while both independent and chained hotels emphasise the impact of green technology on customer experience, independent hotels are more influenced by financial barriers. To address the last research question of this study, our findings also indicate that hotels with green awards, a green committee in place, audited environmental programmes and formal EMS standards (e.g., ISO 14001) are less influenced by the identified barriers. This implies that a well-developed environmental programme reduces barriers to the adoption of environmental technologies.

Based on the research findings, we suggest some strategies for reducing the identified barriers, such as starting with 'small' scale and effective environmental technologies, establishing a formal organisational structure to promote environmental management and working closely with different suppliers of environmental technologies to understand market options. In addition, the findings have several practical implications for hotel entrepreneurs who want to incorporate environmental management in their business, and for local hotel associations and local governments in terms of attracting and sustaining the use of environmental technologies in a hotel context. It is unquestionable that installing environmental technologies does not only help protect our planet, but also improves a company's environmental performance and reduces utilities expenses. Planning the technologies, especially large-scale facilities in the design phase of a hotel project, should be a key consideration to minimise the impact of some of the identified barriers (e.g., environmental feasibility). Seeking assistance from local hotel associations is an efficient way to help bond hotel managers' networks and enhance their knowledge of environmental technologies. Hoteliers can only be attracted and sustained by local governments when less bureaucracy and more administrative support is provided. This is especially important for old hotel buildings that very often need to demolish and rebuild some areas for the installation.

We hope this study encourages hoteliers to adopt environmental technologies and thus eventually contribute to environmental protection. Our findings should assist owners and operators of hotel businesses to better understand possible obstacles so that they can develop a strategy for reducing barriers when considering environmental technologies. However, the study may not be comprehensive enough to reflect the full managerial perspective on barriers to adoption, as the sample was taken exclusively from hotels in Hong Kong and the relatively small sample size for the subgroup analysis may decrease the statistical power of detecting meaningful differences. Furthermore, the research findings may not be globally generalisable to other lodging businesses. Despite these limitations, we expect future studies to validate this study's findings using larger samples of hotels over longer periods and in different countries.

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Table 1 Factor Analysis with Varimax Rotation and Reliability Analysis

Attributes	Mean	Factor Loading	Community	Factor and overall mean	Eigen-value	% of variance	Cumulative variance	Cronbach's Alpha
- After the installation, the maintenance cost of environmental technologies is often very high.	3.74	0.77	0.71	**Monopolised after-sales service (3.52)**	6.06	27.54	27.54	0.79
- Usually, new environmental technologies are very expensive.	4.04	0.75	0.67					
- New environmental technologies are unreliable and frequently malfunction.	3.00	0.64	0.64					
- After-sales service for current environmental technologies is not very timely and effective.	3.30	0.63	0.68					
- Senior executives do not have the time and energy to devote themselves to environmental affairs.	2.85	0.80	0.73	**Human resource limitations (2.84)**	2.31	10.52	38.06	0.76
- Adopting environmental technologies will increase employees' workload.	2.77	0.70	0.66					
- Our hotel is short of manpower to support environmental technologies.	2.91	0.66	0.70					
- Lack of support from the government discourages the adoption of environmental technologies.	3.92	0.71	0.62	**Government and initial support (3.48)**	1.71	7.76	45.82	0.73
- The administration process of adopting environmental technologies is often very complicated.	3.23	0.66	0.63					
- We do not have enough capital to adopt environmental technologies.	3.21	0.62	0.61					
- We do not have enough space to install environmental technologies.	3.54	0.51	0.52					
- Environmental technologies will result in a deficit for our hotel.								

- Adopting environmental technologies will damage the hotel's financial performance.	2.45 2.46	0.93 0.92	0.90 0.90	**Financial performance (2.46)**	1.58	7.20	53.02	0.91
- Lack of knowledge about new technologies hinders hotels from adopting environmental technologies. - Lack of trade association/business network support discourages the adoption of environmental technologies.	3.71 3.38	0.80 0.74	0.75 0.75	**Lack of green knowledge and green network (3.55)**	1.30	5.90	58.92	0.70
- Lack of specialists has a negative impact on adopting environmental technologies. - Adopting environmental technologies affects customer experience.	3.59 2.90	0.69 0.63	0.65 0.58	**Customer experience (3.25)**	1.22	5.53	64.46	0.57
- Environmental constraints have negative impacts on environmental technology adoption (e.g. climate limits the adoption of solar panels). - Long payback period (above 5 years) of environmental technologies discourages their adoption.	3.76 3.63	0.82 0.67	0.75 0.74	**Environmental feasibility (3.70)**	1.04	4.72	69.17	0.58

Table 2 Comparison of Means (one-way ANOVA and t-test) for Barrier Factors Affecting Environmental Technology Adoption

Group No. Factors	Sample Size	Monopolised after-sales service	Human resource limitations	Government and initial support	Financial performance	Lack of green knowledge and green network	Customer experience	Environmental feasibility
Brand								
1. Independent	11	3.40	2.92	3.55	3.10	3.77	3.36	3.77
2. Local brand	34	3.45	2.90	3.35	2.30	3.62	2.91	3.69
3. International	56	3.43	2.80	3.54	2.44	3.45	3.20	3.68
ANOVA (sign. value)		0.96	0.77	0.38	***0.01**	0.24	***0.02**	0.91
LSD multiple comparison					G1>G2; G1>G3		G1>G2; G3>G2	
Grading								
1. 3-star	9	3.51	3.33	3.33	2.67	3.78	3.26	3.56
2. 4 & 5 star	93	3.43	2.79	3.49	2.44	3.52	3.11	3.71
t-test (sign. value)		0.68	0.04	0.50	0.38	0.27	0.48	0.51
ISO14000 Certified								
1. Certified hotel	29	3.41	2.61	3.48	2.16	3.50	3.03	3.66
2. Uncertified hotel	72	3.45	2.93	3.48	2.59	3.57	3.16	3.71
t-test (sign. value)		0.76	***0.05**	0.96	***0.01**	0.64	0.33	0.72
Ownership								
1. Local hotel	87	3.41	2.90	3.48	2.47	3.54	3.13	3.66
2. Foreign hotel	11	3.67	2.48	3.61	2.45	3.59	3.24	3.95
t-test (sign. value)		0.14	0.08	0.53	0.95	0.81	0.56	0.17
No. of Rooms								

1. Below or equal to 300	29	3.57	3.01	3.62	2.38	3.60	3.25	3.66
2. Above 300	73	3.39	2.78	3.41	2.49	3.52	3.08	3.71
t-test (sign. value)		0.14	0.17	0.15	0.48	0.57	0.17	0.70
Green Committee								
1. Established	70	3.39	2.75	3.50	2.41	3.43	3.13	3.67
2. Not established	32	3.54	3.05	3.42	2.56	3.80	3.11	3.75
t-test (sign. value)		0.20	0.06	0.59	0.34	***0.01**	0.88	0.58
EMS System								
1. Have EMS	49	3.41	2.70	3.48	2.31	3.43	3.09	3.61
2. No EMS	53	3.47	2.97	3.47	2.60	3.65	3.16	3.77
t-test (sign. value)		0.62	0.07	0.92	0.06	0.09	0.52	0.22
Environmental Program								
1. Already audited	52	3.37	2.72	3.47	2.28	3.40	3.06	3.59
2. Not audited	49	3.51	2.97	3.49	2.66	3.70	3.19	3.81
t-test (sign. value)		0.19	0.09	0.86	***0.01**	***0.02**	0.28	0.10
Environmental Manager								
1. Have such a position	29	3.38	2.77	3.52	2.43	3.29	3.05	3.69
2. No such position	73	3.46	2.87	3.46	2.47	3.64	3.16	3.70
t-test (sign. value)		0.48	0.55	0.67	0.81	***0.02**	0.38	0.95
Green Award								
1. Have received	50	3.37	2.71	3.43	2.30	3.42	3.12	3.60
2. Have not received	51	3.51	2.96	3.52	2.64	3.69	3.16	3.78
t-test (sign. value)		0.20	0.09	0.47	***0.02**	***0.04**	0.75	0.17

Significance at the 0.05 level is shown in italics.