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The link between eco-innovation and business performance: a Taiwanese industry context

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ABSTRACT

In practice, there are various types of eco-innovation. While each type of innovation has its own attributes, determinants, and contribution to business performance, it is not effective to implement eco-innovation programs without a holistic view. This study draws from the resource-based view theory to investigate inter-relationships among three types of eco-innovation (process, product, organizational) and their relative impact on business performance. Using structural equation modeling with 121 samples collected from Taiwan Environmental Management Association, we find that eco-organizational innovation has the strongest effect on business performance. Additionally, eco-process and eco-product innovations partially mediate the effects of eco-organizational innovation, and eco-product innovation mediates eco-process innovations' effects on business performance. Business performance is directly and indirectly affected by eco-organizational, eco-process, and eco-product innovations. The findings suggest that, in order to develop effective eco-innovation programs, managers must understand the interdependence and co-evolutionary relationships between different types of eco-innovation. Overall, this study extends the discussion of innovation to the area of environmental innovation or eco-innovation.

1. Introduction

Many organizations have advocated innovation programs pertaining to environmental management to effectively reduce waste and improve the utilization of scarce resources (Carrillo-Hermosilla et al., 2010). Kemp and Pearson (2008, p. 7) referred to those innovative programs in relation to environmental management as *eco-innovation*, which is defined as "The production, assimilation or exploitation of a product, production process, service or management or business methods that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources used (including energy use) compared to relevant alternatives." With the ever increasing pressure from the government and marketplace regarding manufacturing sustainability, developing an effective eco-innovation program and making it an integrative part of a firm's management programs is important (Carrillo-Hermosilla et al., 2010; Dangelico and Pujari, 2010).

In practice, there are various types of eco-innovation (OECD and Eurostat, 2005, p. 16), including product innovations, process innovations, organizational innovations and marketing innovations. While each type of innovation has its own attributes, determinants, and contribution to environmental performance (Christensen, 2011; Damanpour et al., 2009), researchers have cautioned that it is not effective to implement innovation programs separately without a systemic view (Damanpour et al., 2009; Chou et al., 2012; Xing et al., 2013). Nonetheless, previous studies have mostly focused on the development and performance of individual eco-innovation programs (e.g., Pujari, 2006; Anttonen et al., 2013), such as product service innovation (Maxwell et al., 2006), service innovation (Chou et al., 2012; Xing et al., 2013), technological innovation (Moore and Ausley, 2004; Tseng et al., 2013), and infrastructure and policy innovation (Rehfeld et al., 2007; Shin et al., 2008).

Developing eco-innovation without a holistic view could be counter-productive. For instance, several researchers addressed eco-innovation issues from a purely technological perspective (e.g., Dangelico and Pujari, 2010; Weinberger et al., 2012). Socio-technical system theory argues that implementing innovations

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should be coupled with proper social and managerial systems in order to optimize business performance (Cummings and Srivastva, 1977). In addition, an organization must be able to adjust and fine-tune its structure and internal activities to support technological aspects of eco-innovation (Lam, 2005). Brunnermeier and Cohen (2003) and Horbach (2008) also pointed out that an effective eco-innovation program should not be the sole responsibility of the R&D unit. Instead, an organization must take a holistic approach to developing and supporting its eco-innovation programs. Accordingly, knowing how different types of eco-innovation complement each other is critical for firms to effectively implement their entire innovation programs.

Responding to the call from the literature, this study intends to offer a holistic view of eco-innovation programs by investigating the inter-relationships among different types of eco-innovation and their impact on business performance. Specifically, this study examines the relative effects and inter-relationship effects of three types of eco-innovation (eco-process, eco-product, eco-organizational). The following section reviews relevant literature on different types of eco-innovation to develop research hypotheses, followed by a discussion of research methodology, including samples and measurements. The statistical results and discussion are presented and, finally, managerial implications and suggestions for future research are provided.

2. Eco-innovation types

The literature defines the boundary of eco-innovation into external and internal eco-innovation. The external boundary of eco-innovation includes all external activities of the organization for green and sustainable activities, including suppliers (Lee and Kim, 2011), regulators (del Río et al., 2010), and market demand (Lin et al., 2013). The internal boundary of eco-innovation activities is related to practices for effectively and efficiently managing eco-innovation processes within organizations, including organizational management (Eiadat et al., 2008), production process (Dangelico and Pontrandolfo, 2010), and new product development (Lin et al., 2013). For the purpose of this study, we focus on the internal boundary of eco-innovation.

Furthermore, researchers have addressed eco-innovation from different perspectives, including government policy (Veugelers, 2012), stakeholders (e.g., customers, suppliers) Klewitz et al., 2012), organizational strategies (Boons and Lüdeke-Freund, 2012), organizational leadership (Chen and Chang, 2012), organizational culture (Porter-O'Grady and Malloch, 2010), and the characteristics of the eco-innovation itself (Lin et al., 2013). With a focus on the internal boundary of eco-innovation, this study investigates the effects of eco-innovation from the organizational strategic perspective.

An extensive literature review was conducted to ensure inclusion of all relevant aspects of the internal boundary of eco-innovation. For example, Kemp and Arundel (1998) argued that eco-innovations include technical, organizational, and marketing innovations. del Río et al. (2010) classified eco-innovation types into process/product innovation, mature/immature innovation, and radical/incremental innovation. Horbach (2008) and Triguero et al. (2013) studied three types of eco-innovation: eco-process, eco-product, and eco-organizational innovations. The Oslo Manual, developed by the OECD (2005), identified four distinct types of eco-innovation: product innovation, process innovation, organizational innovation, and marketing innovation. Overall, for examining internal innovation, the literature seems to suggest a focus on eco-process, eco-product, and eco-organizational innovation activities (Horbach, 2008; Triguero et al., 2013). This classification was later confirmed by a field study consists of interviews with 24 managers who has more than fifteen years of work experience in environmental innovation management. The interviewees shared their experience and offered suggestions regarding the types of eco-innovation activities involved inside of organizations. (More details of the interviews will be described in the research methods section.) This field study revealed that eco-innovation implementation should cover every major aspect of the organization, including activities arising from the setting up of the different forms of organization and management in different functions of the organization, activities related to the change or improvement of the manufacturing process function, as well as activities that contribute to the improvement to existing products or the development of new products.

In conclusion, synthesizing insights from the literature and the fieldwork, three key eco-innovation types (eco-process, eco-product, and eco-organizational innovations) were identified for further study. While those three eco-innovation programs have been studied separately, their inter-relationships have never been properly examined in a holistic manner (Hallstedt et al., 2013; Lozano, 2013). The remainder of this section defines activities related to these three forms of eco-innovations.

An eco-process innovation stands for new elements introduced into an organization's production system for producing eco-products (Negny et al., 2012). In general, eco-process innovation refers to the improvement of existing production processes or the addition of new processes to reduce environmental impact. Rennings (2000) suggested that innovation can be additive solutions (e.g., smokestack scrubbers) or be integrated into the production processes through substitution of inputs, optimization of production, and reclamation of outputs. As a result, eco-process innovation modifies the organization's operation processes and systems, decreases unit costs of production, produces new or significantly improved eco-products, and reduces environmental impacts (Negny et al., 2012).

In contrast, an eco-product innovation is the introduction of new or significantly improved products (regarding their characteristics), such as improvements in technical components and materials (Pujari, 2006). Eco-product innovation is usually inspired by advanced eco technologies, shortening product life cycles, and increasing competition (Carrillo-Hermosilla et al., 2010). The environmental impact of eco-product innovations stems from their use (e.g., fuel consumption and CO_2 emissions of cars) and disposal (e.g., heavy metals in batteries) rather than their production. According to Pujari et al. (2004), product life cycle analysis involves all aspects of a product, from its creation and use, to its disposal. This concept can be applied to eco-product innovations. For instance, electricity produced from wind power is an example of the use of creation. The compact fluorescent bulb is another example of energy saving through the use of a product, while a chlorofluorocarbon-free air conditioner is considered green primarily due to its reduced disposal impact. In short, eco-product innovations aim at reducing environmental impacts during an eco-product's entire life cycle (Christensen, 2011).

Finally, according to Birkinshaw et al. (2008), an eco-organizational innovation refers to upgrading the organization's management processes through a new and eco method in business practices. Eco-organizational innovations thus can improve business performance by supporting necessary changes, reducing administrative and transaction costs, improving workplace satisfaction, or reducing costs of supplies (Cruz et al., 2006). Eco-organizational innovation generally does not reduce environmental impacts directly, but facilitates the implementation of eco-process and eco-product innovations (Murphy and Gouldson, 2000). Kemp and Arundel (1998) summarized that eco-organizational innovations include eco-training programs, eco-