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MCDA APPLIED TO PERFORMANCE APPRAISAL OF SHORT-HAUL TRUCK DRIVERS: A CASE STUDY IN A PORTUGUESE TRUCKING COMPANY

Abstract: Performance appraisal increasingly assumes a more important role in any organizational environment. In the trucking industry, drivers are the company's image and for this reason it is important to develop and increase their performance and commitment to the company's goals. This paper aims to create a performance appraisal model for trucking drivers, based on a multi-criteria decision aid methodology. The PROMETHEE and MMASSI methodologies were adapted using the criteria used for performance appraisal by the trucking company studied. The appraisal involved all the truck drivers, their supervisors and the company's Managing Director. The final output is a ranking of the drivers, based on their performance, for each one of the scenarios used. The results are to be used as a decision-making tool to allocate drivers to the domestic haul service.

Keywords: Multi-criteria Decision Analysis, Performance Appraisal, Long/Short Haul Trucking, Decision Support Systems

1. Introduction

Globalization has changed the company's paradigm regarding global and functional strategies. The main purpose of an organization is to be competitive in the market where it operates and to establish all necessary conditions for achieving its goals. In this scenario, Human Resources emerges from the one of the main factors, combining efforts in the development and adaptation of human capital to the new challenges and needs dictated by the market. Thus, performance appraisal (PA) proves a key tool for organizations because it provides both individual and global knowledge of the company's employees and their needs, towards a greater efficiency in achieving organizational objectives (Anisseh *et al.*, 2007; de Andres *et al.*, 2010).

PA can be seen as a set of structured, formal interactions between the subordinate and the supervisor. In this sense, PA of each subordinate is based on a set of relevant criteria, which are designed in order to identify weaknesses and strengths, as well as opportunities to improve performance and develop skills. Hence, setting up and implementing PA serves numerous purposes, such as promotion, remuneration adjustment, personnel planning, and training needs, among others (Grund and Przemeck, 2012; Zheng *et al.*, 2012).

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Some organizations use PA to disseminate their organizational strategies, goals, and vision amongst the employees. This knowledge may raise employees' levels of commitment due to the additional clarification of the company goals, and thus their own, and to the additional perception of being valued and seen as part of the company's team (Kuvaas, 2006). It is also important to note that for a successful PA you need to convey, to all participants, values such clarity, fairness, accuracy, reliability, validity, amongst others (Almeida, 1996).

Initially PA was essentially carried out by executive staff based on ad-hoc scoring systems, lacking theoretical soundness. PA has been fine-tuned through time to reduce the process' subjectivity, in an attempt to guarantee more clarity, fairness, accuracy, reliability, validity, among others. New methods have emerged, allowing for a greater awareness of the importance of incorporating different points of view. Other members, who deal with staff assessment such as supervisors, colleagues, customers and the employee themselves, have come to be involved as is the case of the 360-degree method - details of such method can be found in Edwards and Ewen (1996) and de Andres *et al.* (2010). This evolution in PA models made the process more extensive and complex, because it started to include different perspectives, reducing the bias and the halo effect (the fact that one or a limited set of characteristics influence the entire evaluation) and encouraging the company's own human resources to establish clearer internal selection policies based on PA (de Andres *et al.*, 2010; Espinilla *et al.*, 2013).

PA involves Decision-making (DM). DM involves subjectivity of the actors involved, their values and their way of acting, which makes decision-making more complex. The actors may be the different stakeholders, implying that the objectives and expectations of each of these, taken individually, may come into conflict, making it necessary to reach a compromise (Bana e Costa and Vansnick, 1999).

In recent years mathematical based methods have been used in PA. These include multi-criteria decision making (Bana e Costa and de Oliveira, 2012), Analytic Hierarchy Process (Albayrak and Erensal, 2004), fuzzy multi-attribute decision making (Manoharam *et al.*, 2011), Goal Programming (de Andres *et al.*, 2010), fuzzy analytical network process (Chen and Chen, 2010) among others. Another recent perspective of PA is the contribution of positive Psychology scholars (see Bouskila-yam and Kluger (2011) for further detail).

PA should not be seen as a punctual management control tool, and should be performed with a fixed frequency. It is important to convey the message that the appraisal and data gathering is carried out throughout the period between appraisals. Feedback can be provided when necessary, as a means of interaction between the evaluator and the evaluated. Hence, there will be a perception of greater concern with the performance of the employees, which will lead to improved levels of involvement with the organization and a greater motivation to perform the tasks in accordance with their objectives (Caetano, 2008). In this case, the PA is performed by using Multi-Criteria Decision Analysis methodology (MCDA), whose purpose is to support decision makers to rank possible solutions. Typically, there is no an optimal solution for this type of problems since the criteria, some or all, are conflicting. Thus, it is necessary to use decision maker's preferences to differentiate between solutions.

The main advantages of MCDA result from (i) the possibility of incorporating quantitative and qualitative criteria, (ii) the ability to deal with criteria which are difficult to quantify and compare, and (iii) the proper balance between analytical methods and decision makers' subjective evaluations. Recent applications of MCDA to PA include Albayrak and Erensal (2004),

Anisseh *et al*. (2007), Manoharan *et al.* (2011) and, Bana e Costa and de Oliveira, (2012).

In this case, the problem of characterizing the drivers, in the context of planning trucking routes for a national company, arises from the importance that allocating a driver to a route has.

Actually, when the manager is planning the routes, he/she takes into consideration a criterion to rank drivers, which is subdivided into several sub-criteria that describe the driver (such as cost and past availability). In this sense, it is essential for the company to have a good knowledge of their drivers, as well as their behaviour in relation to the company's objectives. This knowledge will allow for a better allocation of drivers available to each time slot and a greater understanding of their training needs.

This paper is organized in 5 sections. Section 1 introduces the context of the problem, while Section 2 describes the methodology and models used. The case study is presented in Section 3, and the main results obtained are discussed in Section 4. Finally, Section 5 draws some conclusions.

2. Methodology

MCDA is an approach to problems involving several criteria or objectives, which may have different scales, both quantitative and qualitative, and whose nature is often conflicting. For these problems, usually, there are several alternative solutions that are to be ranked, from the most preferred to the least preferred, and none is the best inasmuch as none is better in achieving all objectives. Thus, the objective is to provide the Decision Maker (DM) with the solution, but also to help the DM understand the conflicts and need for compromise, e.g. options that are more beneficial are usually more costly, which requires his/her judgement regarding both the criteria and the alternatives.

The deployment of the multi-criteria decision aid methodology is a non-linear recursive process comprising several steps (Guitouni and Martel, 1998). The number of steps varies according to the MCDA method to be used (Roy and Bouyssou, 1993; Saaty, 2008). Nevertheless, there are critical steps that traverse the great majority of MCDA approaches, which are the following:

1) Establish the problem context and structure;
2) Identify the set of alternatives;
3) Identify objectives and relevant criteria;
4) Elicit criteria weights;
5) Find the score for each alternative regarding each criterion;
6) Combine weights and scores to obtain an overall value for each alternative;
7) Analyse the results. Perform sensitivity analysis.

Steps 3 to 6 are discussed in greater detail, since in this case study these steps involved group decision strategies due to the fact that several decision makers had been involved.

It should be noted that, the decision makers involved had different roles within the company and thus their judgement were not valued equally. Regarding the identification of the alternatives not much had to be done, as management decided that all drivers should be considered. The strategy to address the identification of criteria was to cluster them under higher-level and lower-level generic objectives in the hierarchy. Then, the objectives were detailed resorting to a value tree.

The performance of each driver on each criterion was assessed using scales representing preferences for the consequences, in particular, relative preference scales. The weights for each of the criterion were obtained, by considering all decision makers' opinions as well. Each of whom provided an opinion after being guided through the swing weighting procedure, i.e. comparing differences

between highest and lowest scores for each of the criterion. An overall preference score is then usually obtained, by computing the weighted average of the drivers' scores on all the criteria. However, since several DMs are considered, this only allowed obtaining each DM's global preference for each driver. Thus, an additional step was required. In this new step an aggregation of individual preferences had to be performed (Ishizaka *et al.*, 2013). A more detailed description is provided in Section 3. The last step provided reliability of the results since it allowed for performing sensitivity analysis to assess the robustness of the preference ranking to changes in the criteria scores and/or the assigned weights.

Sensitivity analysis measured the impact of small disturbances on the variables of the problem (e.g. criteria scores and criteria weights) in terms of alternatives, by comparing the modified ranking with the original one. The closer the rankings, the more robust the method. These steps were important to increase the DM's confidence in the outcome of the multi-criteria decision analysis. There are several different methods to apply to MCDA. Here, we chose to use the Preference Ranking Organization Method of Enrichment Evaluation (PROMETHEE) family of methods and the MMASSI (Pereira, 2003; Pereira and Fontes, 2012). A brief description of each follows.

2.1. PROMETHEE - Preference Ranking Organization Method for Enrichment Evaluation

The PROMETHEE is a widespread method used for addressing decision making problems and it was first introduced by Brans and Mareschal, (2005). (see for instance Behzadian *et al.* (2010) for a comprehensive review of its applications). The PROMETHEE belongs to the European school of thought, which embodies a set of methods relying on the concept of partial aggregation, opposed to the complete aggregation previously proposed by the

American school. Partial aggregation methods are better known as outranking methods. A preference index that expresses the intensity of preference of alternative *a* over alternative *b* is used as the basis to compute "core" quantities, namely the outranking flows. The positive (or leaving) outranking flow measures the degree to which a given alternative outranks all the other alternatives. Likewise, the negative (or entering) outranking flow expresses how much a given alternative is dominated (or outranked) by the other alternatives. The higher/smaller the positive/negative flow, the better the alternative. The balance between these flows is represented by the net outranking flow, which is a dimensionless quantity. A higher value of this net flow reflects the higher attractiveness of alternative *a*.

The PROMETHEE is a family of methods that encompasses the Geometrical Analysis of Interactive Aid (GAIA).The GAIA plane is a geometrical representation of the relative position of the alternatives in terms of contribution to the various criteria. The GAIA directly results from applying the principal component analysis to the matrix of normed flows defined for alternative and criterion *j*. Hence, the n-dimensional criteria space is projected onto a two-dimensional space yielded by the two most representative principal components (linear combinations of the original criteria) so as to preserve as faithfully as possible the original multidimensional information. The GAIA plane has the particularity of projecting both the alternative and the criteria in the same space. Furthermore, it makes it possible to project the criteria weights vector using the so-called decision axis. The decision axis, along with the walking weights, can be used to further perform a sensitivity analysis of the results, according to weight changes.

2.2. MMASSI – Multi-criteria Methodology for Supporting the Selection of Information Systems

MMASSI is a multi-criteria methodology originally devised for supporting the selection of information systems. It relies on existing normative methods, which were developed along the lines of the American school of thought. It can be distinguished from previously proposed MCDA methodologies inasmuch as (a) it provides the DM with a pre-defined set of criteria that tries to generally cover all the relevant criteria in the field of application (b) it does not explicitly requires the presence of a facilitator, or analyst, to guide the DM throughout the decision making process, since it is implemented in a user-friendly and self-explanatory software (c) it uses a continuous scale with two reference levels and thus no normalization of the valuations is required.

MMASSI uses a fixed continuous scale with seven semantic levels with two of them acting as reference levels, so as to set up the ground values based on which the DM assesses each considered alternative against each selected criterion. The construction of this scale was based on earlier work by Bana e Costa and Vansnick (1999). Having defined the criteria, the possible courses of action and a continuous semantic scale, the DM appraises each alternative by allotting the semantic level to each criterion, in the following phase. The last step of MMASSI involves the computation of an overall score for each alternative, according to an additive aggregation model, and the subsequent ranking of the alternatives.

3. Case Study

The company in this case study is a major Portuguese trucking and logistics operator. This company provides transportation services, both domestic and international, general cargo, express courier, intermodal and container, as well as all logistics,

warehousing and distribution operations. In this type of company, the drivers prove to be the company's main contact with the customer, and thus the company's image. Therefore, drivers' PA may be a crucial element for improving organizational performance and assist in achieving company goals. The main objective of PA in the supply chain is to improve the quality of the services provided to the customer and the reduction of costs, adding value in this way. In trucking drivers PA, fleet/traffic managers are concerned mainly with quality issues, as is the case with just-in-time transportation at minimum cost (Simsek *et al.*, 2013).

Having a better knowledge of the drivers, their ability and commitment to the company can be used to improve driver allocation to specific routes. In addition, the company can improve its drivers' training and development. These may, in turn, lead to an increase in the driver's motivation and willingness to adapt their efforts to improve performance and simultaneously carry out their work more efficiently. The main objective of this case study was to appraise the performance of the trucking drivers on short/domestic haul routes. The evaluation period consisted of 15 months, from January 2012 to March 2013. The methodologies used to perform the aforementioned appraisal were the PROMETHEE and the MMASSI.
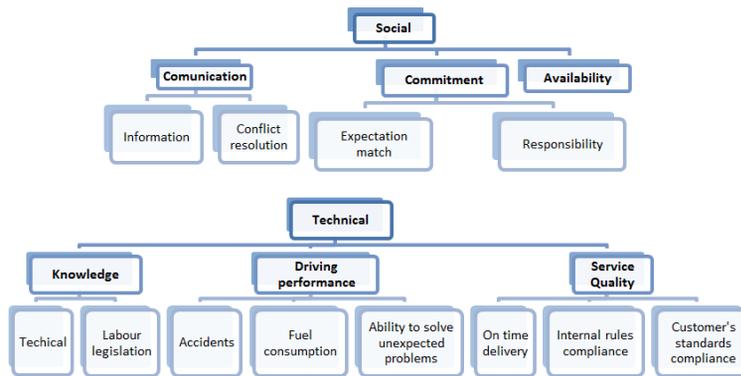
3.1. Criteria

With this type of assessment, it is usual to have mainly qualitative criteria due to the lack of objective, measurable criteria. This is due to the fact that it is difficult to control a large part of the driver's behaviour and results during delivery. To reduce subjectivity, qualitative data is, sometimes, combined with quantitative performance indicators such as speed, rest periods, fuel consumption, among others, in the drivers performance appraisal. Control on these measures will lead to a reduction in accidents, fuel spent, among other problems

(Simsek *et al.*, 2013).

To define the criteria several meetings took place with the traffic director, the traffic managers, the route planner and the cost managers. Some meetings involved several of the above mentioned people, while others involved just one or two. From these meetings, it soon become apparent that there were two major areas of interest: drivers' technical characteristics, which are directly linked to their knowledge, driving performance, and service quality, and social characteristics, related to their communication skills, their commitment to the organization, and availability (to take additional work loads, willingness to work on off duty hours, etc.). Figure 1 presents a schematic with characteristics involved.

Figure 1. Performance appraisal criteria

It should be highlighted that there are only two quantitative criteria (number of accidents and fuel costs), the remaining being qualitative and thus subject to evaluation by the decision makers.

In the case study, there were 15 decision makers deciding which criteria to be used, as well as the weight of each criterion. The decision makers' opinion was not valued equally: 12 of them had an individual weight of approximately 5.56% in the final score, while the remaining three had an individual weigh of approximately 11.11 %. To obtain the global weight for each criterion, a weighted average using individual DM weights (see Table 1) and the weight of their opinion was computed.

Table 1. Criteria weights

	PROMETHEE	MMASSI
Technical knowledge	7,64%	7,59%
Labour legislation knowledge	7,73%	7,75%
Accidents	7,98%	8,00%
Fuel Consumption	7,70%	7,67%
Ability to solve unexpected problems	7,42%	7,43%
Delivery on time	7,97%	8,00%
Internal rules compliance	7,56%	7,59%
Customer's standards compliance	7,73%	7,75%
Information	7,99%	8,00%
Conflict resolution	7,79%	7,75%
Expectation fit	7,38%	7,35%
Responsibility	8,07%	8,08%
Availability	7,05%	7,03%

3.2. Drivers information gathering

Drivers' performance on each of the 11 criteria that were defined was assessed by three DMs, each of whom gave an individual evaluation for each driver. These DMs were considered equal. It should be highlighted that two different evaluation processes could be identified. On the one hand, the first two DMs made use of the full scale to distinguish the performance of the drivers being appraised. On the other hand, the third DM only used a small part of the scale and thus no 'meaningful' differences could be observed in the appraisals done. Furthermore, when appraising, in fact, distinguished drivers, it only did so positively. In addition, this DM only appraised a small number of drivers. Thus, drivers appraised by this DM were at an advantage, as the DM's appraisal improved their overall performance. This led to the existence of two distinct analysis: one involving three DMs (analysis A) and another involving only the first two (analysis B). In addition, drivers were asked to fill in a self-assessment questionnaire. In Table 2, the ranking obtained for each driver, identified by his/her organization number, by both analysis A and B, for both methods, are provided, as well as the one obtained, by using the self-assessment data.

Table 2. Drivers ranking considering 2 or 3 decision makers and self-assessment

	Analysis A 3 decision makers (MMASSI)		analysis B 2 decision makers (MMASSI)		Analysis A 3 decision makers (PROMETHEE)		analysis B 2 decision makers (PROMETHEE)		Self-assessment (PROMETHEE)	
Rank	Driver's n°	Score	Driver's n°	Score	Driver's n°	Score	Driver's n°	Score	Driver's n°	Score
1	85	56,70	85	50,48	85	0,402	85	0,556	155	0,518
2	564	47,40	123	41,49	32	0,320	32	0,476	123	0,367
3	225	44,92	49	40,77	49	0,307	49	0,465	7	0,349
4	136	44,23	32	40,41	564	0,298	123	0,416	53	0,339
5	123	41,49	564	39,22	123	0,293	136	0,328	49	0,285
(…)	(…)	(…)	(…)	(…)	(…)	(…)	(…)	(…)	(…)	(…)
27	671	5,18	447	-1,00	155	-0,264	631	-0,377	68	-0,352
28	6	1,20	192	-1,22	192	-0,270	155	-0,381	206	-0,436
29	447	-1,00	631	-3,60	447	-0,300	447	-0,415	204	-0,439
30	631	-3,60	127	-10,55	127	-0,351	206	-0,474	127	-0,506
31	127	-10,55	206	-10,88	206	-0,356	127	-0,517	6	n.a.

4. Results and discussion

The model created for the trucking drivers' PA was applied with two distinct methodologies to support multi-criteria decision. The difference between the two models is in the way the final ranking of the alternatives is reached. As previously mentioned, none of the two methods provides a final solution, but rather a set of alternatives sorted by perceived benefit.

The PROMETHEE methodology gives us a ranking based on the differences in the preferences of each pair of trucking drivers in each criterion using attractiveness functions, and the MMASSI methodology gives us a ranking based on value functions. As observed during the implementation of the model, a greater differentiation between trucking drivers is possible through the MMASSI method, as the scale operates on a continuous scale, comprised of seven semantic values.

As can be seen from the results reported in Table 2, driver number 85 is the one performing better on all scenarios

considered. Actually, this is the only conclusion, i.e. ranking, on which all scenarios agree. It should be noted, however, that regarding self-assessment this driver judged himself harshly; ranking below the top 50% (actually in position 17). Furthermore, drivers 127 and 206 are reported consistently as having the worst performances, even in their own opinion. It is the organization's responsibility to decide what best adapts to its environment and its needs, bearing in mind that the scale, used in the MMASSI methodology, is more detailed and thorough in its assessment, as it uses a semantic, continuous scale with a wide range of possible assessments.

The PROMETHEE allows for pairwise comparison which is an advantage for differentiating alternatives, computing each pair of drivers' outranking flows for the final ranking.

Another interesting observation is the fact that driver 155 considered himself very good: very good expertise and driving skills, as well as ability to communicate with the traffic manager, excellent at complying with internal and customer standards, with all deliveries on time, and total availability for any additional deliveries. However, the scores given by traffic managers show a different story. The overall performance of this driver is at the most neutral/slightly worse. These results might reveal a communication gap between the organization and the driver, or a possible misunderstanding on what the company expects from the driver. Despite the non-comparability of the resulting rankings, top performing drivers are identified in all scenarios. The company may study in detail the information provided by these appraisals and thus be able to devise additional steps to be taken and provide further feedback in order to improve the drivers' motivation and their performance.

5. Conclusions

Benefits of PA for both the company and the drivers are manifold. From the more accurate knowledge that appraisals provide, the company may plan its activities more appropriately and more accordingly to its strategic objectives. It can also adjust its training programmes to different drivers' needs and profiles, according to previous appraisals, to improve both the company's and the drivers' performance and efficiency. In this sense, it will have a greater grasp of theirs drivers' capabilities and their need for technical and personal development. Lastly, this tool provides the company with information needed to devise motivational action plans. After receiving feedback from their appraisals, trucking drivers can adjust their efforts to improve their performance and simultaneously perform more efficiently. By perfectly matching the trucking drivers' capabilities to their daily work, they will see their efforts recognized by the organisation.

MCDA is a problem solving methodology that organises and synthesizes information regarding a given decision making problem in a way that provides the DM with a coherent overall view of the problem. MCDA methods assisted the company in the process of ranking the drivers, using a set of complex, objective and subjective, and conflicting criteria. The criteria have been measured by several DMs. A coherent and consistent family of relevant criteria is fundamental for any PA, so its determination is a time consuming phase. Any theoretical flaws might compromise the whole PA process. In this phase, it was determined that the model created would comprise the relevant qualitative and quantitative criteria, and therefore the selection fell on the multi-criteria decision analysis. To rank the 31 drivers involved, two alternative MCDA methods were used: PROMETHEE and MMASSI. Sensitivity analysis is a very important step which can be used to examine how the ranking of options might change under different scoring or weighting systems

and also to help solve differences among DMs. In this case, the results obtained have shown to be insensitive to scores and weights variations. Finally, it is important that performance appraisal is repeated periodically to monitor its benefits. In addition, the feedback given to the trucking drivers can be most valuable and lead not only to improving the company performance, but also to improving drivers' personal skills, capabilities, and commitment to the company.

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