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Supplier selection using a multi-criteria decision aid method

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Abstract

An ever-increasing trend in today's industrial firms is to exploit outsourcing for those products and activities deemed to be outside the company's core business. Given the financial importance and the multi-objective nature of supplier selection decision, in this paper an effort is made to highlight those aspects that are crucial to process qualitative and quantitative performance measures. In this paper, the contribution of a multi-criteria decision aid method (PROMETHEE/GAIA) to such problems is investigated, together with how to allow for a simultaneous change of the weights (importance of performance criteria), generating results that can be easily analysed statistically, performing an innovative sensitivity analysis. By way of example, the model is applied to a mid-sized Italian firm operating in the field of public road and rail transportation. The whole suppliers selection model presented (PROMETHEE/GAIA techniques plus high-dimensional sensitivity analysis) seems to be a useful additional tool inside the final choice phase of a supplier selection process. Finally, potential issues for future research are presented.

Keywords: Suppliers selection; Outranking methods; Multi-criteria decision aid methods; Weights assessment; Sensitivity analysis

1. Introduction

Vendor selection and evaluation is one of the most critical activities of firms, traditionally based on invoice cost, supplier's ability to meet quality requirements and delivery schedule. Supplier–customer relationship literature has developed descriptive and normative relationship models (Clark and Fujimoto, 1991; Smitka, 1991; Lamming, 1993) due to the increasing acceptance of the concept of lean supply and the paradigm of lean production, as well as many organisational and managerial modifications developed in vendor-rating systems. Today, from a managerial point of view, a wide set of performance criteria has to be identified (see Weber et al., 1991, for a review) and suitably weighted with reference to their *context-specific* importance. A suitable algorithm is needed in order to obtain a synthetic rating index for each alternative and support decision-makers in their final judgement. Trade-offs usually exist among the various criteria and these may not be apparent when using a single-objective model; a most preferred (optimum) is infeasible, criteria scores have to be balanced and a multiple criteria decision aid (MCDA) approach is necessary. According to any MCDA approach, the process of vendor rating can be schematised as follows:

- Grouping of supplies in homogeneous classes of items, in terms (for example) of impact on product's quality and cost, delivery times, production breaks. In case of supplier's involvement in a complex new product development project we think it is right to use suppliers involvement portfolio matrixes, for a better linking between supplier parameters selection with the different kind of relationship that could be established.
- Elaboration of the evaluation matrix (potential alternatives, criteria and performance).
- Definition of the decisional rules, with assessment of criteria weights.
- Individuation and use of an MCDA procedure for the aggregation of performance.
- Perform a sensitivity analysis to test the influence of the various parameters to the alternatives' ranking.

We observe that the need to weight the evaluative criteria is related to both their different relative importance depending on the specific supply and the

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presence of trade-offs between criteria inside the same supply. By way of an example, it is plain as a close analysis of trade-offs among quality, price and deliver reliability is particularly important in JIT environments (see Ansari and Modarres, 1988).

Furthermore, we note, the set of weights should be a dynamic vector, because of modifications in supply markets, product life cycle or changes in firm's strategies; decision-makers have to update periodically priorities in supplier performance.

Multi-objective techniques provide a methodology to analyse the impacts of decisions that entail a reordering of the priorities on firm's objectives.

In the remainder of this paper we focus on the problem of criteria weights' assessment, on the analysis of robustness of the solution and on the use of a particularly efficient aggregation procedure. After a brief critical review of supplier selection methods, we will try to show how PROMETHEE and Geometrical Analysis for Interactive Assistance (GAIA) techniques (Preference Ranking Organization METHod for Enrichment Evaluations and GAIA, see Brans et al., 1984; Brans and Vincke, 1985; Brans and Mareschal, 1994), seem appropriate to rank alternatives and to analyse the relations between criteria. The really innovative issue of our approach, a high-dimensional sensitivity analysis not currently adopted in any outranking software tool, is described too.

The research question may be defined as testing a well-known Operational Research technique—PROMETHEE integrated with a high-dimensional sensitivity analysis as an additional solution for the weights setting problem in the vendor-rating phase of a supplier selection process. The suitability of the resulting method is not related to a specific industry, but to particular situational characteristics (decision-making context), actual in many purchasing situations: ranking problems, the presence of qualitative as well quantitative evaluation criteria, not fully compensatory decision logic, uncertainty and imprecision deriving from inaccurate data, incomplete agreement of decision-makers on preferences and importance of criteria.

Lastly, the approach is demonstrated in a case of vendor selection for a mid-sized Italian industrial firm operating in rail transportation and wheeled public transport vehicles. This case has been chosen because of the nature of the decision-making context (suppliers deeply involved in product design, heterogeneous qualitative and quantitative criteria).

2. Review of the literature

Two basic issues to highlight are a generalised tendency to enlarge the set of evaluative attributes and a development of sophisticated supplier choice models.

Regarding the first issue, traditionally vendors focused on a "technical" output evaluation, in terms of quality, delivery speed and reliability, price offered (Weber et al., 1991), but when the relationship becomes closer and longer, the number of selection criteria increase, and vendors are selected on their global performances. Global evaluations range from *total costs analysis* (Roodhooft and Konings, 1996; Ellram, 1996; Tagaras and Lee, 1996) to the consideration of supplier's capacity in production planning (Ho and Carter, 1988), their future manufacturing capability (Ellram, 1990) or the closeness of the relation and continuous improvement capabilities (Choi and Hartley, 1996). In strategic evaluations (De Maio and Maggiore, 1992), technological, financial and organisational capabilities are considered together with technological and strategic coherence. A first remark concerns the object of the evaluation (Nassimbeni and Battain, 2000, p. 2). In spite of several studies about the importance of co-design and the integration of suppliers in the new product development (see Ragatz et al., 1997 for an exhaustive literature review), vendor rating is still focused on productive-logistical performance (*selection* based on physical output) and not, whereas it should be necessary, on supplier's co-design capabilities (*monitoring* the quality of the collaboration). In such cases, to assess weights according to the purchases portfolio (like Kraljic, 1983 matrix, or Olsen and Ellram, 1997 *portfolio model*, with *Bootleneck*, *Strategic*, *Non-Critical* and *Leverage* purchases) is wrong. We think that a framework for distinguishing different supplier roles in product development like the Supplier Involvement Portfolio of Wynstra and Ten Pierick (2000) and Wynstra and Sie (1997) fits very well into performance selection and weighting. A second remark concerns the lack, in purchasing literature, of methods for formulation of criteria and their qualification. In De Boer et al. (2001) only two applications are cited, and some Operational Research methods such as *Roughs Sets Theory* (Slowinsky, 1992; Pawlak and Slowinsky, 1994) and *Value focused thinking* (Keeney, 1994) are proposed as suitable for criteria identification and selection.

Regarding the second issue, according to the De Boer et al. (2001) taxonomy, many decision models have been suggested for supporting the supplier selection process along its main steps (problem definition/formulation of the criteria, pre-qualification of suitable suppliers, final choice). Our interest is in "single deal" models for the final choice phase; here, a number of analytic models have been suggested, but most of them are variations of the "weighted sum algorithm" approach, made definitively known to everyone by Timmerman (1986) with his *Linear*