PREFACE

The theme of this research work is based on the application of some multi-criteria decision-making (MCDM) approaches in the context of manufacturing environment. Decision analysis has been well recognized as an important tool for the evaluation of major decisions among the scientific community. When the nature of any decision problem is characterized by its complexity, regularity or significance, the application of a decision-making methodology can effectively support this decision process in a number of ways, in particular by increasing the information frame. MCDM has been described as the most well known branch of decision analysis and is defined by the ‘International Society of Multiple Criteria Decision Making’ as the study of methods and procedures by which concern about multiple conflicting criteria can be formally incorporated into the management planning process. MCDM can be broadly divided into two categories, i.e. multi-attribute decision-making (MADM) and multi-objective decision-making (MODM). The basic difference between MODM and MADM problems is that the former concentrates on a continuous decision space subject to problem specific constraints, while the later aids to evaluate alternatives in a discrete decision space consisting of predetermined set of alternatives. MADM usually consists of identification of the alternatives, specification of each alternative with respect to each evaluating criterion, indicating the relative preference of each alternative over another and finally, scoring the alternatives according to the decision criteria. In a nutshell, MADM methods select the best alternative among a finite number of choices, unlike MODM where the best alternative is designed with multiple objectives based on continuous decision variables subject to various constraints.

The background for this research work is based on the assumption that the success of manufacturing decision-making problems relies on the assessment and integration of different design and selection objectives. The varying design issues and available alternatives call for different areas of expertise to be involved in the decision-making process. This makes it difficult to evaluate the overall ‘goodness’ of a proposed alternative. MADM is basically an approach to rank the feasible alternatives with respect to different attributes. This is achieved on the basis of the impact of the alternatives on certain criteria, may be conflicting in nature, in view of the objective of optimization. In all MADM methods, decision regarding the best alternative amongst the available, can be arrived by giving mathematical treatments to a decision matrix. MADM also largely depends to a high degree on subjective preferences stated by the decision makers as the methodology deals with criteria that are difficult to quantify or assign with a numerical value. No single method of analysis is sufficient to deal with all the different types of decision problems that
occur in the manufacturing environment. Based on the nature of the decision problem and type of the information available, different methods may be suitable for different problems.

Manufacturing technology always plays a vital role for a country’s industrial growth and largely dictates the movement of its economy. Globalization with reformed industrial trade policies has made manufacturing a key element to address global competition. To meet the global challenges, manufacturing organizations have to select appropriate manufacturing strategies, input materials, product designs, manufacturing processes, workpiece and tool materials, machineries and equipment etc. In this context, the aim of modern manufacturing systems has become to achieve overall performance improvement by proper utilization of resources, design development, production, delivery and support to products. Decision-making in the manufacturing environment is a strategic issue, especially in association with the complexity of motivating forces and factors influencing manufacturing system dynamics. The decision-making exercise can be implemented in the manufacturing environment at different stages, if appropriate tools and techniques are made available to the designers, manufacturing planners and production managers. These aspects are considered in this present research work by introducing a special class of MADM tools, popularly known as ‘preference ranking-based methods’. These methods are some special class of MADM tools in which the decision makers’ preferences and preferences on alternatives’ performances are aggregated together to reach the final evaluation and decision.

Preferences are usually incorporated in the decision-making process by assigning a preference function or by defining some preference relations among the alternatives or attributes. The decision maker may also express his/her preferences on attributes by ranking them or by assigning some numerical values for the weights of the attributes. Even, a utility function or aggregation function that represents the decision makers’ preferences may also be considered. Preference functions are useful to make evaluations and comparisons between the alternatives. Using a decision matrix, the preference ranking-based methods compare the alternatives pair-wise with respect to every criterion and the results are expressed using preference functions, which are calculated for each pair of alternatives and can range from zero to one. A zero value signifies that there is no significant difference between the considered pair of alternatives, whereas, one denotes a big difference between them. A global performance index ultimately leads to a total preorder of the alternatives. Some preference ranking-based methods assume that the decision makers’ preferences can be modeled using some preference relations. This approach leads to different order structures, depending upon the preference relations considered. In these methods, the decision maker judges two alternatives based on the notion that one alternative is preferred to another or the two alternatives are indifferent or incomparable. Accordingly, three binary
relations are defined, i.e. a strict preference relation (P), indifference relation (I), and an incomparability relation (R). Thus, a preference structure for a set of alternatives is defined as a triplet (P,I,J) of binary relation. Although, there are several preference ranking-based MADM methods as commonly adopted in the decision-making domain, this present research work considers the following eight preference ranking-based methods for decision-making in some discrete manufacturing applications:

a) EVALuation of MIXed data (EVAMIX) method,
b) COmplex PROportional ASsessment (COPRAS) method,
c) COmplex PROportional ASsessment of alternatives with Grey numbers (COPRAS-G) method,
d) EXtended version of Preference Ranking Organization Method for Enrichment Evaluation (EXPREM2),
e) Organization Rangement Et Synthese De Donnes Relationelles (ORESTE) method,
f) Operational Competitiveness Rating Analysis (OCRA) method,
g) Additive Ratio ASsessment (ARAS) method, and
h) Preference Selection Index (PSI) method.

EVAMIX appears to be one of the most suited methods for solving manufacturing decision-making problems. The main motivation behind adoption of EVAMIX method is that while studying different quantitative and qualitative methods for dealing with varying manufacturing decision-making problems, it has been found that most of these methods do not perform well if the decision matrix consists of both ordinal and cardinal attributes. EVAMIX method is basically designed to deal with this type of decision matrices, containing both ordinal and cardinal criteria. COPRAS method is useful for such decision-making problems, where the value evaluation of maximizing as well as minimizing criteria is involved. Ranking alternatives using COPRAS method assumes direct and proportional dependence of significance and priority of investigated alternatives on a system of criteria. Determination of significance and priority of alternatives employing COPRAS method, can be expressed concisely using very simple mathematical expressions. The use of classical MADM methods always requires crisp or precise data for subsequent evaluation. However, many manufacturing decisions are made in real world situations, where criteria values are not precisely known and often require some kind of prediction. Thus, it is not always possible to precisely determine the relevant data which are necessary for the classical MADM methods. These criteria values are generally expressed in the form of intervals. For this reason, a variant of COPARS method, popularly known as COPARAS-G, is also considered here. EXPREM2 is an extended version of PROMETHEE method, and is a
quite simple ranking tool in conception and application compared with other similar methods used for multi-criteria analysis. In most of the real decision-making problems, the decision maker’s preference should be taken into account. The main advantage of ORESTE method is that as it uses only the ordinal ranking of criteria, it avoids the occurrence of lengthy discussions among the decision makers to set weight importance of the attributes. Since ORESTE method only takes into account the ranking of alternatives and criteria, it is mainly suited to the problems with ordinal data, but it can also be used for problems with cardinal and mixed data. OCRA method is generally used to measure the relative performance of a set of production units, where resources are consumed to create value-added outputs. OCRA is a decision-making model with particularly emphasizing on performance measurement procedure. The main advantage of this method is its very general and simple computational approach, which is applicable to both tangible and intangible data, and well suited for the measurement and analysis of an alternative’s performance. ARAS method is based on quantitative measurement and utility theory. In this method, the utility function is directly proportional to the relative effect of the criteria values and weight importance of the considered criteria. The complex relative efficiency of the feasible alternatives can be determined according to the utility function values. The PSI method easily deals with qualitative criteria as involved in the decision-making process and an appropriate alternative is selected without considering the relative importance of different attributes.

The past researchers have adopted different decision-making tools for evaluating, justifying and selecting materials and advanced manufacturing technologies, but all those methods are either very complicated or require lengthy computations and sometimes need the help of linear programming tools to solve the developed models. Also, for the decision-making problems with large number of attributes and smaller number of alternatives, those approaches may occasionally give poor results. The present research work takes this opportunity to explore the application feasibility and potentiality of the eight above-mentioned preference ranking-based methods to provide more precise and accurate rankings of the feasible alternatives. According to the best knowledge of the author, there have been very few applications of these preference ranking-based methods for decision-making in manufacturing environment. Few successful implementations of these methods can be found in construction engineering, financial analysis, waste water management etc. However, most of these preference ranking-based methods have never been applied in any of the manufacturing decision-making situations. Vicious global competition has forced the manufacturing organizations to improve their quality and responsiveness in a cost-effective manner. The use of proper materials and advanced manufacturing technologies, like flexible manufacturing system (FMS), robotic system, rapid
prototyping (RP) process, non-traditional machining (NTM) process, and computer-aided machine tools offers great potentials for improving manufacturing performance and helps to attain organizational objectives. A wrong alternative selection may result in loss of productivity and profitability. The complexity of the selection process makes multi-criteria analysis an invaluable tool in the engineering design process. Thus, the main purpose of this research work is to reveal the computational easiness and demonstrate how the eight preference ranking-based methods can be effectively adopted for decision-making in various manufacturing situations to solve the followings:

a) a gear material selection problem,
b) material selection for a cryogenic storage tank,
c) two flexible manufacturing systems selection problems,
d) a pick-n-place robot and an industrial robot selection problems,
e) a rapid prototyping process selection problem for a conjoint-designed test part,
f) a rapid prototyping process selection problem for a benchmark test part,
g) a non-traditional machining process selection problem for drilling cylindrical through holes on ceramic materials,
h) a non-traditional machining process selection problem for shallow cutting operation on glass materials,
i) a machine selection problem for a flexible manufacturing cell, and
j) a computer-aided machine selection problem in a web-based manufacturing environment.

Table 1 summarizes the details of the decision-making problems as considered in this present research work.

All the eight preference ranking-based methods are successfully applied to different manufacturing situations as already mentioned and the results are compared for better visualization. The following six performance analysis tests are executed to assess the degree of agreement between the ranking orders as obtained by these methods, while keeping the performance measures in the evaluation matrices for all the considered examples constant. The corresponding performance test tables are also developed to observe the results of different tests in a conclusive way.
Table 1 Structures of the considered decision-making problems

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Decision-making problem</th>
<th>No. of alternatives</th>
<th>No. of criteria</th>
<th>Nature of the criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Gear material selection problem</td>
<td>9</td>
<td>5</td>
<td>4  4  0  5</td>
</tr>
<tr>
<td>2.</td>
<td>Cryogenic storage tank material selection</td>
<td>7</td>
<td>7</td>
<td>3  4  0  7</td>
</tr>
<tr>
<td>3.</td>
<td>FMS selection problem 1</td>
<td>8</td>
<td>8</td>
<td>5  3  5  3</td>
</tr>
<tr>
<td>4.</td>
<td>FMS selection problem 2</td>
<td>8</td>
<td>7</td>
<td>5  2  2  5</td>
</tr>
<tr>
<td>5.</td>
<td>Pick-n-place robot selection problem</td>
<td>7</td>
<td>5</td>
<td>4  1  0  5</td>
</tr>
<tr>
<td>6.</td>
<td>Robot selection problem 2</td>
<td>5</td>
<td>4</td>
<td>3  1  0  4</td>
</tr>
<tr>
<td>7.</td>
<td>RP process for a conjoint-designed test part</td>
<td>6</td>
<td>6</td>
<td>2  4  2  4</td>
</tr>
<tr>
<td>8.</td>
<td>RP process for a benchmark test part</td>
<td>5</td>
<td>8</td>
<td>6  2  4  4</td>
</tr>
<tr>
<td>9.</td>
<td>NTM process for drilling cylindrical through holes on ceramics</td>
<td>5</td>
<td>7</td>
<td>2  5  2  5</td>
</tr>
<tr>
<td>10.</td>
<td>NTM process for shallow cutting operation on glass</td>
<td>6</td>
<td>6</td>
<td>2  4  2  4</td>
</tr>
<tr>
<td>11.</td>
<td>Machine tool selection problem 1</td>
<td>10</td>
<td>4</td>
<td>1  3  0  4</td>
</tr>
<tr>
<td>12.</td>
<td>Machine tool selection problem 2</td>
<td>5</td>
<td>6</td>
<td>2  4  0  6</td>
</tr>
</tbody>
</table>

a) In the first test, scatter diagrams are plotted between the ranks derived by the past researchers and those obtained using different preference ranking-based methods to observe rank similarities between them.

b) In the second test, similarity of rankings provided by all the considered preference ranking-based methods is determined using Kendall’s coefficient of concordance value.

c) In the third test, similarity in the ranking performance between the eight preference ranking-based methods is validated using Spearman’s rank correlation coefficient value.

d) The fourth test is based on the calculation of 95% confidence intervals for the rank correlation coefficients based on Fisher’s Z transformation model.

e) In the fifth test, the agreement between the top three ranked alternatives is determined for all the preference ranking-based methods.

f) The last test is performed to determine the percentage of overall rank match for the eight preference ranking-based methods.

Some comprehensive weight sensitivity analysis techniques, as enlisted below, are also adopted to show the consistency of the preference ranking-based methods through the assessment of uncertainties in the derived results. The sensitivity analysis approaches, as adopted in this research work, also determine the extent of output variation when an input parameter (criteria weight) is varied over narrower and wider ranges.

a) single dimensional non-proportional non-additive weight sensitivity analysis,

b) single dimensional non-proportional additive weight sensitivity analysis, and

c) high dimensional sensitivity analysis consisting of determination of the most critical criterion, followed by a proportional weight sensitivity analysis.

In this research work, a power transmission gear material selection problem is considered first. Nine alternative gear materials and five selection attributes, such as surface hardness, core hardness, surface fatigue limit, bending fatigue limit and ultimate tensile strength are considered.
Carburised steel and cast iron emerge out as the best and the worst selected gear materials for the power transmission application. Those two materials were also suggested as the best and the worst alternatives by the past researchers. During the performance analysis tests, it is observed that EVAMIX and PSI methods produce maximum number of dissimilar ranking patterns for the intermediate gear material alternatives. When the overall ranking agreement among all the preference ranking-based methods is determined using the Kendall’s coefficient of concordance (z), its value is obtained as 0.9213, indicating an almost perfect rank conformity. Very high Spearman’s rank correlation coefficient (r_s) values are also observed during the performance analysis. COPRAS, COPRAS-G, EXPROM2, ORESTE, ARAS and OCRA methods are almost in perfect agreement with respect to the observations of the past researchers, and these methods also show higher percentage of matched ranks. When the ranking robustness of the preference ranking-based methods is explored using single and high dimensional weight sensitivity analyses, COPRAS, COPRAS-G and ORESTE methods are found to be the most stable performers, whereas, EVAMIX and EXPROM2 methods appear to be the worst performers with respect to weight stability intervals.

The second material selection problem is related to a cryogenic storage tank, which is used for transportation of liquid nitrogen. For this problem, seven feasible material alternatives with seven thermo-mechanical properties, including toughness index, yield strength, Young’s modulus, density, thermal expansion coefficient, thermal conductivity and specific heat are considered. SS 301-FH and Al 2024-T6 are identified as the best and the worst materials by most of the preference ranking-based methods as well as by the past researchers. The obtained z value of 0.7927 indicates very good overall ranking agreement among the considered methods. The performance of EXPROM2, ORESTE and OCRA method seems to be comparably poor in terms of r_s value and percentage of matched ranks. Based on the results provided by the comprehensive weight sensitivity analyses, ORESTE outperforms all other methods with the highest global weight stability interval, while EVAMIX comes out as the worst performer with the least weight stability interval.

The first FMS selection problem consists of eight alternatives and also eight attributes. These attributes are capital and operating costs, required floor space, work in progress, product flexibility, volume flexibility, expansion flexibility, lead time reduction and quality improvement. FMS A_3 appears as the best selected FMS configuration. The performance analysis tests indicate that ORESTE, ARAS and PSI methods show the highest number of rank similarities as compared to the past researchers. For this FMS selection problem, z value is obtained as 0.8318, which indicates excellent rank similarity between the considered methods. The Spearman’s rank
correlation test indicates ORESTE method as the best performer. Other performance test results also indicate ORESTE, ARAS and PSI methods as the best performers in terms of ranking agreement between the top three ranked FMS alternatives and number of total ranks matched. When the weight sensitivity analyses are performed, it is found that although the local weight stability intervals of all the preference ranking-based methods are quite reasonable, ORESTE outperforms all other methods with the best global weight stability intervals and EVAMIX method evolves out as the most unstable performer.

The second FMS selection problem also consists of eight FMS alternatives and seven attributes, like reduction in labour cost, reduction in work-in-progress, reduction in set up cost, increase in market response, increase in quality, capital and maintenance cost, and floor space used. FMS A₃ and FMS A₇ emerge out as the most competent alternatives. The performance test analyses derive a z value of 0.9553, suggesting a superior rank agreement among the considered methods. ORESTE produces exactly the same ranking pattern as compared to that of the past researchers, whereas, EVAMIX and EXPROM2 methods provide much dissimilar ranking patterns. When r, values are computed between different pairs of considered methods, it is observed that most of the preference ranking-based methods almost have perfect agreement between themselves. EVAMIX method shows relatively poor rank conformities as compared to the other methods. When the agreement between the top three ranked FMS alternatives and the overall percentage of matched ranks are considered, it is found that COPRAS, COPRAS-G, ORESTE, ARAS, OCRA and PSI methods show higher than 50% matched ranks, whereas, EVAMIX and EXPROM2 methods show comparatively poor performance. Now, when the sensitivity analyses are carried out to observe the effects of changing criteria weights on the ranking performance of these preference ranking-based methods, it is observed that most of the preference ranking-based methods show relatively good ranking robustness during the non-proportional weight changes, whereas, during high dimensional sensitivity analysis, all of the preference ranking based-methods, except ORESTE, fail to retain their original ranking patterns.

In the pick-n-place robot selection problem, five alternative robots and five different robot selection attributes, such as load capacity, repeatability, maximum tip speed, memory capacity and manipulator reach are considered. Cybotech V15 Electric and Cincinnati Milacronne T3-726 robots evolve out as the two most preferred alternatives. The past researchers also suggested these two robots as the most competent choices. EVAMIX, COPRAS, COPRAS-G, OCRA, ARAS and PSI methods show much dissimilar rankings as compared to those of the past researchers. When the z value is computed to determine the overall ranking agreement among all the considered methods, its value is found as 0.8104, suggesting a very high rank conformity
among all the methods. EVAMIX, OCRA and PSI methods emerge out as comparatively poor performers in terms of $r_s$ values. EXPROM2 and ORESTE appear to be the best methods during the entire performance analysis test. When the non-proportional and proportional weight sensitivity analyses are performed, it is found that ORESTE and OCRA methods outperform all other methods in terms of weight stability intervals.

The second industrial robot selection problem consists of four attributes and five alternative robots, short-listed based on the threshold values set for those attributes. Load capacity, repeatability error, vertical reach and degrees of freedom are considered as the most pertinent attributes, affecting this robot selection problem. Most of the preference ranking-based methods indicate Robot $A_3$ as the best chosen alternative, followed by Robot $A_2$. Robot $A_5$ is the worst choice among the five considered alternatives. It is also observed that COPRAS, COPRAS-G, EXPROM2, ORESTE, ARAS and PSI methods provide exactly the same ranking patterns as compared to those derived by the past researchers, whereas, for EVAMIX and OCRA methods, the amount of scatter is slightly higher due to few dissimilar rank orderings. The overall rank conformity in terms of $z$ value is obtained as 0.9506, indicating superior rank similarities among the considered methods. The six performance analysis tests indicate ORESTE, ARAS and PSI methods as the best performers. The sensitivity analysis results show that ORESTE method outperforms all other methods in terms of weight stability intervals.

The first example of RP process selection for a conjoint-designed test part considers dimensional accuracy, surface roughness, tensile strength, elongation, cost of the part and build time as the most important selection attributes, and six alternative RP processes. Most of the preference ranking-based methods and observations of the past researchers indicate Quadra and SLA3500 as the best and the second best RP processes. However, EVAMIX and OCRA methods indicate the exactly opposite results. The $z$ value for this RP process selection problem is obtained as 0.9336. All the performance analysis tests indicate EVAMIX as the worst performer as compared to the other methods. The results of different sensitivity analyses indicate ORESTE as the most robust performer, but the ranking performances of other preference ranking-based methods are also found to be satisfactory.

Another example of RP process selection for a benchmark test part is cited to validate the results produced by the preference ranking-based methods. This test part is suited for fabrication on different RP processes, such as fused deposition modelling, stereolithography, 3D printing, selective laser sintering, solid ground curing etc., as reported by the past researchers. The decision matrix for this RP process selection consists of five alternative RP processes and eight selection criteria, such as accuracy, surface finish, tensile strength, maximum part size, cost, speed,
reliability and flexibility. All the preference ranking-based methods suggest SLA-7000 as the best choice. For this RP process selection problem, the z value is obtained as 0.8031, indicating very high rank conformity among all these methods. The developed performance test results indicate that except for EVAMIX method, the ranks obtained using most of the preference ranking-based methods perfectly match for the top three rank positions. The results of sensitivity analysis suggest EVAMIX and ORESTE methods as the most robust performers, whereas, EXPROM2 and ARAS methods emerge out as the most unstable performers.

To demonstrate the computational flexibility and application convenience of the eight preference ranking-based methods, an NTM process selection problem for drilling cylindrical through holes on non-conductive ceramic materials is considered. Abrasive jet machining, ultrasonic machining, chemical machining, electron beam machining and laser beam machining processes are considered as the most feasible alternatives to be judged on the basis of tolerance, surface finish, surface damage, taper, material removal rate, work material and cost criteria. Chemical machining process evolves out as the best alternative as suggested by the considered preference ranking-based methods and also by the past researchers. The z value is obtained as 0.7135, indicating strong rank conformity among these methods. However, the performance test results indicate EVAMIX, EXPROM2 and ARAS methods as the worst performers. The results of non-proportional weight sensitivity analysis suggest ORESTE and OCRA methods as the most robust performers, and ARAS as the most unstable method in terms of global weight stability intervals. When the results of proportional sensitivity analysis are interpreted, it is found that ORESTE and OCRA methods outperform others in terms of ranking consistency, whereas, COPRAS, COPRAS-G and ARAS methods appear to be the most unstable performers.

An NTM process selection decision matrix for a shallow through cutting operation on glass materials is developed to further demonstrate the application feasibility of the eight preference ranking-based methods. This NTM selection problem consists of six alternative processes, e.g. abrasive jet machining, water jet machining, ultrasonic machining, chemical machining, electron beam machining and laser beam machining, and six selection criteria, such as maximum material removal rate, workpiece material suitability level, minimum surface finish, minimum surface damage, taper and machining cost. Water jet machining process appears to be the best chosen NTM process for the application considered. However, the ranking preorder of PSI method differs significantly with respect to other methods. For this NTM process selection problem, the z value is obtained as 0.6500, suggesting good rank conformity among all the preference ranking-based methods. The performances of EXPROM2 and PSI methods, in
comparison to others, are found to be relatively poor. The results of the sensitivity analysis indicate ORESTE and OCRA methods as the best performers among the considered approaches.

Now, a machine selection problem for a flexible manufacturing cell (FMC) is considered. An FMC is generally used as a tool to implement flexible manufacturing processes to increase competitiveness of the manufacturing systems. The past researchers considered a FMC machine selection problem consisting of four selection criteria, like total purchasing cost, total machine floor space, total machine number and productivity with ten alternative FMC machines. Alternative A₄ is the best chosen FMC machine for the application considered. However, the ranking preorder of EVAMIX differs significantly with respect to other methods. The past researchers also suggested alternative A₄ as the best choice. The z value is obtained as 0.8153, suggesting a strong rank similarity among all the preference ranking-based methods. The ranking performances of the preference ranking-based methods are in good agreement with each other, although, the performance of PSI method is found to be slightly worse in comparison to other methods. However, PSI emerges out as the best method in terms of total number of ranks matched when compared with the observations of the past researchers. The results of the sensitivity analysis indicate ORESTE as the most robust performer among the considered methods.

The second example is related to a machine selection problem in a web-based manufacturing environment. Five alternative CNC machines and six attributes, including machine cost, end item design life, mean time between failures, mean time to repair, preventive maintenance cost and corrective maintenance cost rate are considered. Machine alternatives A₁ (10HC DAEWOO horizontal lathe) and A₂ (TUR-630M) appear as the best and the second best economical machines, as indicated by most of the preference ranking-based methods. However, EVAMIX and EXPROM2 methods suggest A₂ (TUR-630M) as the best choice. For this machine selection problem, the overall rank agreement among all the methods in terms of z value is obtained as 0.4156, indicating acceptable rank similarities. The developed performance test table indicates that except for EVAMIX, EXPROM2 and PSI methods, the ranks obtained using the other preference ranking-based methods are in perfect agreement with each other. The results of non-proportional sensitivity analysis suggest ORESTE and EVAMIX methods as the most robust performers, whereas, EVAMIX and EXPROM2 emerge out as the most unstable methods. However, the high dimensional weight sensitivity analysis results suggest COPRAS (COPRAS-G), OCRA and ARAS methods as the most stable performers.

In a nutshell, the performance analysis tests and weight sensitivity analysis approaches, as adopted in the present research work, suggest that the ranking performances of ORESTE and
COPRAS (also COPRAS-G) are better than those of the other methods, and these two are the least sensitive methods for a wider range of changing criteria weights for most of the decision-making problems. EVAMIX and EXPROM2 show comparatively poor ranking performance as well as poor rank stability intervals. However, it may be concluded that any of these preference ranking methods can be successfully applied for any type of manufacturing decision-making problem. In few cases where strong disagreements in the ranking patterns as derived by the preference ranking-based methods occur, it is due to the presence of mixed ordinal-cardinal data in the decision matrices. Several types of selection problems can be approached in an adequate way by making proper use of these methods. A number of perspectives and future research possibilities are also outlined related to both the applications of these techniques and decision-making process. Thus, this research work is expected to become an essential reading for the industry and academia, as it makes the decision-making easier, logical, systematic, efficient and effective.