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An approach for steering products and services offering variety towards economic and environmental sustainability

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ABSTRACT

Customers' individual preferences are calling for greater variety of firms' offerings. Faced with this situation, firms endeavour to meet customer requirements while reducing their costs and impact on the environment to remain competitive. The attainment of these goals entails various issues that must be addressed including multiple performance drivers and criteria relating to environmental and economic sustainability and variety. Accordingly, trade-offs must be defined and balanced among such heterogeneous criteria to facilitate the decision-making process on a variety of levels regarding environmental and economic sustainability. These trade-offs should involve decision makers to reflect the firm's priorities and consider its business field. This paper proposes an approach supporting the decision-making process on offering variety to the market while considering environmental and economic sustainability criteria. More specifically, the approach uses economic and environmental performance indicators and inputs from decision makers to determine the variety of the offering to meet a given demand. The paper highlights the impact of variety steering on environmental and economic sustainability indicators.

Introduction

The increasing customer demand for tailored solutions compels firms to seek customer satisfaction more effectively, thus broadening the conventional focus on productivity to integrate customer expectations and satisfaction. This has led to more customer-centred strategies in both Business to Customer (B2C) and Business to Business (B2B) contexts, including Mass Customization (MC) and Product–Service Systems (PSS). Whereas MC aims to fulfil individual customer needs with near-mass-production efficiency [1], product service systems aim to offer a solution with a combination of products and services that satisfies an identified customer need [2]. Therefore, MC and PSS are well suited for current markets in multiple sectors. Customers' individual preferences are calling for more variety of firms' offerings in terms of products and services. Under these circumstances, firms endeavour to meet diversified customer demands while reducing their internal costs and impact on the environment to remain competitive. Achieving such a goal entails various issues be addressed such as the heterogeneity of the multiple performance drivers and criteria relating to environmental and economic sustainability and variety. Accordingly, trade-offs must be defined and balanced between such heterogeneous criteria to facilitate the decision-making process on variety levels regarding the environmental and economic sustainability impact. The key point is how to maintain a good a level of variety in the offering at a reasonable cost and relatively low environmental impact. Obviously, defining trade-offs regarding these two rather conflicting objectives first requires involving the decision makers to reflect firm priorities and consider its business field.

This paper proposes a model supporting the decision-making process on various solutions delivered to the market while considering environmental and economic sustainability criteria. More specifically, the model uses performance indicators calculated by life cycle assessment tools, applies weights to these indicators, and finally balances the production among variants to meet given demand requirements. The paper highlights the impact of variety steering on environmental and economic sustainability indicators. The remainder of this paper is organized as follows: section "State of the art" provides an overview of product variety, followed by an environmental and economic sustainability assessment, which are the two objectives to be reconciled. The proposed approach is presented in section "Proposed approach". An illustrative case study is presented and discussed in section

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"Illustrative case study". Section "Discussion" discusses the added-value and limitations of the proposed model. The paper ends with concluding remarks in section "Conclusion".

State of the art

The multifaceted problem addressed by this paper requires a multidisciplinary approach that provides valuable decision support to companies that encounter this problem. Subsequently, three literature streams are required to set the foundations of the proposed approach. Section "Impact of offering variety on products and product–service production systems" identifies some of the most common impacts of variety on production systems. Section "Green considerations in operation management" elaborates on the need for and underlying approaches of mitigating the impact of variety on production systems. Section "Business considerations in operation management" provides an overview of environmental and economic sustainability impact optimization in production systems. The aim is to explore existing models and tools used to assess the economic and environmental sustainability of a given product offering characterized with a certain variety level. Because the assessment and optimization of economic and environmental sustainability of a product offering entails multiple criteria, proper decision-making procedures are required to provide valuable support for decision makers. In this vein, section "Decision-making and indicator aggregation" discusses some solution approaches for the multi-criteria decision-making problem. A summary of the findings of the literature review is presented in section "Summary of the state of the art".

Impact of offering variety on products and product–service production systems

Increasing the variety of products and services has been shown to be an answer to diversified demands that shape current product and service markets. From a mere product perspective, variety refers to the diversity of products that a production system provides to the marketplace [3]. The manufacturing sector has witnessed a shift from conventional channels of product sales to a new paradigm in which the product is integrated with a set of services to maximize the added value and meet specific customer demands [4]. This paradigm shift has led to the emergence of PSS. According to Goedkoop et al. [5, p. 18], a PSS *is a marketable set of products and services capable of jointly fulfilling a user's need*. Subsequently, product variety cannot be decoupled from service variety because the *product and service can be equally important for the function fulfilment*. Therefore, many firms have recognized the need for increasing the variety of their offering (including products and services and integrated solutions) to increase their attractiveness [6,7].

The other side of variety relates to the complexity induced by the high number of product and service variants. Product complexity can be approached by the degree to which the individual parts/subassemblies have physical attributes that cause difficulties during the handling and insertion processes in manual or automatic assembly [8]. Obviously, increasing the number of product and service variants to meet as many customer requirements as possible is likely to induce an increase in the number of components, modules, process sequences, service delivery activities, operators, and suppliers [8,9]. This involves additional efforts on the part of the operators to move from one variant to another during production (because activity sequences, tools and raw materials, for example, are not similar among the variants) or deliver a variety of services requiring each specific qualification. Consequently, the increased variety may burden the cost benefits of scale production owing to lower production lot sizes, high change over time and heavy workload, in terms of quantity (e.g., demand for service) and quality (e.g., required qualification), to ensure good service quality. The variety level of supplied components or modules also impacts the supply cost by increasing the unit cost with decreasing purchased lot size because companies must be able to efficiently produce, sort, ship and deliver small quantities of highly differentiated products [10]. These impacts on cost go hand in hand with the variety impact on lead time. Basically, the variety-induced complexity in the production systems extends the setup times and introduces some stochastic aspects in the production lead times depending on the level of customization of each product variant [11]. The scarcity of some supplied or outsourced components implies higher average lead time of the variant(s) using those components. Obviously, this problem also impacts service delivery performance, particularly for services that require components to be delivered (spare parts, consumables, etc.). All of these factors violate the rationale of variety, which is to efficiently (in terms of time and cost) meet customers' diversified demands. Furthermore, the offering of high variety has an effect on the overall environmental impact of a given mix of products or services because of the lack of resource sharing. For instance, the process variety induced by product variety calls for more flexibility of the production system. Although flexibility simplifies working with a wide variety of customer orders, it may entail more energy and material consumption. The point is that manufacturing modular products or processes (typically used in flexible and reconfigurable manufacturing systems), for instance, may require more material and energy than manufacturing conventional products and processes [12]. This means that the variety of the offering must be properly steered towards the objectives of the company and should not be seen as goal in itself.

Whereas variety is seen as a way to meet specific customer demands, it has been emphasized that too much variety confuses customers [13]. Hence, the benefits generated by variety may not keep pace with the increasing customer demands of products and services. Gardner [14, p. 55] argued that *it is often best to offer a feature or option to make the offering relevant to the marketplace, not merely because the company can offer it*. Additionally, careful decisions must be made regarding what to offer to the market because of the capacity burdens within each company.

From a green perspective, managing the overall environmental impact of a high-variety mix of products or services can be challenging because of the growing number of SKU (stock keeping unit) types. In fact, each SKU has a specific environmental impact that is usually decoupled from the demand for that specific SKU. For example, a given SKU may have a high greenhouse gas impact (e.g., because of the raw material extraction method) but have only a minor demand. At this point, it is convenient to consider this impact when defining the variety level of the offering. The service delivery activities may also have various impacts on both the environment and costs, depending on the consumables, transportation means, distance to customer premises, and qualification of the service operators (and thus unit costs).

Green considerations in operation management

The emergence of green considerations in operation management is witnessed by the large body of literature relating to this topic, which involves typically the question of trade-offs between environmental and business concerns [15,16].

Environmental sustainability is increasingly emerging in the operation management domain. The typical indicator used in the literature is greenhouse gas emissions. Some authors went a step further by attempting to capture a broader spectrum of sustainability dimensions. Mirzapour et al. [17] proposed an optimization

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