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A measurement scale to evaluate sustainable innovation performance in manufacturing organizations

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Abstract

Sustainable innovation in manufacturing involves developing of new products, processes, services and technologies that enable economic development and well-being of stakeholders and institutions while respecting the worlds' natural resources and regenerative capacity. Defining and measuring even conventional innovation in manufacturing organizations, let alone sustainable innovation, is difficult. This study will present an initial effort at developing a scale for measuring sustainable innovation. For this, first, literature is thoroughly reviewed to identify sustainable innovation measurement related studies. The measurement model is developed from literature and is based on evaluation of decision points. The measurement scale is obtained by evaluating each item for their relevance considering a number of criteria. This study presents the first known scale to measure sustainable innovation performance and can be used by manufacturing companies to evaluate sustainable product or process innovativeness.

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Keywords: Mesurement, Model, Performance, Scale, Sustainable innovation

1. Introduction

Sustainable development or sustainability is defined as meeting the needs of the present generation without compromising the ability of future generations to meet their needs [1]. In manufacturing systems, sustainable product and process innovations, as well as system innovation play an important role to meet the responsibilities to the environment and society. It is hard to define and measure even conventional innovation in manufacturing organizations, let alone sustainable innovation. There are some different terminologies and definitions for sustainable innovation in literature, such as 'sustainability oriented innovation' [2] and 'sustainability related innovation' [3]. We prefer the term 'sustainable innovation' in this study. Sustainable innovation can reasonably be defined as "the development of new products, processes, services and technologies that contribute to the development and well-being of human needs and institutions while respecting the worlds' natural resources and regenerative capacity" [4]. Bos-Brouwers [5] defines sustainable innovation as "innovations in which the renewal or improvement of products, services, technological or organizational processes not only delivers an improved economic performance, but also an enhanced environmental and social performance, both in the short and long term have the capacity to generate positive social and environmental impacts." Another definition is "a process where sustainability considerations (environmental, social, and financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialization". This applies to products, services and technologies, as well as to new business and organizational models [6]. We define sustainable innovation as "any new or significant improvement of products, services, technological or organizational processes, commercialized or internally implemented, that not only provide economic benefits but also generate positive social and environmental impacts."

The remaining sections of this paper are organized as follows. Section 2 presents literature review. Section 3 presents model development. In Section 4, item generation

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and scale development are discussed. Conclusion and further research are presented in Section 5.

2. Literature Review

In this part of the study, the literature was reviewed thoroughly to identify sustainable innovation measurement related studies. 155 measurement related articles and 5 index studies were obtained to evaluate their basic approaches. These articles consist of not only sustainable innovation but also environmental (or green or eco) innovation because sustainable innovation covers environmental innovation and incorporates societal dimensions alongside and environmental aspects as can be seen in Fig.1.

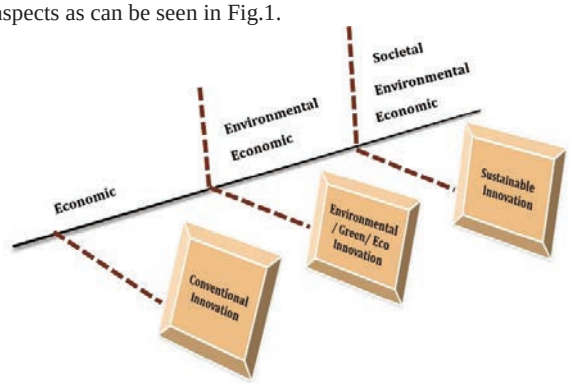

Fig. 1. Evolution of sustainable innovation

There are some prominent studies about green innovation measurement. Chen et al. [7] divide ‘‘green innovation performance’’ into ‘‘green product innovation performance’’ and ‘‘green process innovation performance.’’ They use 4 items for each green innovation type. Chen [8] revised these items and used them in another study. Both studies focus on emissions, end of life management, environmental issues, and usage of energy, material and other resources. Many studies {[9]; [10]; [11]; [12]; [13]; [14]; [15]; [16]; [17]; [18]; [19]} refer to these items of Chen et al. [7] or Chen [8]. A few studies {[20]; [21]} use the items from Community Innovation Surveys (CIS) of the European Commission conducted in 2009 that focus on: Pollution, CO_2 emissions, recycling and, the adoption of procedures such as Environmental Management Systems (EMAS), ISO14001, and usage of energy, material and other resources. At the same time, Arundel & Kemp’s [22] study is one the most prominent studies about measuring eco-innovation. They measure eco-innovation using the following four measures: input, intermediate output, direct output, and indirect impact. Many authors have cited their study. The study by Cheng and Shiu [23] is about developing an eco-innovation implementation scale. This instrument is the first known validation study about an eco-innovation measurement instrument in the literature. They divide eco-innovation implementations into 3 groups as: Eco-organization, eco-product and eco-process. They develop 6, 7, and 4 items for each group respectively. Cheng et al. [24] revise and use the same items in their study about the link between eco-innovation and business performance. In order to measure sustainable innovation, some studies use the number of patents and citations. Aguilera-Caracuel and Ortiz-de-Mandojana [25] use the number of green patents to measure green innovation intensity. Markatou [26] measures sustainable innovation with patent based analysis that focus on newly patented technological product innovations that can be described by sustainability related fields. In contrast, Petruzzelli et al. [27] measure the value of green innovations by the total number of citations the specific patent received within 5 years of the filing date, excluding self-citations belonging to the focal company. Similarly, Berrone et al. [28] use the total number of citations received by the patents granted each year to a focal firm to measure environmental innovation. In another study, Wagner [3] developed a proxy to measure ‘innovation with high social benefits’ using three useful variables of the Kinder Lydenburg Domini (KLD) social rating database and Padgett and Moura-Leite [29] use the same variables as well. Three different outcomes to measure sustainable innovation used by Ketata et al. [30] are: reduction in resource/energy consumption, reduction of environmental stress, and improvement of health and safety.

At the same time, some index studies were reviewed. Shuaib et al. [31] develop a product sustainability index that is one of the most important studies in the literature. They consider economic, environmental, and societal aspects of sustainability. This study has 13 clusters and 45 sub-clusters to evaluate product sustainability. The other prominent evaluation schema, Global Report Initiative [32] is a guide that has different items in sub-indexes to evaluate the sustainability aspect of an innovation. Apart from these studies, measurement scales to evaluate sustainable innovation are lacking in literature. The study presented in this paper is an initial effort at developing such a scale to fill this gap. For this purpose, we propose a model and develop an initial measurement scale based on the literature review as presented in the following sections.

3. Model Development

In the model development phase, studies in literature were reviewed thoroughly to propose a measurement model. We had some critical points to ask the question, what would be the boundaries of the model? Fig.2 shows that there are different decision and alternative points that could be used to propose a model. The color boxes indicate our selections. According to the points that we chose, the measurement model should be result and output oriented because we aim to develop a scale to measure sustainable innovation performance. Also, performance measurement is more related to output and result-oriented processes while capability measurement is more related to the input and process. At the same time, we focused on product and process level innovation. These two levels are more observable to evaluate sustainable innovation than the system level. This study is an initial work and the system level could be taken into