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Adoption factors of cleaner production technology in a developing country: energy efficient lighting in Malaysia

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ABSTRACT

To address the environmental impact of lighting systems, new technologies, such as light-emitting diodes, are gaining interest, as they are more energy efficient and result in lower carbon emissions than traditional lighting methods. However, adoption of new energy-efficient technologies is slow, resulting in delay in the decrease of ongoing damage to the environment. This study investigates factors that may play significant roles in successful adoption of light-emitting diodes-based lighting in Malaysia. In defining these factors the modified Unified Theory of Acceptance and Use of Technology is used. Relationships between factors for light-emitting diodes purchase decision were examined using path analysis, and a research model of influential factors is presented. Results from a survey of 221 respondents from multiple cities in Malaysia were used to test the model and hypotheses. The Partial Least Square test was chosen to quantitatively evaluate the impact of the key constructs of the modified Unified Theory of Acceptance and Use of Technology model: behavioral intention, effort expectancy, facilitating conditions, performance expectancy and social influence. The results confirmed that a modified Unified Theory of Acceptance and Use of Technology model could be used to determine behavioral intention of consumers and predict adoption of light-emitting diodes technology in Malaysia. Results show that Performance expectancy, Effort expectancy, Social influence, Facilitating conditions and Behavioral intention are the main factors in adoption of light emitting diodes-based lighting in Malaysia.

1. Introduction

The rapid changes in both technology and market necessitate studying the factors which affect technology adoption in order to be able to catch up the pace of the growth in supply and demand. Also the Paris Agreement of the climate change in December 2015 sets need to utilize all possible ways to decrease the use of energy (Paris, 2015). This is particularly important for energy-efficient technologies since there has been a huge amount of focus in developing these technologies. These technologies can reduce negative effects on environment, and on resource use significantly (Zailani et al., 2015). To get the full benefit from new technologies, users must be able to adopt that particular technology and learn about its benefits and how to utilize it. This cannot be achieved without the help of technology adoption processes (Cowan and Daim, 2013). Rogers (2003) has defined five stages in the adoption process: Knowledge, Persuasion, Decision, Implementation and Confirmation. This shows that the first step in the technology adoption process is to gain proper knowledge on that particular technology. There are several factors which could affect any of these steps leading to disadopting the technology (Cowan and Daim, 2013). Previous research in clean energy technology diffusion shows lack of information, awareness, policies and social acceptance are possible barriers for technology adoption (Flamos

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et al., 2008; Painuly, 2001; Suzuki, 2015). Increasing electricity charges and rising concerns regarding climate change and energy independence are moving the global lighting market towards the use of energy-efficient light sources (U.S. Department of Energy, 2013), and many countries are beginning to phase out the use of incandescent light bulbs. Khorasanizadeh et al. (2015b) have discussed the amount of energy savings by changing the light source in a case study of Malaysia. It was concluded that even if government subsidizes the light-emitting diode (LED) lamps for the whole country up to 40%, the amount of money spend could be returned back within the first year of investment through saving energy. These governmental actions can be considered a top-down push for new, energy-efficient technologies. Despite governmental support, a positive public attitude is essential for successful implementation of new technologies (Wüstenhagen et al., 2007). Positive attitude towards a new technology is necessary for a person to move from becoming aware of a technology to accepting and using the new technology (Rice and Aydin, 1991). Studying technology adoption from the perspective of behavior brings into light factors, which are significant to motivate ongoing adoption. It is also important to understand how these adoption factors affect users, as this information can be used in product design and business models to encourage adoption of the technology (Farquhar and Surry, 1994). This information can also be applied to the development of policies promoting energy-efficient lighting technology. Because new technologies are generally not accessible to many potential users, due to high cost; early customers often have to invest more for an energy-efficient product than they would for similar conventional products. The success of any novel technology depends, thus, on a practical business model and general acceptance by consumers (Pode, 2010) besides the initiatives by the government policies as described earlier. Fishbein and Ajzen (1975) proposed that behavioral intent (BI) results from attitude and beliefs about the given behavior as well as about the accepted standards. Strong interest about a new technology can lead to more positive views about the costs and returns of investment for the technology and to clearer valence beliefs about the impact of its use (Bang et al., 2000). Rogers (2003) in his book named relative advantages, compatibility, complexity, triability and observability as characteristics which explain different rates of adoption.

2. Technology adoption model

Previous technology adoption studies have taken various directions. Some scholars have studied and tested the processes in depth (Beaudry and Pinsonneault, 2005). For example, Lee et al. (2012) examined the influence of Facebook users' arousal and valence on intention to attend a festival. It has been suggested that affective experiences are best characterized by two main dimensions: arousal and valence. The dimension of arousal ranges from calming or soothing to exciting or agitating, whereas the dimension of valence ranges from highly positive to highly negative (Russell, 1980). These emotions could affect the adoption behavior of the users. Others have studied the relationships between technology adoption and various individual factors. The Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM) are examples of this approach (Im et al., 2008; Saadé and Bahli, 2005). The UTAUT was developed using the results of an evaluation that combined concepts from earlier models describing application behavior for various information systems. Four main aspects of this theory i.e. performance expectancy, effort expectancy, social influence, and facilitating conditions; serve as determinants of utilization intent and behavior intent (Verhoeven et al., 2010). The UTAUT model is a valuable combination of eight significant theories including Technology Adoption Life Cycle (Beal and Bohlen, 1957), Base Model of Diffusion (Greenhalgh et al., 2004), Theory of Reasoned Action (Sheppard et al., 1988), Motivational Model (Igbaria et al., 1996), Theory of Planned Behavior (TPB) (Ajzen, 2011), Decomposed TPB (Shih and Fang, 2004), Innovation Diffusion Theory (Lee et al., 2011), and Technology Acceptance Model (Venkatesh and Davis, 2000) and has been tested on a considerable number of samples. It also accounted for 70 percent of the variance in usage intention, better than any of the eight models alone (Anderson and Schwager, 2004). The UTAUT model has been applied to various technologies, including bulletin board (Marchewka et al., 2007), information kiosk (Wang and Shih, 2009), website (Indrawati, 2014), Telehealth (Diño and De Guzman, 2015) and enterprise systems (Venkatesh et al., 2003). UTAUT has largely been applied to projects involving the implementation of Information and Communication Technology (ICT), where user participation after implementation is critical. A similar approach is relevant for adoption of energy-efficiency technologies, as user participation after implementation is essential to realize the full advantage of the system.

A series of interviews were conducted as the prior step of this study and the UTAUT model was selected based on the results of the interviews of that study (Khorasanizadeh et al., 2015a). In brief 18 semi-structured interviews were conducted, involving 9 pilot interviews with experts in energy and environment and 9 interviews with normal electricity consumers. The length of the interviews varied between 16 min and 41 min in a semi-structured design allowing participants to express their particular views. In this research phase, the questions were divided into three themes: In theme one, the aim was to explore the characteristics of green technology. In the second theme the focus was given on knowledge of participants about energy efficient lighting such as LED. In the third theme the interviewees were asked about the changes that should be made to publicize energy efficient technologies. The results revealed that regarding the integration of energy efficient technologies among Malaysian public it would be important to inform people about their easiness to understand (how easy to use a specific technology i.e. effort expectancy), reliability, usefulness, match everyday life (help them in their daily tasks i.e. performance expectancy) and being new are the important factors. It is considered important to communicate with the public that these are important factors. This information can be spread through different channels such as weblogs, social networks, NGOs, advertisements etc. In addition, these efforts should be supported by regulations, consumer rebates, subsidies etc. (incentives policies, and public environmental consciousness i.e. facilitating conditions). The results of interviews and the literature review supported the suitability of UTAUT approach in the current study.

Strong initiatives from the government as well as utility and industrial participants can possibly assist technological procurement and address market challenges in technology adoption (Jaffe et al., 2005). Nevertheless, initiatives may fail to fully address all challenges that can drastically limit the acceptance of LEDs in various commercial and residential lighting applications (Lucas et al., 2002). To overcome limitations to the acceptance of LEDs, it may be important to understand the point of view of consumers and identify factors that influence their perceptions and attitudes. For instance, different cultures exhibit different approaches to new and sustainable technologies (Ceschin, 2013). Although, some studies can be extrapolated to different regions (Mohamad et al., 2012), cultural, societal and many other macro-level factors can result in deviations that could limit the use of extrapolation (Hanson and Narula, 2013). Social impacts, such as relationships and publicity, may possibly be associated with the adoption of energy-efficiency technologies as well (Nair et al., 2010). Since nationality and culture exert different influences on the behaviors