Full length article

Improving corporate sustainable development by using an interdependent closed-loop hierarchical structure

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A B S T R A C T

Firms act to reduce environmental impact and contribute to improving the quality of the environment. However, corporate sustainability is lacking with regard to development in practice, and the decision-making process is absent from a hierarchical structure that has complicated interdependent relationships among the attributes. However, the elimination of less important criteria from various measures and the criteria that are encountered remain with respect to both qualitative and quantitative measures. Thus, this study proposes to develop a corporate sustainability model for a focal firm in supply chain networks using the fuzzy Delphi method, interval-valued triangular fuzzy numbers and analytical network process method. The findings are as follows: the firm focused on the environmental operation design aspect, and it ranked five criteria, which included (1) decreasing the generation of toxic and hazardous matter; (2) environmental certificates; (3) service cycle processing time; (4) reducing the service costs, i.e., the service costs as a percentage of the revenue; and (5) the service output per hour/facility utilization. Sensitivity analysis is performed on the coordination of green design in operations and products, which indicated the corporate sustainable development criteria for the next frontier. The implications and conclusions are discussed.

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1. Introduction

Environmental consciousness and protection have motivated the manufacturing industry to gradually adopt a green imperative over the past two decades. Firms act to reduce the environmental impact and collectively contribute to improving the environmental quality. Thus, the green imperative drives firms to not only develop their competitiveness but also to enact a transition toward corporate sustainability (CS). This approach embraces green consumerism, green innovation and economic concerns; thus, the manufacturing industry has arrived at a win–win green and competitiveness position (Delmas and Toffel, 2004; Lin and Tseng, 2014; Tseng et al., 2008). Many studies have demonstrated the adoption of green practices and their benefits for the manufacturing firms (Chan and Hawkins, 2010; Chou, 2014; López-Gamero et al., 2011; Zhu and Geng, 2001). For example, Chang et al. (2013) and Erkuş-Öztürk and Eraydın (2010) have presented that the environmental governance networks among firms have shown an increase

in local collaborations for supply chain networks on the basis of economic considerations. Lozano (2012) indicated that corporate activities that proactively seek to contribute to sustainability have included the economic, environmental and social (triple-bottom-lines, TBL) aspects within a firm's management functions. These previous studies have been extended to incorporate the TBL aspects that are included in the firm's management to pursue CS as well as extend their supply chain networks (Tseng et al., 2015; Su et al., 2015).

Nevertheless, in principle, the CS model is an approach to corporate management functioning that considers the operations, social impact and firm's value creation (Coles et al., 2013; Waligo et al., 2013). Many previous studies have proposed and analyzed the CS model, including the TBL aspects in combination with the management functions in the supply chain (Christen and Schmidt, 2012; Lin and Tseng 2016; Witjes et al., 2016). Nevertheless, there is still a lack of clarity as to how to address the CS for the next frontier, which is called corporate sustainable development (CSD). While looking for the attributes of the next frontier, there are also complicated interdependence relations among the attributes (Lourenço and Branco, 2013; Tseng, 2010; Wu et al., 2010). For example, Lodhia and Martin (2014) proposed a set of criteria for improving a

firm's performance by developing a practical multi-criteria decision making (MCDM) tool, and they indicated that there are complicated relationships among the attributes. Among the prior studies, Tseng et al. (2015) proposed a sustainable adaptation model to increase the resilience without jeopardizing the economic viability, social justice and environmental integrity. However, in response to these challenges, adaptation and measures were proposed in prior studies (López-Gamero et al., 2011; Tang et al., 2014; Tseng et al., 2014b). These extant CS models have revealed a hierarchical structure; however, currently, most studies ignore the interdependence relations and proper explanation of how the hierarchical structure was arrived at among the measures (Dyllick and Hockerts, 2002; Lozano et al., 2015).

The ongoing debate considers that there are complicated interdependence relations among the criteria, usually with two types of analytical information, which are operational data and linguistic preferences. This study applied interval-valued triangular fuzzy numbers (IVTFN) to address the vagueness measures and transform the linguistic preferences onto a comparable scale. In addition, only a few studies have presented an elimination of the less important criteria in the analytical process (Windolph, 2011; Tseng, 2013; Tseng et al., 2015). Hence, the fuzzy Delphi method (FDM) was proposed to initially eliminate the less important criteria (Chen et al., 2014; Lin and Tseng, 2014; Bouzona et al., 2016). Nevertheless, to eliminate the less important criteria, confirming the interdependence relations and building the hierarchical structure are still lacking in the previous studies. There is a need to build a hybrid analytical method to address the aforementioned situation. Exploratory factor analysis (EFA) has been proposed to analyze and group the interdependence criteria together and to confirm the validity of the CS aspects and the criteria in the hierarchical structure (Tseng et al., 2008; Leão de Carvalho and Salgueiro, 2015). This study confirms the hierarchical structure and interdependence relations in the model. This study proposes the analytical network process (ANP) to address the interdependence relationships and closed-loop hierarchical structure as well as to rank and weight the aspects and criteria (Su et al., 2015; Tseng, 2010; Tseng et al., 2014a). In conclusion, a sensitivity analysis presents the different viewpoints between the practitioners and academic experts for CSD guidance.

The objectives are as follows: 1. to identify the criteria and structure the interdependence relations using a hybrid method approach and 2. to identify the different viewpoint of CS between the practitioners and academicians for the next best practices, which is called CSD. The contributions of this study are three-fold. First, this study collected qualitative and quantitative measures to compose a resulting set of measures. Second, this study extends and describes the literature by proposing and forming a closed-loop hierarchical structure that has interdependence relations. Third, the sensitivity analysis provides guidance to the management on their view toward the next frontier. This study is organized as follows. Section 2 provides and develops a literature review on CS, its methods and measures. Section 3 presents the case background, methods and proposed analytical steps. The results are discussed in detail in Section 4. Section 5 presents the theoretical and managerial implications. The final section presents the conclusions, contributions, limitations and future studies.

2. Literature review

This section presents the relevant literature, proposed measures and proposed methods. In Section 2.1, the literature is reviewed. Next, this discussion provides the relevant literature on the proposed method in Section 2.2, and Section 2.3 presents the analytical measures.

2.1. Corporate sustainability

The terminology "corporate sustainability" provides that sustainability is a firm-level systems concept. Knowles et al. (1999) argued that CS that lacks operationalization with environmental principles, which is implicit within the practices, is encountering the emergence of a debate between theory and practice. Azzone and Bertele (1994) and Lin and Tseng (2016) focused on the overall sustainability practices of a firm level's operations to enhance the competitive edges in the supply chain networks. The adoption of a CS model requires a change in the core assumptions with regard to the interdependence of ecological firm operations and ensures the effective achievement of the firm's performance. However, the criteria are composed prior to the approach, and there is a lack with respect to how the criteria are to be filtered in the analytical process. Dyllick and Hockerts (2002) indicated that the attributes require practical scrutiny and that the environmental drivers of social sustainability are in need of analyses. Their study posited that business relevancy is a decent environmental criterion and acknowledges the attributes. Similarly, the TBL aspects assisted firms on both internal and external practices (Benjamin et al., 2015; Tamajón and Aulet, 2013; Lin and Tseng, 2016). The useful criteria was provided as a highly practical tool for corporate governance, resource management and environmental monitoring (Labuschagne et al., 2005; Lodhia and Martin, 2014; Tan et al., 2014). Tseng (2013) proposed a set of sustainable production attributes to evaluate the production impact and operational management activities. The attributes behind this approach must include the proposed criteria that consider the environmental regulations, the customer pressure and the suppliers' selections in the supply chain. However, there are no prior studies on how to select valid measures.

Nevertheless, Witjes et al. (2016) presented CS activities that have been developed in isolation and supported by enhancing the integration of both physical and social aspects into their business activities. Garcia et al. (2016) presented a multi-criteria decision aid method and proposed a model that helps corporate decision-making while considering the TBL aspects and a stakeholder view to generate a sustainability balanced single measure and performance indices. Docekalová and Kocmanová (2016) presented a CS model for measurement with a complex performance indicator that integrated the TBL aspects and aggregated sub-criteria to enable a detailed analysis of the impact of various performance attributes. Su et al. (2015) proposed a novel hierarchical structure MCDM method under incomplete information in supply chain management toward sustainability. However, these studies did not address the complicated interdependence relationships among the criteria. Lin and Tseng (2016) used decision-making methods to assess the hierarchical structure in identifying the ranking of competitive priorities; however, their study lacked a filter for selecting the valid criteria. In summary, these prior studies do not address the proven interdependence relations when constructing the hierarchical structure and the operations data and qualitative information evaluation together (Delmas and Toffel, 2004; Antonopoulos et al., 2014; Docekalová and Kocmanová, 2016). Hence, the interdependence of relations, a valid hierarchical structure with qualitative and quantitative measures and sensitivity analysis, must be addressed for future CS development in this study.

Several recent studies have presented internal environment practices to identify top management support, designs for the environment, teamwork, and environmental training and reward systems, which are important operational criteria when achieving sustainability (Labuschagne et al., 2005; Lodhia and Martin, 2014). For example, Fuisz-Kehrbach (2015) presented CS criteria that contribute to improving a firm's social, environmental, health, and safety performances toward sustainability. Küçüksayraç (2015) determined that in the design for sustainability, it is necessary