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## Developing an assessment framework for managing sustainability programs: A Analytic Network Process approach

Chinho Lin <sup>a,\*</sup>, Christian N. Madu <sup>b</sup>, Chu-hua Kuei <sup>b</sup>, Hua-Ling Tsai <sup>c</sup>, Kuai-ni Wang <sup>c</sup><sup>a</sup> Department of Industrial and Information Management, Institute of Information Management, College of Management, National Cheng Kung University, No. 1, University Rd., 701 Tainan, Taiwan, ROC<sup>b</sup> Department of Management and Management Science, Lubin School of Business, Pace University, 1 Pace Plaza, New York, NY 10038, United States<sup>c</sup> Department of Industrial and Information Management, National Cheng Kung University, Taiwan, ROC

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## ABSTRACT

This paper applies an Analytic Network Process (ANP) to supplier selection at a Taiwanese Electronics Company. The selection process is based on the Triple Bottom Line (TBL). It shows that the use of ANP helps to capture the imprecision in human judgment while TBL enables the consideration of social development, environmental protection, and economic development issues. With TBL, a holistic view of the company is taken in the decision making process. A framework is developed to enable general application of ANP. A case study using ten company executives from an anonymous Taiwanese company is used to illustrate the framework, and also to identify the key factors in supplier selection. Our results, which are consistent with other research findings, show that product design for sustainability and green supply chain management are the most important factors in supplier selection. This is also consistent with our earlier results in the paper which showed environmental protection has the highest priority index among the three components of TBL, namely social development, environmental protection, and economic development.

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### 1. Introduction

Sustainable operations are needed to create value and customer care, and these may be implemented by focusing on social development, environmental protection, and economic development (Sridhar & Jones, 2013). These three areas constitute what is known as the Triple Bottom Line (TBL). Hewlett-Packard (HP) has made the TBL concept a priority (Kuei & Madu, 2009). Promoting and implementing executable plans toward the TBL has been of paramount importance during the rapid growth of HP in the past decade, and enterprises of all sizes are now embracing TBL (Gmelin & Seuring, 2014). Feng and Ma (2009) report on the “cradle-to-grave” approach adopted in a color TV firm in China, and argue that organizations that respond proactively to the TBL concept have the opportunity to achieve supply chain excellence. Facca-Miess and Santos (2014) show that there is a significant positive relation between corporate sustainability and market value. While there are few studies that integrate the three dimensions of sustainability.

Sarkis, Helms, and Hervani (2010), Moore and Manring (2009), and Ciliberti, Pontrandolfo, and Scozzi (2008) address this issue by using the TBL in their works. Ciliberti et al. (2008), for example, classify logistics social responsibility into five areas: purchasing social responsibility, sustainable transportation, sustainable packaging, sustainable warehousing, and reverse logistics. Moore and Manring (2009) also note that small and medium sized enterprises do have a strong motivation to adopt TBL, as they need to become highly efficient suppliers, valuable sustainable investment targets, and create highly competitive networks of small and medium sized enterprises. One of the challenges to modern enterprises is to analyze alternatives for improvement in TBL performance. Good strategic/tactical decision making is thus fundamental to achieving TBL. To this end, it is important to choose the best set of decision making tools for both decision makers and stakeholders.

The importance of multi-criteria models in supplier selection is increasingly being emphasized in the literature (Hsu & Hu, 2009). A strategic analysis enables the organization to identify the most critical factors that will ultimately influence the successful selection of suppliers. Dou, Zhu, and Sarkis (2014), for example, use the Analytic Network Process (ANP) as a model for selecting the best green supplier development programs. The ANP is the second generation of the Analytic Hierarchy Process (AHP), which has

\* Corresponding author. Tel.: +886 6 2757575x53137 (O); fax: +886 6 2759451.

E-mail addresses: [linn@mail.ncku.edu.tw](mailto:linn@mail.ncku.edu.tw) (C. Lin), [chrismadu@aol.com](mailto:chrismadu@aol.com) (C.N. Madu), [ckuei@pace.edu](mailto:ckuei@pace.edu) (C.-h. Kuei), [r3897107@mail.ncku.edu.tw](mailto:r3897107@mail.ncku.edu.tw) (H.-L. Tsai), [r36974038@gmail.com](mailto:r36974038@gmail.com) (K.-n. Wang).

been widely used for multi-criteria decision making problems (Deng, Hu, Deng, & Mahadevan, 2014; Saaty & Sodenkamp, 2008). Through the AHP, decision makers and stakeholders are able to conduct a series of pairwise comparisons of criteria, and priority indices can thus be derived. The role of the AHP in multi-criteria decision making is well-documented in Madu, Kuei, and Madu (2002, p. 267), and is summarized as follows:

- (1) It allows a systemic consideration of the problem by identifying all the important tangible and intangible factors.
- (2) It allows for the use of major stakeholders in the decision-making process.
- (3) It allows a team of stakeholders to reach a consensus while maintaining consistency in their judgment.
- (4) It helps to breakdown a complex problem into a decision hierarchy.
- (5) Its application may facilitate the acceptance of the final outcome by members of key stakeholders.

As noted by Ayag and Ozdemir (2009, p. 369), however, “the AHP cannot accommodate the variety of interactions, dependencies and feedback between higher and lower level elements.” The ANP is thus the model of choice when dealing with more complex decision making problems (Dou et al., 2014).

In order to implement the AHP/ANP, a nine-point scale system is normally adopted (see Appendix A) to obtain decision makers’ professional evaluations. This approach is known as a crisp-based system, although it may be less effective when analyzing ill-structured decision problems. Recent studies (e.g. Kannan, De Sousa Jabbour, and Jabbour (2014), Nguyen, Dawal, Nukman, and Aoyama (2014)) demonstrate the need to establish ranges, intervals, or fuzzy scales in such cases. Fuzzy set theory can thus be used to provide a sound basis for the procedures that are used when dealing with the un-certainty inherent in certain expert judgments. Transforming crisp values into fuzzy ones is carried out using a fuzzification process. This begins with the definition of a fuzzy membership function. One of the most popular fuzzy membership functions is perhaps the triangular function (Nguyen et al., 2014), and this is applied in the current work in order to improve the traditional, crisp nine-point scaling scheme.

An ANP approach to TBL is needed to address the multiple criteria and stakeholders that are involved in reaching TBL decisions, and thus the current work proposes a strategic decision framework for applying sustainable criteria to a supplier selection problem. The proposed framework adopts the ANP approach and ensures that TBL action plans are realistic and achievable. In the next section we review the earlier research on the dimensions of the TBL and ANP. In section three, we present an integrated decision-making process for sustainable supplier assessment. In section four, an example of a multinational firm in Taiwan is used to illustrate the ANP approach to the determination of the importance weights (priorities) of survey items.

In Section 5 we discuss the implications of this work for strategy and further research. We believe that the results of this work will be helpful to policy makers, enabling them to better understand the key aspects of sustainable management and multi-criteria decision making.

## 2. Research background

### 2.1. Dimensions of the Triple Bottom Line (TBL)

The TBL model suggests that businesses should focus on social development, environmental protection, and economic development. Hutchins and Sutherland (2008) present four fundamental

flows in and out of a company that can be used to consider the sustainability of a firm, and these are related to information, physical substances, and human resources. Sustainability requires that enterprises maintain the integrity of social and environmental systems while reconfiguring information, physical substances, and human resources to maximize their financial performances. Using social sustainability as an example, Hutchins and Sutherland (2008) identify five themes: equity (poverty, gender equality), health (mortality, sanitation, drinking water, nutritional status, healthcare delivery), education (literacy, educational level), housing security (crime, living conditions), and population change. These themes need to be addressed effectively to design and deliver a well-developed social system. The development of an environmental system focuses on green supply chain management (GSCM). Srivastava (2008, p. 536) defines GSCM as “integrating environmental thinking into supply chain management including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.”

Using the Dow Jones Sustainability Indexes, Ortas, Burritt, and Moneva (2013) prepared a list of corporate sustainability assessment criteria, as in explained in more detail below. In the area of social development, the key items are “corporate citizenship/philanthropy, stakeholder engagement, labor practice indicators, human capital development, knowledge management/organizational learning, social reporting, talent attraction and retention, standards for supplier, and industry specific criteria” (Vann & White, 2004, p. 21). For the environment cluster, major items include environmental policy/management, environmental performance, environmental reporting, and industry specific criteria. As for the economic development group, nine items are listed. They are codes of conduct/compliance/corruption and bribery, corporate governance, customer relationship mgt. financial robustness, investor relations, risk and crisis mgt. scorecards/measurement systems, strategic planning, and industry specific criteria.

Kuei and Madu (2009) also offer a set of corporate sustainability assessment criteria. In total, ten items are considered in their study: competence trust, contractual trust, goodwill trust, supplier base, product design for sustainability, strategic and internal benchmarking, supply chain management, end-of-life management, lean system, and six sigma operations. To effectively select a supplier that meets the requirements in hazardous substance management (HSM), Hsu and Hu (2009) focus on the following aspects: procurement management, R&D management, process management, incoming quality control, and management system.

Several authors have offered different dimensions for TBL, as outlined in Table 1, and these are adopted in this paper for developing a TBL model.

### 2.2. Background of the Analytic Network Process (ANP) models

The Analytic Network Process (ANP) can be used by decision and policy makers to present a non-linear network structure of a multi-criteria decision making problem with possible interdependencies and feedback (Nguyen et al., 2014; Saaty & Sodenkamp, 2008). A hierarchical structure, normally adopted by the widely used Analytic Hierarchy Process (AHP), is a special case of the ANP. Table 2 presents some of the recent research on ANP, and some key studies are noted below.

Hsu and Hu (2009) apply ANP to the selection of suppliers for a Taiwanese OEM electronics company. Nguyen et al. (2014) use ANP for decision making within a green supply chain, and note that the major drawback to its application is the large amount of decision-maker input that is required. However, the ANP is a viable alternative to the AHP and other multi-criteria approaches, since it allows decision and policy makers the flexibility to “identify and

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