

Chapter 8

Motor Vehicle Improvement Preference Ranking: A PROMETHEE and Trigonometric Differential Evolution Analysis of their Chemical Emissions

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ABSTRACT

The central theme of this chapter is a preference ranking analysis of a group of motor vehicles based on their chemical emissions. Beyond the initial ranking of the motor vehicles, operationalised using the multi-criteria decision making technique PROMETHEE, further analysis is given on how the manufacturers of a motor vehicle could improve its preference rank position, based on reducing its current levels of chemical emissions. The rank improvement analysis, is defined as a constrained optimisation problem, solved here using Trigonometric Differential Evolution. Further, an identification of a prescribed order to these chemical emissions reductions is then identified, offering practical findings to motor vehicle manufacturers when considering their position in a competitive market. The employment of Trigonometric Differential Evolution along with PROMETHEE in this chapter demonstrates a clear example of soft-computing in a practical problem.

INTRODUCTION

The motor vehicle has provided mobility and individual freedom for millions of people; however, it also embodies the dilemma of contemporary industrialisation in the environmental costs of

automobility (Zachariadis *et al.*, 2001), with the environmental impact of vehicle emissions (Karls-son, 2004). Vehicle manufacturers have invested considerable research and development resources to create new combustion control technologies (to reconcile toxic and climate change emissions criteria including, carbon monoxide and hydrocarbons).

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Motor Vehicle Improvement Preference Ranking

Historically, consumers purchasing ranking preferences have not included the environmental performance of a vehicle (Prothero, 1994), but more recently environmental issues have become more prominent in consumer choice (Noblet *et al.*, 2006). Ranking systems are well established with respect to other associated consumer choice criteria, which often use toxic emissions per vehicle in their criteria (Walton *et al.*, 2004). Manufacturers are aware consumer interest has grown over recent years, importantly, the ranking systems intermediate between consumers and the vehicle manufacturers. Typical of the interests of government in terms of vehicle environmental performance and consumer choice are the views expressed in ABC Online (2004),

For those of us with an interest in all aspects of a vehicle's performance you can now check up closely on its environmental performance, and establish and weigh appropriately in your own mind about how you ought to go about combining your practical needs with your commitment to the environment.

The details presented in this chapter are in the spirit of these views, and we consider a number of issues arising from an initial preference ranking analysis of a small number of motor vehicles, based on certain criteria, namely exhaust chemical emissions levels. These issues include the motor vehicles' subsequent perceived preference rank improvement opportunities - identifying chemical emission levels to achieve this (defined as a constrained optimisation problem) and targeted rank improvement - the order in which a motor vehicle's chemical emissions levels should be changed to the previously identified levels to achieve improvement (defined through the iterative employment of ranking analyses).

The ranking findings are found using the multi-criteria decision making technique PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation, Brans *et al.*, 1986). The

PROMETHEE technique is employed since it is characterised by simplicity and clarity to a decision-maker (Brans *et al.*, 1986). PROMETHEE is also considered to have a transparent computational procedure (Georgopoulou *et al.*, 1998). Put simply, the ranking achieved using PROMETHEE produces a series of final 'net' values which are used to rank objects (vehicles), found from the aggregation of constituent 'criterion' values, which express the levels of preference of the objects over different individual criteria.

These characteristics of PROMETHEE have made it a versatile methodology in many areas of study, including in particular energy management (Pohekar and Ramachandran, 2004; Simon *et al.*, 2004). It is noted, there exist other ranking techniques, such as ELECTRE (Beccali *et al.*, 1998; Wang, and Triantaphyllou, 2008) and TOPSIS (Lai *et al.*, 1994; Abo-Sinna and Amer, 2005), offer alternative approaches to the ranking problem considered here, and could potentially be employed instead of PROMETHEE in the analysis in this chapter.

Beyond the initial preference ranking findings using PROMETHEE, the preference rank improvement opportunities consider the changes to a motor vehicle's chemical emissions levels to improve its preference rank position, and require the solution to a constrained optimisation problem, solved using the evolutionary computation algorithm, Trigonometric Differential Evolution - TDE (Fan and Lampinen, 2003). The evolutionary computation work (using TDE), originally termed the PROMETHEE based uncertainty analysis in Hyde *et al.* (2003) and Hyde and Maier (2006), here utilises the minimisation of the Euclidean distance measure (and concomitant constraints). Moreover, it identifies the minimum changes necessary to the chemical emissions levels of a considered low preference ranked motor vehicle that improves its preference rank position to that of a comparatively higher preference ranked motor vehicle. Evolutionary computing, in the form of genetic algorithms, has been used previously in

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