



Identifying Robust portfolios of suppliers: a sustainability selection and development perspective



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ABSTRACT

The initial selection and development of suppliers is a critical and increasingly complex component of organizational supply chains. In recent years sustainability issues have played an increasing role in making these decisions, though there has been limited activity in the literature in this regard. We develop an optimization model that simultaneously addresses supplier selection, supplier development, and sustainability considerations. Sustainability is integrated in the form of supplier sustainability ratings and sustainable supplier development through investment and training budgets. To handle the considerable complexity concerning such decisions, we demonstrate a recent algorithmic approach that can identify a portfolio (set) of multiple high-quality and yet collectively diverse solutions. This approach is carried out on a selection of randomly generated, representative test instances. Encouraging computational results and managerial implications are analyzed and discussed.

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1. Introduction

As industrial competition continues globalizing, intrepid organizations have sought to strengthen their local and international supply networks to maintain their competitive positions. Strategic partnering and development play a central role in building these networks. Recognition of the central role that suppliers and supply chains have in organizational competitiveness has further underscored the importance of supplier selection, maintenance, and development in managerial and organizational decision making. In response to this recognition and evolving competitive environment, supplier selection, vendor management, and supplier development analytical studies have seen marked growth in recent years.

In addition to issues of economic and global competitiveness, there are intensifying stakeholder pressures to ensure that social and environmental sustainability dimensions, from the triple bottom line definition of sustainability, are taken into consideration when supply chain management efforts are implemented. These additional sustainability concerns introduce greater uncertainty and complexity to organizational supply chain management and decision making. Multiple functions, decision makers, and

organizations become involved in supporting dynamic supply chain decisions. Decision tools that can support managers in this continuously evolving environment are increasingly desirable (Brandenburg et al., 2014).

The need for analytical decision research is growing and many different research directions and gaps still remain for general supplier management modeling (Ho et al., 2010), and more specifically for sustainable and green supply chain management modeling (Brandenburg et al., 2014; Govindan et al., 2013a). In addition to standalone analytical models, integrative models that can coherently and effectively address the multiple decision and managerial dimensions of supply chains are of great value.

The joint evaluation of supplier selection and development has seen limited, if any, analytical or decision modeling research (Meisel, 2012). Recent works on separate analytical and decision modeling for supplier selection, and to a much lesser extent supplier development, have seen increases. Even when excluding sustainability dimensions, the authors are unaware of any joint consideration of these issues. Thus, given the recent importance in sustainability, supplier selection and development, our investigation seeks to contribute to the literature by building on sustainable supplier selection and development research.

We address this gap by developing and evaluating a new optimization model that embodies the dual stages of supplier selection and supplier development. An equally significant contribution is due to our subsequent analysis on test instances of this model using

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a recent algorithmic approach that can identify a portfolio (set) of multiple high-quality and yet collectively diverse solutions (Trapp and Konrad, 2013). Competitive, natural environment, and social uncertainties require careful and simultaneous examination of multiple suppliers by management to help reduce the risk in supplier selection and development. Consideration of the dynamic, multiple stakeholder environment requires some flexibility in the selection of the supplier portfolio. That is, an ultimate decision may not always be the best for each and every decision maker or scenario, especially given the many implicit and explicit dimensions of the decision environment. So, while a diverse set of solutions is highly desirable in this context, at the same time these solutions should not sacrifice on the solution quality, in terms of business and/or sustainability measures. The approach can, while maintaining high quality, allow for a variety of diverse solutions from which decision makers may further refine their choices.

The remainder of the paper is structured as follows. In the next section a foundation of research and practice literature related to the topics of supplier management and sustainability are overviewed. The mathematical formulation and methodology are then introduced. Next an illustrative example is discussed that outlines a small instance and how the solution approach can aid in identifying alternate solutions that are both high-quality and diverse. Computational experiments are subsequently reported with some initial observations concerning the results presented. A discussion and conclusion follows with clear practical and research implications. The conclusion also provides an overview of the limitations and directions for future research.

2. Background and literature review

We provide a review of the general supply chain modeling and supplier selection literature to properly situate our study in its greater context. This background will help inform the development and evaluation of the analytical model that we subsequently introduce. We also survey related works that focus on the integration of sustainability into supplier selection and development. The practical and managerial issues facing the supplier portfolio selection process are also introduced and set the stage for practical application of the aforementioned tool, which we will return to in subsequent discussions.

2.1. Supply chain management – supplier selection and development

The supply chain management literature includes a number of issues which need attention for maintaining a strategic and competitive supply chain, including management concerns such as (Talluri and Narasimhan, 2004):

- Which suppliers should be considered for partnering?
- Which suppliers should be part of supplier development initiatives?
- Which suppliers must be removed from the supply base?
- How can weak suppliers improve their performance?
- How can firms effectively allocate resources to supplier development programs?

Among these, in this paper we focus on supplier partnering/selection and development. While some have defined supplier development solely as supplier selection (Chan and Kumar, 2007), supplier development extends beyond supplier selection. Specifically, supplier development also includes aiding suppliers through investment of various resources either by a buyer, or jointly with a supplier, to improve supplier capabilities and performance

(Praxmarer-Carus et al., 2013). Yet, supplier selection criteria can play a role in further evaluation of supplier development (Hahn et al., 1990; Lee et al., 2001).

The number of supplier selection models has increased exponentially over the past couple of decades (De Boer et al., 2001; Ho et al., 2010). Many modeling approaches have been utilized from basic vendor selection optimization models with traditional business criteria (e.g. Sarkis and Semple, 1999) to integrated techniques that utilize multiple methods and address a wide variety of tangible and intangible criteria (e.g. Kasirian et al., 2013). In many cases supplier selection decision modeling has transcended the traditional boundaries of deciding which supplier(s) to select. For example, the supplier selection decision has been integrated with benchmarking and improvement (Liu et al., 2000), production planning constraints (Ghodsypour and O'Brien, 2001), inventory management considerations (Aissaoui et al., 2007; Xia and Wu, 2007), purchase/procurement quantities (Ting and Cho, 2008; Zhang and Chen, 2013), supplier failure (Ruiz-Torres et al., 2013), and sustainability/environment issues (Genovese et al., 2013; Govindan et al., 2013a).

Outside of supplier benchmarking and some post-hoc evaluation using similar criteria, supplier selection models have overlooked the explicit integration of supplier development issues (Mesquita et al., 2008). This oversight is unfortunate, as supplier development is important for a variety of reasons. These reasons range from benefits to the focal organization, competitive posture improvement, supplier development through higher quality, shortened product development cycles, and lower costs (Brennan and Turnbull, 1999), to overall improvement in supplier satisfaction, capability, flexibility and profitability (Carr et al., 2008; Praxmarer-Carus et al., 2013), to improvement of trust and general collaborative capabilities of the focal company–supplier relationship (Blonska et al., 2013; Krause et al., 2007). The breadth of these benefits exemplifies some of the complexities involved in making decisions in this environment and the need for tools to help managers make difficult decisions.

While sustainable supply chain management has many of the above traits in common with general supplier selection and supplier development, it also has additional considerations. We next provide an overview of some of these key features and considerations.

2.2. Sustainable supply chain management – supplier selection and development

Although no consensus definition exists for green and sustainable supply chains, sustainable supply chain management can be defined as incorporating various dimensions of social, economic, and environmental sustainability into supply chain management (Ahi and Searcy, 2013). Sustainability has been defined as an intergenerational philosophy (Brundtland, 1987), i.e. using resources today without compromising the needs of future generations, and through the triple-bottom-line concept of integrating environmental, social, and economic dimensions into organizational decision making (Elkington, 1998).

The additional cross-functional and inter-organizational characteristics of sustainable supply chain management complicate even the simplest sustainability-oriented decisions, though this complexity is dependent on the defined boundaries of a particular supply chain (Sarkis, 2012). The integration of environmental sustainability practices into organizations range from reactive activities in response to regulations, e.g. management of hazardous materials, to more proactive activities that include developing plans to gain competitive advantages from greener practices, such as eco-design and green marketing (Buysse and Verbeke, 2003; Wu

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