An Analytic Network Process (ANP) Approach to the Project Portfolio Management for Organizational Sustainability

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Abstract

As a preliminary research of development of a comprehensive management tool for organizational sustainability, this paper discusses the difficulty of achieving organizational sustainability in today's complex business environment. It explains why Analytic Network Process (ANP), a general form of Analytic Hierarchy Process (AHP), is an appropriate approach to the project portfolio management for success in organizational sustainability. It proposes a generic ANP model via the Triple Bottom Line (TBL) framework for the evaluation and prioritization of projects based on their potential contribution to an organization's sustainability initiative. The paper then demonstrates the model through an illustrative problem.

Keywords
Organizational sustainability, triple bottom line (TBL), analytic network process (ANP), project portfolio management

1. Introduction
In recent years, as environmental problems and their impact on nature, people and economies have become better understood, the term sustainability has developed into a household word. Even so, the term sustainability is somewhat ambiguous. The definition made in 1987 by the World Commission on Environment and Development [1], the economic development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs, can be considered as the starting point for the sustainability concept. From an organizational perspective, in 2002 Dyllick and Hockerts [2] define corporate sustainability as meeting the needs of a firm's direct and indirect stakeholders without compromising its ability to meet the needs for future stakeholders. In general, corporate sustainability is defined as a business approach that creates long-term shareholder value by embracing opportunities and managing risks derived from the developments in three sustainability dimensions - economic, environmental and social (i.e., Triple Bottom Line or TBL) [3]. Further, and possibly more important, it is also claimed that organizational sustainability performance is an investable concept that can have a positive effect on society and the economy [3]. Based on these definitions, an organization's sustainability can be improved by investing in the projects that provide the maximum benefits from the potential opportunities of sustainability practices while minimizing or avoiding related costs and risks. To this end, our research focuses on the development of a project portfolio management tool that can be used to improve organizational sustainability. Utilizing the Analytic Network process (ANP) to manage the complexity of sustainability concept, decision makers are enabled to evaluate and prioritize potential projects for investment according to their contribution to sustainability.

2. Problem Statement
One of the major problems in organizational sustainability is "For which projects should an organization invest in to improve or maximize its sustainability performance?" Before suggesting a solution procedure, it is necessary to clarify the complexity of this problem. First, it is a *strategic decision* since it is closely related to developing plans and setting objectives to guarantee both short-term and long-term economic, environmental and social sustainability of an organization. Second, it involves *multiple stakeholders.* And, since stakeholder groups often have different

perceptions, expectations and objectives, it also involves *quantification difficulty* and *subjectivity*. For instance, a shareholder's primary interest in sustainability is that the company's financial performance and profit rate are continued; and for employees it means that a company provides high wages, high quality working conditions and a variety of training opportunities. Finally, it needs a *proactive* approach and *interdisciplinary* work to tackle *uncertainty* about the future availability of resources, state of the natural environment, needs and composition of future generations, state of financial markets and technological development, and *mutual-dependency* among the three dimensions of sustainability.

3. Analytic Network Process (ANP) Methodology

Analytic Network Process (ANP) and Analytic Hierarchy Process (AHP) are the multicriteria decision making (MCDM) techniques that enable decision maker to prioritize a discrete set of alternatives based on his/her preferences. AHP is based on relative comparisons of the alternatives with respect to a certain goal and criteria set which are in a hierarchical structure [4, 5]. The final product of an AHP study is the prioritization of the alternatives according to their contribution to the goal [6]. ANP is structured on the same basis of AHP; however, it differs from AHP in two ways. First, ANP does not assume that the alternatives, attributes and criteria are independent from each other. Their potential dependencies are handled through the feedback mechanism [7, 8]. Second, ANP has a network structure that is composed of subnetworks and submodels. The single hierarchical structure of AHP is constrained and inadequate, as the dependency and feedback mechanism are necessary for the decision making process [7, 8]. In that sense, it can be said that ANP reflects the complexity of the decision in a more accurate way.

The first step in an ANP study is to build the problem as a network structure. Generally, an ANP network structure has four parts: (1) the main model, (2) the benefits, opportunities, costs and risks (BOCR) model, (3) the ratings model and (4) the subnetworks. The main model contains the goal node and it is connected to the BOCR model through the ratings model. In the ratings model, alternatives are assessed according to their contributions to the goal in terms of BOCR. The second step is to perform pairwise comparisons between the various criteria and alternatives. As with AHP, Saaty [7] recommends that an acceptable consistency ratio (CR) should be less than or equal to 0.10. If the CR exceeds 0.10, pairwise comparisons should be repeated to ensure that the decision maker is consistent. Finally, the rankings of the alternatives are calculated and a sensitivity analysis is performed to observe the sensitivity of the final rankings to the changes in the judgments performed throughout the pairwise comparisons.

In the literature, there are several criticisms on AHP and ANP. For instance, when a new alternative is added to the decision problem, the rankings of the existing alternatives can change [9, 10]. In addition, because AHP and ANP models often require a large number of comparisons, the judgments made by decision makers can be taxing. In 1995, Olson et al. [11] showed that the requirement to answer a large number of questions reduced the attraction of the AHP in the eyes of decision makers although the questions themselves were considered to be easy. However, in our research the ANP model is an appropriate project portfolio management approach for organizational sustainability due to several reasons. First, organizational sustainability requires a long-term perspective; hence the evaluation and prioritization of potential projects is a strategic decision not a periodic tactical or routine operational decision. Further, because of the complexity of the organizational sustainability concept ANP actually allows for a more practical approach than other methods. Finally, although there are some literature based applications of ANP on project selection [12-16], an ANP approach to organizational sustainability is relatively new.

4. Proposed Model and Demonstration

4.1 Assumptions on the Model Development and Demonstration

The development and demonstration of the proposed ANP model has several assumptions. The new ANP model is an extension of the AHP model for organizational sustainability developed by Turan et al. [17]. Similar to this model, the TBL [18] sustainability index system developed in 2007 by Wang and Lin [19] is used as the criteria and subcriteria set in the hierarchy of the ANP main model. No industry specific criterion is assumed. The proposed ANP model is demonstrated on the same illustrative example as Turan et al. [17], which is based on the evaluation and prioritization the project alternatives shown in Table 1. These alternatives consider the current trends and issues in the U.S. electric utility industry. The comparisons of the nodes and clusters in the main model are performed similarly to those comparisons in the AHP model of Turan, et al. [17]. Finally, the comparisons reflect a single person perspective.

Table 1: Common issues in the U.S. electric utility industry and the related project alternatives [17]

Major Issues in the U.S. Electric Utility Industry	**Related Project Alternatives**
Future Capacity Concerns	Capacity Expansion Project
Absence of Green Power	Green Power Applications Project
Emissions Control and Allowances	Emissions Control Project
Continued Financial Performance	Financial Performance Improvement Project
Aging Workforce	Workforce Refreshment Project

4.2 Main Model

Figure 1 provides the ANP main model that was built using SuperDecisions [20], an AHP/ANP software package. As seen in the goal node, the objective of the main model is to maximize organizational sustainability. The connecting criteria cluster is comprised of the three main sustainability dimensions and their overlapping areas (i.e., economic prosperity, environmental quality, social justice, eco-environmental, eco-social, socio-environmental, eco-socio-environmental). In turn, each node in the criteria cluster is connected to the nodes of the related subcriteria clusters. For instance, economic prosperity is connected to the nodes in the 1EC1, 2EC2, 3EC3 and 4EC4 subcriteria clusters. Due to space limitation, subcriteria cluster names and their nodes are labeled as 1EC1, 1EC11, etc. (also used by Wang and Lin [19]). The exact names can be found in the related publication of Wang and Lin [19]. Additionally, the nodes of all subcriteria clusters are connected to the BOCR model through the ratings model, shown in Figures 2 and 3 respectively.

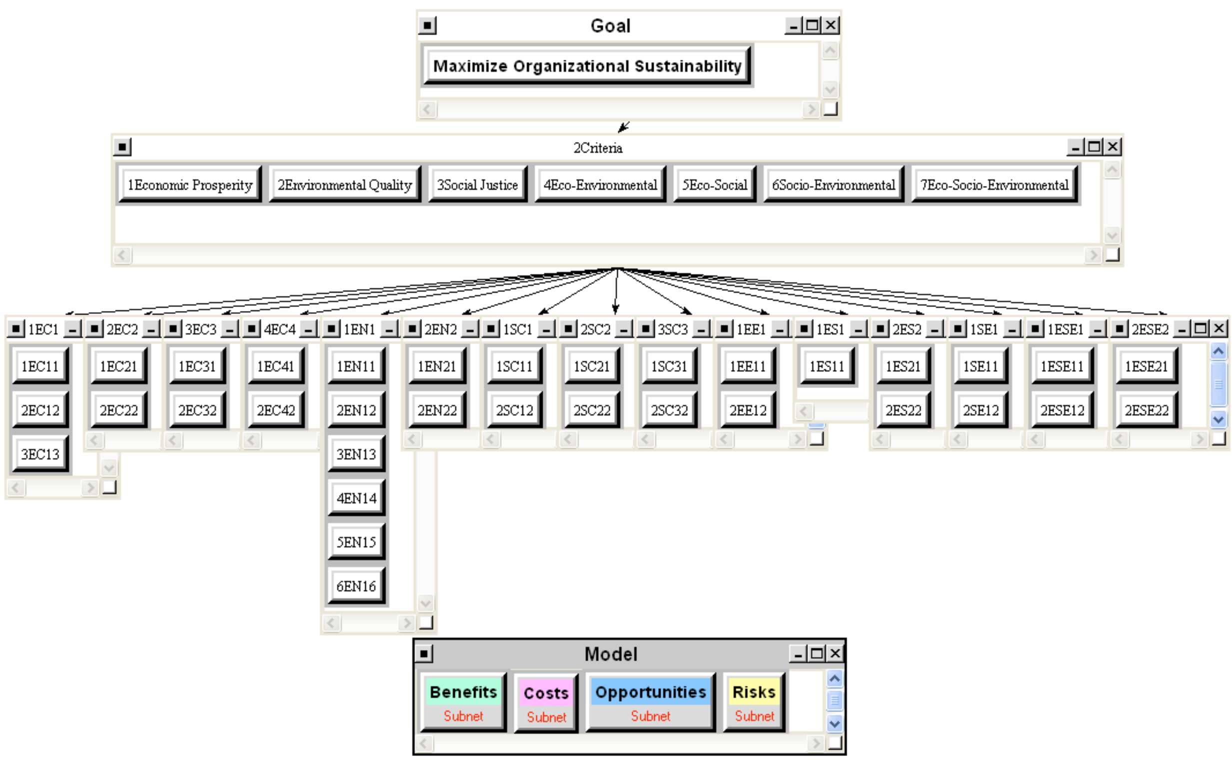

Figure 1: ANP Main Model - Hierarchy of strategic criteria and BOCR model

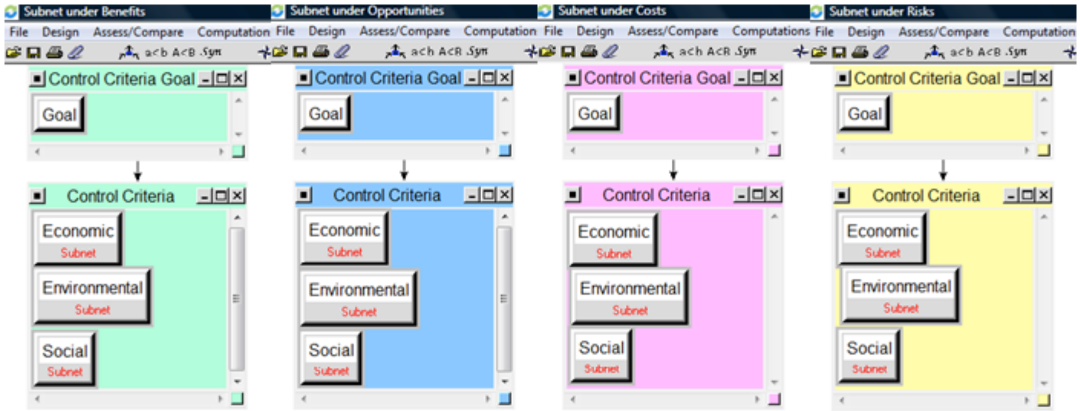

Figure 2: BOCR model

Ratings for Super Decisions Main Window: ANP Model for Organizational Sustainability

Super Decisions Ratings

	Priorities	1EC11 0.009640	2EC12 0.058628	3EC13 0.023772	1EE11 0.012006	2EE12 0.012006	1EN11 0.000860	2EN12 0.003720	3EN13 0.001706
Benefits	0.292688	Hi	Hi	Hi	Med	Med	Hi	Hi	Hi
Opportunities	0.230307	Med	Med	Med	Lo	Lo	Med	Med	Med
Costs	0.272946	Hi	Hi	Hi	Lo	Lo	Med	Med	Med
Risks	0.204059	Med	Med	Med	Lo	Lo	Lo	Lo	Lo

Figure 3: A portion from ratings model

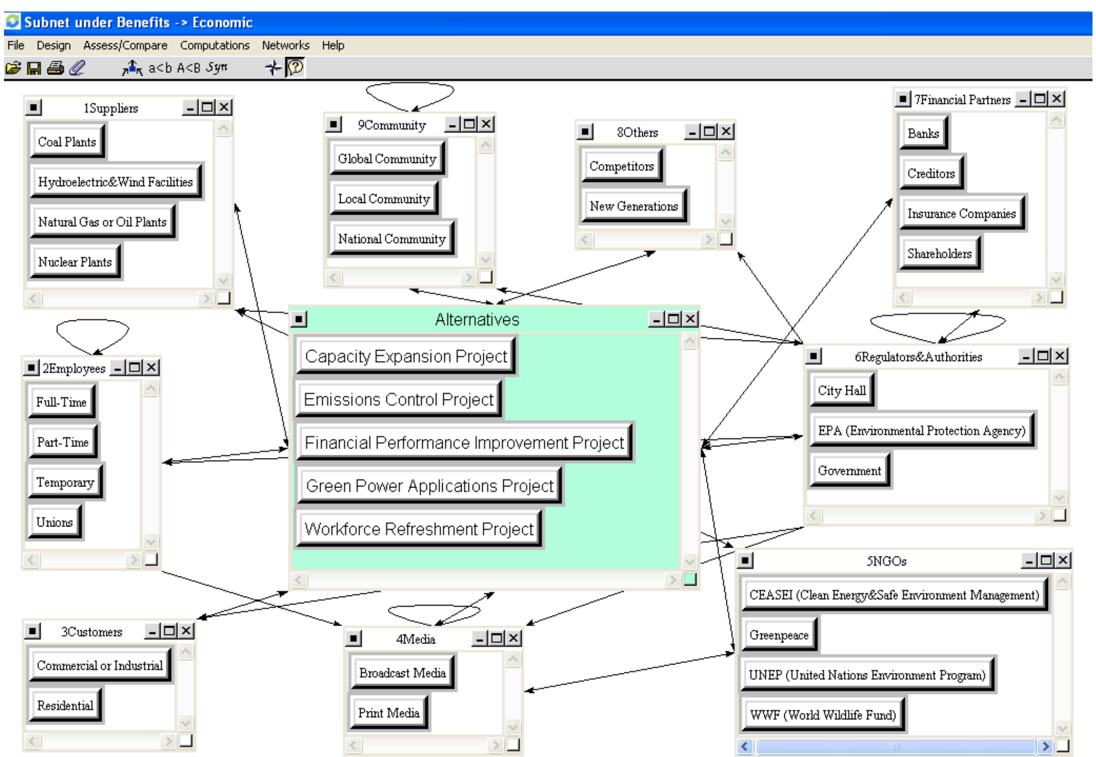

Figure 4: Subnetwork for economic benefits

4.3 Subnetworks

As shown in Figure 2, under each node of the BOCR model, three subnetworks are delineated - economic, environmental and social. To further illustrate, the economic benefits subnetwork under the benefits node is shown in Figure 4. It is composed of one alternatives cluster and nine stakeholder clusters – suppliers, employees, customers, media, NGO's, regulators and authorities, financial partners, community and others. The alternatives cluster contains the five project alternatives described in Table 1. The stakeholder clusters and their nodes are created by considering the typical stakeholders of a U.S. electric utility company. It is assumed that an electric utility company has four different potential suppliers – coal plants, hydroelectric and wind facilities, natural gas or oil plants and nuclear plants. Another perspective can be the communities are potentially affected by the utilities' activities - categorized as local, national and global communities.

The network in Figure 4 displays various dependency and feedback. For example, the priority of each project alternative is strongly related to the feedback that is obtained from each stakeholder group. Similarly, the impact of an alternative project on the global community is dependent on its impact on the national community which is also dependent on its impact on the local community. All the feedbacks and dependencies in the subnetwork are represented by the two sided arrows and loops in Figure 4, respectively.

4.4 Results

By asking the question "How much more strongly does this project possess the property than does the project with which it is being compared?" [6], the decision maker makes a series of pairwise comparisons. Using the *total outcome formula* (i.e., *b*B+*o*O+*c*C+*r*R) [7] in combining the four control merits, final priorities of the five project alternatives are derived, as shown in Figure 5. Green power applications are currently being explored by many utilities, and several states are implementing legislation to promote use and development of green power through renewable portfolio standards. Culturally, green power is a "vogue" subject, so it follows that green power applications would rank highest in the model. Emissions control projects are closely related to green power applications, because these projects involve scrubbing emissions from coal and other fossil plants, making the plants more eco-friendly. Given the current economic climate and deregulated environment, it follows that the capacity expansion project would rank lowest in the model. These projects are capital-intensive, and in a deregulated environment, no longer receive guaranteed recovery in rates. As a result, companies tend to prefer updating and improving current assets, rather than building and developing new generation capacity assets.

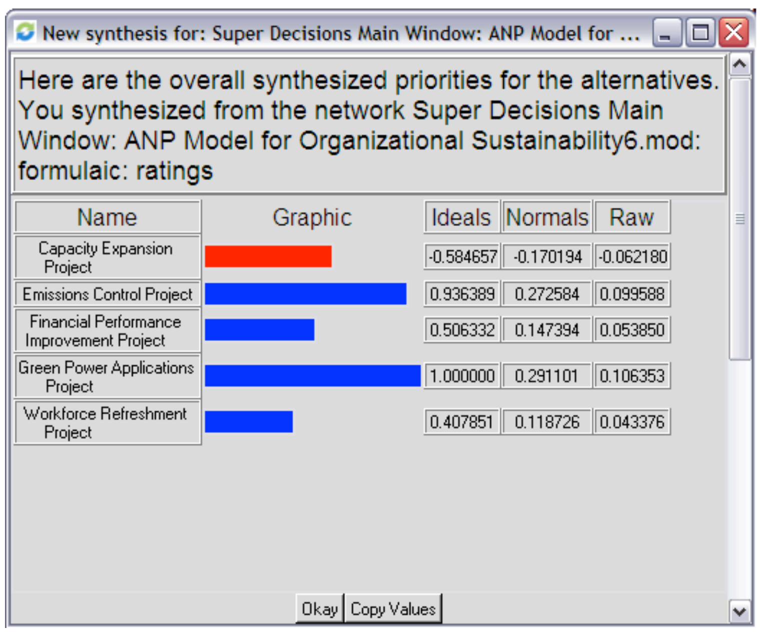

Figure 5: Subnetwork for economic benefits

5. Conclusion and Future Research Directions

As Saaty [21] indicates, in today's complex business world it is necessary to treat organizations not as independent systems, but as subsystems of larger societal, national, international, and environmental supersystems. In that sense, the proposed model can be used as a tool for this purpose, which can be verified by mapping the model with real applications. In this regard, the paper provides preliminary research as well as several future lines of work. First, if the decision maker's attitude towards risk is of interest, one can focus on the individual prioritization results of the BOCR subnetworks. For instance, if the decision maker is risk-seeking, the priorities associated with the benefits and opportunities subnetworks can be of primary interest. On the other hand, if the decision maker is risk-averse, attention may be given to the priorities obtained from the costs and risks subnetworks. Further, the *ratio formula* (BO/CR) rather than the *total outcome formula* may be applied [7]. Second, as previously mentioned, the pairwise comparisons in the model reflect a single individual's perspective. To develop a reliable result, it will be necessary to integrate the perspectives of experts from multiple fields into the decision making process and perform sensitivity analysis. Third, depending on the application, there can be adjustments to the TBL sustainability index system such as eliminating certain criteria, adding industry/company specific criteria or changing aspects of the hierarchy. Finally, although the proposed model evaluates and prioritizes project alternatives based on their contribution to an organization's sustainability initiative, creating a balanced investment portfolio requires financial input from each project alternative.

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