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Exploring eco-innovation in dynamic organizational capability under incomplete information in the Taiwanese lighting industry

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ABSTRACT

Taiwanese lighting manufacturers are adopting sustainable operational processes from eco-design and searching for green materials in a dynamic environment. Hence, dynamic organizational capabilities and eco-innovation are necessary for sustainable development. Dynamic organizational capability primarily allows manufacturers to reduce the impact of eco-innovation and environmental changes. It might be possible to discover eco-innovation opportunities in the green markets by enhancing the dynamic organizational capabilities of a single firm. However, existing studies have not yet comprehensively assessed dynamic organizational capability and eco-innovation together in the Taiwanese lighting industry because of incomplete information. Hence, this study proposed interval-valued triangular fuzzy numbers to convert the experts' opinions into comparable measures and used grey relational analysis to facilitate and clarify the weights of eco-innovation under dynamic organizational capability. The results show that path-dependent learning is the top priority and that manufactures should consider opportunity-sensing capability and integrative capability simultaneously in the operational process.

1. Introduction

Thus far, 80% of Taiwanese lighting manufacturers are adopting sustainable operational processes based on eco-design and are searching for green materials to deliver green products to their customers (Hsu and Hu, 2008; Wu et al., 2015). For operational processes to be sustainable, supply chain networks need to be fully utilized to achieve one-stop service. Green suppliers comply with the Directives of Waste Electrical and Electronic Equipment (WEEE), the Restriction of Hazardous Substances (RoHS), Eco-design for Energy-using Products and Energy Star Certification from the European Union and America (Sanderson and Simons, 2014; Wu et al., 2015). Eco-innovation generates added value for green products given product differentiation in the eco-design process. In addition, eco-activities that rely on the dynamic organizational capability (DOC) are instrumental in identifying the correct and efficient resources or processes to meet economic and environmental challenges (Burgelman and Maidique, 1988; Tseng, 2010; Daniel et al., 2014). DOC helps embrace, renew and reconfigure skills, resources and functional competencies to align with the changing environment (Dixon et al., 2014).

Eco-innovation has been considered a combined evaluation of performance in terms of the economy, the environment and sustainable development (Boons and Wagner, 2009; Dong et al., 2014). Carrillo-Hermosilla et al. (2010) emphasized that eco-innovation not only improves performance, but may also occur as a side effect of other goals, such as reducing production costs. Several studies have highlighted that DOC is positively related to performance (Daniel et al., 2003; Winter, 2003; Teece, 2007). However, Jiao et al. (2013) argued that researchers have not provided a compelling explanation for the effect of environmental dynamism on the relationship between DOC and eco-innovation performance. Although previous studies have examined empirical operations for eco-innovation, it is still unclear whether these operations affect DOC development and performance (Matus et al., 2012; Sierzchula et al., 2012; Cai and Zhou, 2014). Thus, the explicit examination of eco-innovation is usually omitted from the discussion of DOC (Lawson and Samson, 2001; Dixon et al., 2014). This omission highlights the need for research to model the antecedents of eco-innovation and to identify the DOC in industry settings because of the difficulty in developing, testing and applying a multidimensional framework (Barreto, 2010; Salunke et al., 2011; Shuen et al., 2014).

With regard to these issues, some studies have demonstrated that DOC has aggregate and multidimensional features (Winter, 2003; Camison and Monfort-Mir, 2012; Michailova and Zhan,

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2014), but literature on the analysis of the multidimensional structure of DOC is still lacking. Although some studies have adopted basic statistical hypotheses and case studies to explore diverse dimensions, the discussions still focused on narrow sectors and omitted the link between DOC and eco-innovation (Ellonen et al., 2009; Camison and Monfort-Mir, 2012; Cai and Zhou, 2014). Thus, this study adopts grey relational analysis (GRA) to measure the performance between aspects for evaluation criteria. In addition, the use of interval-valued triangular fuzzy numbers (IVTFNs) makes it possible to overcome the complexity, fuzziness and uncertainties within the subjective and qualitative evaluations (Lam et al., 2010; Lin and Tseng, in press). This evaluation contributes to the theory by adding a discussion of eco-innovation and DOC to enhance understanding. Significantly, this study is the first to consider the lighting industry and offers precise guidelines for manufacturers on the key operational eco-activities in the production process.

Therefore, this study provides an extensive theoretical evaluation of DOC. Increased DOC development and eco-innovation application have led the Taiwanese lighting industry to generate differentiation in intense low-cost competition. Hence, the objectives of this study are to identify specific DOC by evaluating performance and to provide precise guidelines to manufacturers in eco-innovation applications. A literature review that focused on (1) the theoretical identification of DOC, (2) selection of appropriate measurements of eco-innovation and (3) design of the multidimensional framework is presented in the next section. Section 3 illustrates the hybrid method and addresses the proposed evaluation procedures. Section 4 presents the case study and results of empirical evaluation. The evaluation results consist of expert linguistic variable assessment in the lighting industry and are converted into the IVTFNs-GRA method. Section 5 provides theoretical and managerial implications. Discussions are based on the ranking of aspects and criteria from empirical results. The contributions, conclusion, limitations and potential future studies are described in the final section.

2. Literature review

This section presents the foundations of DOC and eco-innovation, providing the connections for formulating the aspects and criteria for evaluation. DOC, eco-innovation and the proposed method and measurements are discussed.

2.1. Dynamic organizational capability

According to Teece et al. (1997), *"dynamic" refers to the capacity to renew competencies so as to achieve congruence with the changing business environment; certain innovative responses are required when time-to-market and timing are critical, the rate of technological change is rapid, and the nature of future competition and markets difficult to determine.* Helfat and Peteraf (2003) stated that *"organizational capability" is the ability of an organization to perform a coordinated set of activities utilizing organizational resources for the purpose of achieving a particular end result*. Judge and Elenkov (2005) stated that DOC adapts to the threats and opportunities posed by the organization's environment, in contrast to static organizational capability. Moreover, it seeks specific processes to utilize resources to adapt to and even create market change under uncertainty, as well as allowing manufacturers to shape the environment through innovation and collaboration along the entire supply chain (Eisenhardt and Martin, 2000; Teece, 2007; Liao et al., 2009). Jiao et al. (2013) emphasized that through effective DOC, manufacturers can transform information into innovative products, services and processes, leading to better technical and administrative performance.

Disaggregating and clarifying the component aspects of DOC under uncertain environment and dynamic markets have been a critical focus in previous studies (Wang and Ahmed, 2007; Dixon et al., 2014). Other studies have stressed that incorporating substantial alterations into the business model with uncertain information should be considered an important aspect (Daniel and Wilson, 2003; Daniel et al., 2014). Accurate volume and risk prediction in investment proposals assists manufacturers in identifying specific opportunities to use DOC (Judge and Elenkov, 2005; Feiler and Teece, 2014). Several studies have argued that integrative capability, which includes configuring, deploying and redeploying resources or processes to capture and exploit changing opportunities, should also be considered in DOC (Wu, 2006; Chen et al., 2008; Liao et al., 2009). Another proposed critical aspect of DOC is the path dependency of learning as history matters: where an organization can go in the future depends on both its current position and where it has been (Schreyoegg and Kliesch-Eberl, 2007; Russo, 2009; Zhu et al., 2013). Hence, top managers and technical experts play an important role in identifying the path for opportunity-sensing, so manufacturers should extend their understanding of the laws in industries and seize upon changing trends (Voola and O'Cass, 2010; Jiao et al., 2013; Kindstrom et al., 2013).

Consequently, within the managerial and organizational process, client-focused learning tries to build, create and extend the processes to provide support for the conceptualization of DOC (Koch, 2010; Drnevich and Kriauciunas, 2011; Salunke et al., 2011), and reconfiguration to addresses the transition of a manufacturer's asset structure through vigilant surveillance of the environment for discontinuities and subsequent radical changes (Pavlou and El Sawy, 2011; Jiao et al., 2013; Shuen et al., 2014). While the concept of DOC has received increasing attention in the literature, only recently have attempts been made to look deeper into the process that links its antecedents and the manufacturer's eco-innovation performance (Zollo and Winter, 2002; Winter, 2003; Zott, 2003; Hung et al., 2010; Beske et al., 2014). Therefore, DOC and eco-innovation have become a key concerns for many manufacturers today, with some studies even mentioning them as essential drivers of consistent high performance over time (Kindstrom et al., 2013). An understanding of these capabilities is the first step for a manufacturer to be able to obtain the benefits of future eco-innovation; otherwise, there is a risk of the manufacturer becoming stuck in activities delivering ever-reducing returns and establishing incrementally rigid barriers (Teece, 2007; Chen and Jaw, 2009; Kindstrom et al., 2013; Michailova and Zhan, 2014).

2.2. Eco-innovation

Kemp and Pearson (2008) described eco-innovation *as the production, application or exploitation of a good, service, production process, organizational structure, management or business method that is novel to the firm or user and which results, throughout its life cycle, in a reduction of environmental risk, pollution and the negative impacts of resource use (including energy use) compared to relevant alternatives.* It refers to wide range of innovations such as renewable energy technologies, pollution prevention schemes, waste management equipment, eco-design products and the adoption of biological materials (Kemp, 2010). However, there has been confusion about the use of different concepts and terminology to describe innovations for reducing negative environmental impact (Schiederig et al., 2012). Specifically for "green innovation" and "eco-innovation", several studies have concluded that these concepts are used interchangeably and are synonyms in terms of reduced environmental impact (Schiederig et al., 2012; Karakaya