



Business cases for ecodesign implementation: a simulation-based framework

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ABSTRACT

The lack of quantitative mechanisms aimed at evaluating the potential business benefits of ecodesign prior to implementation is a major barrier to wider adoption in manufacturing companies. Ecodesign is defined as the consistent integration of environmental aspects into product development processes. Within this frame, there is a need to understand how the development of ecodesign capabilities affect overall business performance over time. Drawing upon the Ecodesign Maturity Model (EcoM2) as the theoretical foundation, this paper systematically reviews the literature on (i) relevant applications of dynamic modelling and (ii) relationships between ecodesign management practices and key business performance outcomes, in order to develop a simulation-based approach aimed at deriving a business case framework for ecodesign implementation. The resulting framework originates the “business case simulator”, which was subjected to the judgement and evaluation of six industry experts regarding its applicability and usefulness to manufacturing settings. The results are discussed and future research streams – coupled with improvement opportunities to the business case simulator – are pointed.

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1. Introduction

Despite the significant growth in the number of researchers and corporations reporting the benefits of ecodesign-related efforts (Haned et al., 2015; IRRC Institute, 2015; Plouffe et al., 2011), a number of challenges still hinder a broader and consistent implementation of ecodesign in manufacturing firms. There is a particular lack of proper mechanisms to evaluate the potential business benefits originated by ecodesign (Boks, 2006; Dekoninck et al., 2016; McAlloone, 1998; Rodrigues et al., 2017a, 2016b), which can be defined as a proactive approach for the integration of environmental aspects and considerations into the product development processes (Pigosso et al., 2013, 2015). With that, the concept of “business case” emerges as the set of arguments that support and elicits the key reasons why an organization should implement or advance a specific cause (Carroll and Shabana, 2010; Rodrigues et al., 2018a,b; Schaltegger and Lüdeke-Freund, 2012; Weber, 2008; Whelan and Fink, 2016). In general, most business cases typically account for a *posteriori* analysis of the influences of

ecodesign-related practices, as opposed to *a priori*, *predictive* business cases, which focuses on how to collect information and measure the overall and strategic performance of a company in financial (e.g. profitability, revenues, costs, return on investment etc.) and non-financial terms (e.g. water usage, material usage, energy usage, CO₂ emissions, water footprint etc.).

The integration of ecodesign aspects into product development is considered a complex task, which means that it typically has high interconnectedness and trade-off among key variables over time, such as cost, potential revenue, profitability, risk or environmental/social performance, among many others (Costa et al., 2014; Rodrigues et al., 2016a; Tatikonda, 2007). As a very simple example, the selection of material influences the product's environmental performance as well as its cost and applicability over time which, in turn, feeds back into the material decision as a set of criteria. Therefore, this is a problem that displays dynamic complexity, which arises from the interactions of several agents and relationships over time (Stermann, 2000). Some fundamental characteristics of systems with dynamic complexity are: *constantly changing and past-dependent*; *tightly coupled and governed by feedback* (i.e. strong interaction among variables with feedback loops); *self-organizing* (the system's structure drives its behavior over time); *adaptive* (i.e. resistance to change and adaptation to newly introduced policies)

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