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Sustainability evaluation model for manufacturing systems based on the correlation between triple bottom line dimensions and balanced scorecard perspectives

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ABSTRACT

The evolution of the concept of sustainability associated with the demands of society has transformed the management models of manufacturing systems. Several models of sustainability evaluation based on indicators that represent the economic, environmental and social dimensions of the triple bottom line (TBL) concept have been proposed in the literature. However, the definition and coverage of sustainability indicators have become a challenge. Thus, the aim of this article is to propose a sustainability evaluation model based on a correlation matrix between the dimensions of the TBL concept and the perspectives (learning and growth, process, market and financial) of the balanced scorecard (BSC) management model. Based on the literature review, this study proposes performance indicators for each of these correlations, obtained via the TBL X BSC matrix, which resulted in the sustainability evaluation model. This model also provides a governance logic establishing a flow to assure the compliance of the matrix. The proposed model was applied to a Brazilian manufacturer in the market of food and beverage, through visits and interviews. This application showed that the 12 correlations of the TBL X BSC matrix allow for a comprehensive and detailed evaluation of a manufacturing system, because it involves the TBL dimensions and the BSC perspectives, and enables the definition of indicators for each correlation. The model can also be useful for defining performance indicators for sustainability assessment models and can be integrated into multi-criteria decision methods to improve organizational sustainability and performance.

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1. Introduction

The evaluation of sustainability in manufacturing systems has been the subject of several academic studies in the past several years and has particularly focused on the association between sustainability and manufacturing system performance. Amui et al. (2017) identified that the alignment of organizational strategy with sustainability results in the increased competitiveness of manufacturing systems. Edgeman and Eskidsen (2014) argued that traditionally, the evolution of manufacturing systems' excellence has not directly related to the application of sustainability, and they highlighted the difficulty of integrating the three dimensions of sustainability of the triple bottom line (TBL) concept.

Thus, an increasing number of researchers have studied performance indicators to evaluate the sustainability levels of manufacturing systems considering TBL integration. Govindan et al. (2016b) highlighted the importance of the balance among the economic, environmental and social dimensions in a company through the correlation between performance indicators and TBL dimensions. Goyal et al. (2013) identified performance indicators based on the critical success factors obtained through the risk analysis of the association between organizational strategy and sustainability. Faulkner and Badurdeen (2014) and Helleno et al. (2017) developed a sustainability evaluation model for manufacturing systems based on the integration between value stream mapping (VSM) and the TBL dimensions in manufacturing. These studies highlight the importance of using the TBL dimensions to evaluate manufacturing systems' performance.

In parallel, reports and indicators based on TBL dimensions, such as the Global Reporting Initiative (GRI) and the Dow Jones

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Sustainability Index (DJSI), have been developed as benchmarking solutions for assessing the levels of sustainability of manufacturing systems (Searcy and Elkhawas, 2012; DJSI, 2016; GRI, 2016). Reports such as the DJSI, DAX Index (Deutsche Akzien Index) and GRI have become important standards in business management (Hahn and Kühnen, 2013) and, according to Hahn and Lülfs (2014), although some companies provide additional sustainability information to the index on their homepages, the authors consider in their study that the GRI guidelines cover all relevant aspects of sustainability performance.

However, the study of reports such as the DJSI exposes the fragility of their practical implications because the corporations have implemented by chance a variety of sustainability initiatives as a response to the increase of internal and external pressures to consider the environmental and social impacts of their operations (Searcy and Elkhawas, 2012). Searcy and Buslovich (2014) concluded that the practical application of these reports is sometimes just to validate internal engagement in the companies once the nonprescriptive requirements of the standards are frequently modified or ignored by the corporations.

In addition to using the TBL dimensions for sustainability evaluation, in the scope of the manufacturing system analysis, the balanced scorecard (BSC) is one of the techniques widely explored in operations management models, considering both the financial and nonfinancial aspects of performance evaluation (Franco-Santos et al., 2012). The BSC has normally been associated with sustainability in an attempt to integrate it with organizational performance.

With the aim of integrating the BSC with the concept of sustainability, studies have addressed and developed various models. One of these models, the sustainability balanced scorecard (SBSC), integrates social, environmental and ethical issues into the BSC design as an approach to sustainability-oriented organizational development, considering the structure of the BSC to support the corporate sustainability strategy (Hansen and Schaltegger, 2016).

Therefore, even the integration of sustainability and manufacturing system performance is a subject of current studies, and several of these research studies have proposed models to assure this integration. However, no consensus has been reached on the definition of how to do so and concerning which indicators can be used to assure the compliance of the models. In this context, the aim of this article is to propose a sustainability evaluation model by integrating the TBL dimensions with the BSC perspectives. Thus, the intent is to increase the scope of the sustainability assessment considering social and environmental responsibilities and actions that seek to maintain a company's competitiveness in the market.

In this study, the following sections are presented: Section 2—*Theoretical background*: provides a conceptualization and the literature background of sustainability, manufacturing system performance and the models integrating these concepts; Section 3—*Proposed model*: introduces the research method for the model construction; Section 4—*Case study*: shows the application of the conceived model at a Brazilian manufacturer in the food and beverage area. Finally, Section 5—*Conclusion*: concludes the study with academic and practical contributions.

2. Theoretical background

Corporate sustainability can be defined as the achievement of the direct and indirect stakeholders' needs (involving employees, clients, communities etc.) without compromising the ability to meet their future needs, considering both the administrative and the operations activities of the organization (Dyllick and Hockerts, 2002). According to Lopez et al. (2007), organizations consider sustainability to be an element that differentiates them from their competitors, and with this, sustainability can be a strategy for adding value to maintain competitiveness.

Although the existing corporate sustainability issues are varied, this is considered a strategic issue (Lee and Saen, 2012) and is directly associated with the TBL concept (Elkington, 1998). Elkington (1998) defined the dimensions of the TBL concept as follows: (i) economic: represents the profit and earnings per share as part of the company's accounting; (ii) environmental: indicates the environmental agenda that the executives of the enterprises have defined to meet the market expectations; and (iii) social: comprises the social, political and ethics issues.

The TBL concept is a core and dominant idea today that orients sustainability reporting and the incorporation of the TBL key performance indicators (KPIs) into manufacturing systems (Milne and Gray, 2013; Ahi and Searcy, 2013). Govindan et al. (2016b) complemented the TBL concept by establishing that economically sustainable enterprises ensure liquidity and financial returns to stakeholders; environmentally sustainable companies are committed to preserving the ecosystem; and socially sustainable ones enrich communities with the management of their social capital. In this context, a company must harmoniously meet the three dimensions of the TBL concept to be considered sustainable.

With the aim of developing a model to integrate the TBL dimensions, Dyllick and Hockerts (2002) proposed the criteria presented in Fig. 1, identifying six criteria for evaluating corporate sustainability through the TBL.

Fig. 1 shows the association among the TBL dimensions, considering the evolution of socio-effectiveness, eco-effectiveness and efficiency as a way to achieve corporate sustainability. The interaction among the three dimensions results in six criteria that need to be respected to assure compliance with the TBL concept.

In the same sense, Faulkner and Badurdeen's (2014) concept of sustainable VSM (Sus-VSM) brought to the empirical context the use of the three dimensions of the TBL to evaluate the manufacturing system, establishing indicators for measuring environmental and social risks. In this model, economic performance is considered to be based on the classical VSM metrics of cycle time, changeover times, number of operators involved in the process etc.

Jabbour et al. (2014) presented indicators associated with organizations' green performance, confirmed in practice through a structural model that linked manufacturing practices with green

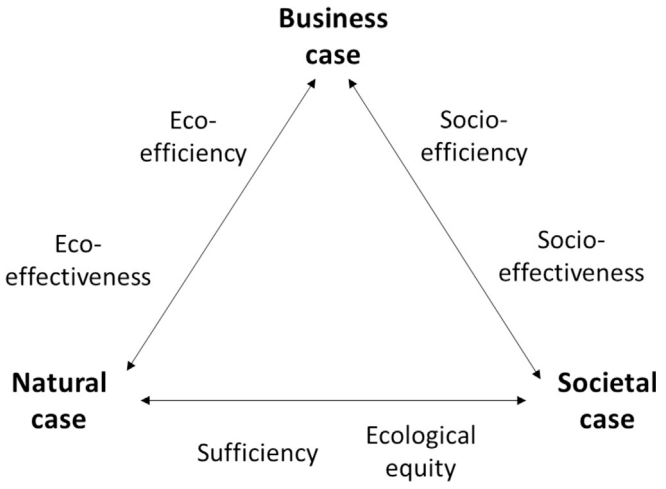

Fig. 1. Overview of criteria of corporate sustainability (source: Dyllick and Hockerts, 2002).

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