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A Quantitative Approach for Assessing Sustainability Performance of Corporations

Payman Ahi[a,*], Cory Searcy[b], Mohamad Y. Jaber[b]

[a] *Department of Global Management Studies, Ted Rogers School of Management, Ryerson University, Toronto, Canada*
[b] *Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Canada*

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ABSTRACT

This paper proposes a probabilistic model for assessing corporate sustainability performance. The need for probabilistic approaches to sustainability measurement is on the rise. Existing approaches to measuring strong sustainability, which emphasize the non-substitutability of resources, overwhelmingly focus on the national- or regional-levels. Few "strong" sustainability models explicitly address performance at the company level. The model proposed in this paper is also unique in that it addresses situations where the variables used to measure performance are dependent on one another. Existing approaches focus on independent variables. The model is provided in a generalized form and offers a straightforward approach to assessing the sustainability performance of corporations. Also discussed in the paper are some managerial and academic implications of the model.

1. Introduction

Sustainability is becoming an increasingly important concept for governance, policy development, and decision making, particularly at the corporate level. Many of the concepts and practices of sustainability have made their way into corporations, which has impacted the traditional way of conducting business and managing operations (Gimenez and Tachizawa, 2012). Sustainability is an expansive, complex and profoundly contested topic (Wilkinson et al., 2001). It stipulates an inter-generational philosophical position, where the decisions made today do not negatively impact future generations. Myriad discussions have focused on the sustainability implications and the types of philosophies and standards that may be required to achieve sustainability (e.g., Kemp, 1994; Hart, 1997; Myers et al., 1997). Further investigation is required, however, regarding the development of frameworks that explicitly address the need for corporate sustainability performance assessments.

The above suggests that a multi-faceted perspective is needed today when defining strong sustainability. The strong sustainability perspective heavily emphasizes the non-substitutability of resources. Furthermore, the use of this perspective requires that the ecological and socio-economic dimensions of sustainability are brought together with inter- and intra-generational equities (Tang and Zhou, 2012; Dedeurwaerdere, 2014). However, operationalizing this approach remains a challenge as the possible transition(s) between sustainable and unsustainable states is (are) not always evident (Ahi and Searcy, 2013). This paper provides a quantitative approach that could help in addressing such issues at the corporate level.

Ahi and Searcy (2014) developed a stochastic model for strong sustainability, which is extended in this paper to encompass practical scenarios not considered before. The earlier research by Ahi and Searcy (2014) developed a stochastic model that explicitly addressed the potential barriers and enablers to sustainability, with a focus on measuring and assessing the sustainability performance of a company. The model conceptualized a variable characterization for the involved sustainability factors, which provided a realistic analytical model for a company's sustainability behavior. One of the fundamental assumptions in the earlier model was that all of the variables representing barrier factors (i.e., acting as challenges to the company) and enabler factors (i.e., supporting the capacity of the company) in moving towards sustainability were assumed to be independent. Assuming independence among the involved variables is a common assumption in operations research and applied modelling approaches (e.g., Erlebacher and Singh, 1999; Guiffrida and Jaber, 2008; Roghanian and Pazhoheshfar, 2014). However, to enable decision-making in practical circumstances (e.g., the dependence between environmental factors in the real world), a model that comprehensively considers dependence among variables is needed.

The model proposed in the current research is unique in that it considers the use of dependent variables in measuring performance from a strong sustainability perspective. This is something rarely considered in models of sustainability measurement, including the previous

* Corresponding author at: Global Management Studies, Ted Rogers School of Management, Ryerson University, Toronto M5B 2K3, Canada.
E-mail address: payman.ahi@ryerson.ca (P. Ahi).

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Table 1
Fundamental issues expressed in the weak and strong sustainability perspectives.*

Strong sustainability	Weak sustainability
Focused on the notion that each of the natural and economic capitals should be sustained separately.	Focused on the aggregation of economic capital (i.e., manpower, machines and knowledge) and natural capital sources.
Based on the argument that many natural ecological functions (e.g., the natural resource stock of fossil fuels) are largely irreplaceable.	Based on the argument that virtually all natural capital, with limited exceptions for unique places (e.g., Niagara Falls) can be replaced by economic capital.
Argues that modification and redirection of growth is necessary, however, economic growth cannot surpass ecological limits.	Argues that sustainability is dependent mainly on economic growth.
Based on a view that any physical stock of the natural environment should be safeguarded and carefully conserved for the future generations.	Based on a view that sustainability can be obtained by safeguarding of an optimal amount of economic capital for the future generations.
Assumed no "substitutability" as it is highly unlikely that the core services provided by nature can be substituted by humans and/or artificial (i.e., manufactured or man-made) systems.	Assumed perfect substitutability between man-made generated capital and natural capital.

* Adopted from Gutes (1996), Neumayer (2003), Gowdy (2005), Wilson et al. (2007), Dietz and Neumayer (2007), Ayres, 2008, Ramos and Caeiro (2010), and Singh et al. (2012).

model proposed by Ahi and Searcy (2014). It is an important issue as environmental performance in one area is often dependent on performance in another. For example, climate change brought on by increased greenhouse gas (GHG) emissions could lead to changes in rainfall patterns which could, in turn, lead to changes in ground and surface water levels. This could result in localized water shortages. There are many other examples of the dependence between key environmental factors (see e.g., Rockstrom et al., 2009). Ignoring these interrelationships is a key weakness in many existing sustainability measurement schemes. Moreover, probabilistic approaches to sustainability measurement are important given that performance on the range of factors used in any analysis cannot always be perfectly predicted. There remains a need for probabilistic approaches to corporate sustainability measurement (Ahi and Searcy, 2014; Brandenburg et al., 2014).

A stochastic sustainability model under the green economics paradigm is proposed in this paper to respond to this need. It is one of the first models that offers a generalized measurement approach for assessing a company's performance explicitly under the strong sustainability concept. Moreover, the proposed model provides a reasonable basis for assessing the overall sustainability progress of a company, a requirement highlighted in the literature (see e.g., Azapagic and Perdan, 2000; Veleva and Ellenbecker, 2001). The model uniquely incorporates the issue of dependence among the involved variables representing different sustainability factors. Additionally, the stochastic nature of the model considers the uncertainty inherent in many sustainability issues. The model, lastly, can also be used as a tool to investigate and compare the sustainability progress of various companies, provided that the data required for employing the model is collected, allocated and reported in the same way for each company being compared.

The organization of the paper is as follows. A brief review of the most relevant literature to the research in this paper is provided in Section 2. A detailed discussion of the proposed model formation is provided in Section 3. An illustrative example of how to apply the proposed model is presented in Section 4. A discussion of results follows in Section 5. The paper concludes by highlighting the contribution of this work, the main findings and their relevance, limitations and some future research directions in Section 6.

2. Literature Review

Sustainability is often conceived in terms of the "triple bottom line" of environmental, economic, and social performance (Elkington, 1998). Much of the research over the last three decades has emphasized the interactions between economic growth and environmental protection, while social considerations have generally received less emphasis (Fleischmann et al., 1997; Sarkis, 1998; Veleva et al., 2003; Quariguasi Frota Neto et al., 2009; Putzhuber and Hasenauer, 2010; Govindan et al., 2014; Ahi and Searcy, 2015a; Gurtu et al., 2016). The need to sustain human activities over a long period of time within the boundaries of the ecosystem has been widely discussed (Chiesura and De Groot, 2003; De Groot et al., 2003; Ekins et al., 2003; Diwekar, 2005; Brand, 2009; Rockstrom et al., 2009). Some authors, however, have highlighted that there can be a tension between human activities, economic development, and protection of the natural environment. These tensions can be viewed through the lens of the "strong" and "weak" sustainability perspectives (Neumayer, 2003).

The tensions between strong and weak sustainability are often viewed as a dispute between ecological economics (e.g., Ekins and Max-Neef, 1992; Costanza and Daly, 1992) and neoclassical economics (e.g., Solow, 1993). Strong sustainability is the belief that investment and human-made systems cannot substitute for the resources that nature provides (Ayres, 2008). Based on this concept, many natural ecological functions (e.g., the natural resource stock of fossil fuels) are unique, and, hence, are not replaceable (Dietz and Neumayer, 2007). The rival position, the concept of weak sustainability, has been articulated by focusing on the aggregation of economic capital (i.e., manpower, machines and knowledge) and natural capital sources. The advocates of this concept believe that economic capital can replace almost all kinds of natural capital except for specific places, such as Niagara Falls. The amplified theory of capital convertibility (Solow, 1974, 1986, 1993) is the basis of the weak sustainability concept, which suggests saving fundamental and necessary wealth (capital) resources for the benefit of future generations. Accordingly, it seeks to maximize the flow of income and minimize the consumption of natural resources, so as not to deprive future generations of the economic capital (assets). Strong sustainability, in contrast, emphasizes the irreplaceability of natural ecological functions and the need to separately maintain natural and economic capitals.

Table 1 summarizes the fundamental disconnects between the strong and weak sustainability perspectives. Drawing on the above and also as shown in Table 1, the key distinction between strong and weak sustainability is focused on the substitutability of resources. The strong sustainability perspective argues that one cannot substitute one capital (i.e., economic and natural capital) for another since ecological functions are believed to be irreplaceable. Weak sustainability is the opposite, with limited exceptions.

The unique functions of natural capital have been elaborated by a number of authors. For example, Ekins et al. (2003) outline the following four function categories of natural capital:

1. The raw materials required for production and direct consumption (i.e., food, wood and fossil fuels).
2. Absorption of the waste produced by the production and consumption.
3. Providing amenity services (i.e., the visual amenity of a landscape).
4. Providing the basic life-support functions on which human life, as well as the first three categories of natural capital functions are dependent on.