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Evaluation of Knowledge Management Levels Based on Multi Criteria Analysis

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Abstract

For thousands of years, humans have been discussing the meaning of knowledge, what it is to know something, and how people can generate and share new knowledge. It is interesting to consider, that despite the pervasiveness of epistemological discussions throughout history, the world of business has begun to recognize the importance of knowledge as a resource recently, and today, it is considered as a leading driving force behind any organization. Today, organizations are getting involved in more and more *knowledge management* (KM) activities, out of which performance of knowledge management has acquired prime importance. The performance evaluation of knowledge management is a scientific evaluation of the effectiveness of organizing knowledge management activity. In present research work, evaluation of knowledge management levels based on multi criteria analysis is proposed by the candidate. For this purpose, different *Multi criteria analysis* (MCA) techniques, *Analytical Hierarchy Process (AHP), Simple Additive Weighting (SAW), TOPSIS (Technique for Order Preference by Similarity to Ideal Solution),* and *Višekriterijumsko Kompromisno Rangiranje or Compromise Ranking (VIKOR)*, are used for evaluation of alternatives. For the purpose hidden variable identification for a set of KM evaluation criteria, a well known multivariate technique *Principal Component Analysis (PCA)* is also used.

Key words: Knowledge Management (KM); Multi criteria analysis (MCA; Analytical Hierarchy Process (AHP); Simple Additive Weighting (SAW); TOPSIS (Technique for Order Preference by Similarity to Ideal Solution); Višekriterijumsko Kompromisno Rangiranje or Compromise Ranking (VIKOR); Principal Component Analysis (PCA); Evaluation

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INTRODUCTION

The concept of *knowledge* has been there for ages as generations have used it for achieving prosperity. Individual and organizational knowledge has been invisible on balance sheets, overlooked in reward and incentive systems. But as a discipline and a field of research, it is very recently that it is gaining wider acceptability (Chawla & Joshi, 2010). Companies have realized that, while managing data and information is important, true competitive advantage lies in leveraging the unique, powerful knowledge of the organization (Paliszkiewicz, 2007). The push to embark on the *knowledge management* (KM) journey is no longer an option, but an absolute necessity. The knowledge management initiative provides opportunities for value creation and increasing the competitive advantages (Poh & Wee, 2004).

According to Girard and Girard (2015), *knowledge management* has become a critical subject of discussion in the business literature. Both business and academic communities believe that by leveraging knowledge, an organization can sustain its long-term competitive advantages (Bhatt, 2001). KM implementation is one of the major attractions among the researchers and practitioners. The business organizations are more concerned about building the knowledge assets for their competiveness (Singh & Kant, 2008). Business and academic circles both at home and abroad have been conducted on knowledge management for nearly three decades on the research of theory and practice (Tong, 2009). Large numbers of organizations are taking great interest in the idea of knowledge management and many are launching knowledge management initiatives and programs (Storey & Barnett, 2000). The area of KM is taking on renewed significance with the emergence and ascendancy of the knowledge worker. Investing in developing the knowledge and capabilities of a company's workforce is becoming a measure of the value of an organization because this investment is now seen as increasing the knowledge content and capability of an organization. At the same time, such an investment also helps to attract the best knowledge workers in a highly competitive knowledge worker market (Binney, 2001). According to relevant documents, researches on performance evaluation of knowledge management at home and abroad are basically based on the quantification of knowledge resources, the evaluation of intellectual capital, the appraise of enterprise core competence, the assessment of enterprise competitiveness and other respects. As an important part of KM, the KM performance evaluation tries to find out the key factors restraining the enhancement of the enterprises' performance (Wang et al, 2011).

Present research work is targeted on the evaluation of knowledge management levels of manufacturing industries from different cities of Malwa reason in Madhya Pradesh. The reason behind this selection is that Madhya Pradesh has marked 12.5% growth as compared to the other states of India. In last ten years, it has proven itself the fastest developing state. In these *ten* years, many national as well international companies have appeared here. So, therefore, it becomes very necessary to evaluate the levels of KM so that companies can reevaluate themselves as well as government can take positive steps in this direction.Multi (ple)-criteria analysis (MCA) or multiple-criteria decision analysis (MCDA) or Multi criteria Decision Making (MCDM) is a method of decision analysis that involves the use of scoring of weighting systems based on criteria in order to test and compare the impacts of alternatives. MCA is applicable to very broad range of interdisciplinary issues. It addresses situations where decisions are needed to handle complex problems involving alternative options that are evaluated against several conflicting criteria. (Linkov et al., pp.445-469). In present research work, evaluation of knowledge management levels based on multi criteria analysis is proposed. For this purpose, different MCA techniques are used for evaluation of alternatives and their comparison is presented. For the purpose latent variable identification for a set of KM evaluation criteria, a well known multivariate technique *principal component analysis* (PCA) is also used.

1. KNOWLEDGE MANAGEMENT

The field of *knowledge management* is very vast. Due to its interdisciplinary nature its fundamentals are being nurtured by various researchers and industry personnel over years. Here, attempts are made to focus on various aspects of *knowledge management*, including definitions, KM objectives, KM maturity models, and performance evaluation principles.

1.1 Definitions of Knowledge Management

KM and its implications are frequently discussed at seminars and conferences. Researchers and academics have taken different perspectives on knowledge management, ranging from technological solutions to the communities of practices, and the use of the best practices (Bhatt, 2001). Some of the definitions proposed by the researchers are given as follows:

- Knowledge Management is a key strategy which many organizations have been leveraging upon because of its potential in achieving competitive advantage (Bamgboje- Ayodele & Ellis, 2015);
- Knowledge management is an interdisciplinary business model with all aspects of knowledge creation, coding, sharing and using knowledge to enhance learning and innovation in the context of the company and its working (Meihami & Meihami, 2014);
- Knowledge management is a process to improve the competitiveness of enterprises and identify the knowledge, acquire it and play its full role in the process (Niu & Li, 2010);
- Knowledge management is the source to improve enterprise core competitive ability in the knowledge economy ages (Cao et al., 2010);
- Knowledge management can be defined as the creation, acquisition, sharing, and utilization of knowledge for the promotion of organizational performance (Wenzhi, 2010);

After analyzing above definitions of KM, one can conclude that all these definitions hint at the same idea, but each one focuses on different aspect of knowledge management.

1.2 Objectives of Knowledge Management

Following are some of the objectives of knowledge management:

- KM improves the quality of management decision-making by ensuring that reliable and secure knowledge, information and data is available through the service lifecycle (Pinkscan Assessment Report, p.46);
- It enable the service provider to be more efficient and improve quality of service, increase satisfaction and reduce the cost of service by reducing the need to rediscover knowledge (Ibid.);

- It ensures that staff has a clear and common understanding of the value that their services provide to customers and the ways in which benefits are realized from the use of those services (Ibid.);
- Maintains a Service Knowledge Management System (SKMS) that provides controlled access to knowledge, information and data that are appropriate for each audience (Ibid.);
- To enhance the knowledge environment (Davenport et al., 1998);
- To manage knowledge as an asset (Ibid.);
- Supporting innovation, the generation of new ideas and the exploitation of the organization's thinking power (Levett & Guenov, 2000).

1.3 Knowledge Management Maturity Models

According to Vanini and Bochert (2014), KM maturity can be defined *as the extent to which KM is explicitly defined, managed, controlled, and affected*. Knowledge management maturity model (KMMM) in an organization describes some steps of growth that can be expected by the organization to reach its knowledge management development. One maturity model is made up of some maturation levels that can be obtained step by step by an organization over a period of time. Maturity level indicates precisely a level of capabilities that an organization may have such that it has been obtained through the transformation of one or more sections of organizational processes. During recent years various KM maturity models have been developed in order to structure the KM implementation process. Table 1 shows the summary of different KM maturity models available in literature:

Table 1
Summary of Different KM Maturity Models Available in Literature

S.No.	Researcher (year)/ firm	Name of KM model	Level 1	Level 2	Level 3	Level 4	Level 5
1	Vanini & Bochert (2014)	G-KMMM	Initial	Aware	Defined	Managed	Optimizing
2	Tissayakorn et al. (2013)	Organizational knowledge management maturity model	Ad-hoc	Preliminary	Systematic standardizing	Quantitative measuring and controlling	Continuous improvement and optimization
3	Khatibian et al. (2010)		Initial	Managed	Defined	Quantitatively managed	Optimizing
4	Hubert & Lemons (2010)	APQC's levels of knowledge management maturity	Initiate	Develop	Standardized	Optimize	Innovate
5	Minonne & Turner (2009)		Existing awareness for KM	KM topic addressed	Individual practices implemented	Policy and methods standardized	Policy and methods fully standardized
6	Hsieh et al. (2009)	Knowledge Navigator Model (KNM)	Knowledge chaotic stage	Knowledge conscientious stage	KM stage	KM advanced stage	KM integration stage
7	Pee & Kankanhalli (2009)		Initial	Aware	Defined	Managed	Optimizing
8	Siemens (2004)	Siemens' KMMM	Initial	Repeated	Defined	Managed	Optimizing
9	Infosys Technologies	Infosys technologies KMMM	Default	Reactive	Aware	Convinced	Sharing
10	Tiwana (2002)		Initiation	Propagation	Integration	Networking	
11	Tata Consultancy Services (2005)	5iKM maturity model	Initial	Intent	Initiative	Intelligent	Innovative

1.4 Knowledge Management Performance Evaluation

Knowledge management performance evaluation can reflect the enterprise knowledge management status and the future development trend. It is an important means of enterprise knowledge management to awareness and understanding itself. Through KM performance evaluation enterprise can manage its own level of knowledge before and after comparison, or have the knowledge management horizontal. Therefore, how to make the objective and accurate evaluation of the knowledge management performance level has very important significance on effective supervising to achieve knowledge management as well as the enterprise's development and changes, finding out the key factors which influence on the performance improving, and taking the effective measures in time. The research of Knowledge management performance evaluation method has gained broad attention from many experts and scholars (Wu et al., 2009). When designing evaluation index system for enterprise KM performance, the following principles should be followed (Tong et al., 2011; Zhu & Wu, 2010):

a) **The feasible principle:** Index system should be practically feasible. And the data should be easily collected;
b) **The systemic principle:** The external environment and internal conditions should be taken into account and the knowledge management level and knowledge management capabilities of an enterprise should be fully reflected in the index system;
c) **The independent principle:** Every single index should be independent of other indices as far as possible, and the correlation among indices should be minimized or reduced in case that it may affect the evaluation results;
d) **The Principle of Scientificity:** The accuracy and reasonableness of the evaluation results have a closely relationship with the scientificity of the indicators design.

1.5 Gaps in Literature

On the basis of literature review of available literature, following research gaps are found:

a) There is very limited research which tells about the evaluation of *knowledge management* levels;
b) There is almost no research available which tells about the *evaluation of knowledge management levels* for Indian industries;
c) Multi criteria analysis is a versatile tool for decision making, but its use in evaluation of knowledge management levels is not found in the literature.

1.6 Objectives of Research

On the basis of above said gaps, following research objectives are being proposed:

a) **Establishment of set of criteria for the purpose of KM evaluation.** A set of criteria helps in viewing the problem with a clearer vision. An established set of criteria is proposed which applies on a generalized class of industries.
b) **Evaluation of KM levels.** Evaluation acts as a mirror. Evaluation shows the plus points as well as the loop holes at a common platform. Evaluation makes the firms able for self assessment as well as makes them think to work out in the direction of improved knowledge management.
c) **Comparison of different MCA techniques.** Comparison of different MCA techniques is proposed which shows their suitability for the purpose.

2. SOLUTION METHODOLOGY

Solution methodology of the present research work is *three* fold, which contains *hypothesis testing, criteria finalization* and *evaluation of knowledge management levels using multi criteria analysis* techniques. Following approaches are being used to solve above mentioned stages of solution methodology:

- *Hypothesis testing*: Chi-square test;
- *Criteria finalization*: Principal components analysis;
- *Evaluation of knowledge management levels*: Multi criteria analysis techniques.

Details of above mentioned analyses/techniques are given as follows.

2.1 Hypothesis Testing

The word *hypothesis* is made up of two Greek roots which mean that it is some sort of *sub-statements*, for it is the presumptive statement of a proposition, which the investigation seeks to prove. According to Gulford (1954, p.327), hypothesis is a tentative supposition or provisional guess which seems to explain the situation under observation. According to Kothari (2004, p.191), the various steps involved in hypothesis testing are stated below:

a) Making a formal statement;
b) Selecting a significance level;
c) Deciding the distribution to use;
d) Selecting a random sample and computing an appropriate value;
e) Calculation of the probability;
f) Comparing the probability.

According to Kothari (2004, pp.236-237), *Chi-square (χ^2) test* can be successfully used as non-parametric test and as such no rigid assumptions are necessary in respect of the type of population. He further guides, in such a case require only the degrees of freedom (implicitly of course the size of the sample) for using this test. As a non-parametric test, thus, the chi-square test is applicable in large number of problems. In order that we may apply the chi-square test either as a test of goodness of fit or as a test to judge the significance of association between attributes, it is necessary that the observed as well as theoretical or expected frequencies must be grouped in the same way and the theoretical distribution must be adjusted to give the same total frequency as we find in case of observed distribution. χ^2 is then calculated as follows:

$$\chi^2 = \Sigma \frac{(O_{ij} - E_{ij})^2}{E_{ij}}, \quad (1)$$

where, O_{ij} = observed frequency of the cell in i^{th} row and j^{th} column;

E_{ij} = expected frequency of the cell in i^{th} row and j^{th} column.

2.2 Principal Component Analysis

According to Ilin and Raiko (2010), *principal component analysis* (PCA) is a classical data analysis technique that finds linear transformations of data that retain the maximal amount of variance. The aim of PCA is to explain as much of the variance of the observed variables as possible using few composite variables (usually referred to as components) (Lorenzo-Seva, 2013, p.3). Kothari (2004, p.330) says principal components method of factor analysis, seeks to maximize the sum of squared loadings of each factor extracted in turn. *Principal component analysis* can be used to compress data sets of high dimensional vectors into lower dimensional ones. This is useful, for instance, in visualization and feature extraction. The aim of PCA is the construction out of a given set of variables Xj's (j = 1, 2,…,k) of new variables (p_i), called *principal components* which are linear combinations of the Xs.

Following steps are usually involved in principal components method:

a) Estimates of aij's are obtained with which X's are transformed into orthogonal variables i.e., *the principal components*.

b) Next step is the regression of Y on these principal components, i.e.,

$$Y=y_1 p_1+y_2 p_2+.....+y_m p_m (m<k) . \quad (2)$$

c) From the a_{ij} and y_{ij}, one can find b_{ij} of the original model, transferring back from p's into the standardized X's.

The principal components, so extracted and retained are then rotated from their beginning position to enhance the interpretability of the factors. The amount of variance explained (sum of squared loadings) by each principal component factor is equal to the corresponding characteristic root. When these roots are divided by the number of variables, they show the characteristic roots as proportions of total variance explained. The variables are then regressed against each factor loading and the resulting regression coefficients are used to generate what are known as factor scores which are then used in further analysis and can also be used as inputs in several other multivariate analyses (Kothari, 2004, p.330, 332).

2.3 Multi Criteria Analysis

Multi (ple)-criteria analysis (MCA) or multiple-criteria decision making (MCDM) or multiple-criteria decision analysis (MCDA) is a method of decision analysis that involves the use of scoring of weighting systems based on criteria in order to test and compare the impacts of alternatives. MCA is applicable to very broad range of interdisciplinary issues. It addresses situations where decisions are needed to handle complex problems involving alternative options that are evaluated against several conflicting criteria. It also aggregates miscellaneous criteria and makes a tradeoff between positive and negative impacts (Linkov et al., 2007, p.461). According to Toutos et al. (2009), following are the reasons behind choosing MCA approach:

- It allows for investigation and integration of the interests and objectives of multiple actors since the input of both quantitative and qualitative information from every actor is taken into account in form of criteria and weight factors;
- It deals with the complexity of the multi actor setting by providing output information that is easy to communicate to actors. The user-friendliness of the approach lies on two aspects: the suggested criteria are estimated and given values that are consistent and comparable with the input data (as a measure of appropriateness); and the *simple* format of the output of the method that makes the method's results meaningful and directly applicable for the interested actors;
- It offers well-known and applied methods of alternatives' assessment that also includes different versions of the method developed and researched for specific problems and/or specific contexts;
- MCA allows objectivity and inclusiveness of different perceptions and interests of actor without being energy and cost intensive;
- MCA methods can provide solutions to increase complex management problems.

MCA methods can be classified as multi objective decision making (MODM) approaches working with an indefinite set of possible scenarios, and multi attribute decision making (MADM), suggesting a finite set of scenarios (Hwang & Yoon, 1981; Buchholz et al., 2009). In present research work, the MCA techniques used are Analytical Hierarchy Process (AHP), Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), the details of which are as follows:

2.3.1 Analytical Hierarchy Process (AHP)

The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education (Saaty, 1980).

AHP procedure involves following steps:

Step 1: Model the problem as a hierarchy.

The first step in the *analytic hierarchy process* is to model the problem as a hierarchy. In doing this, participants explore the aspects of the problem at levels from general to detailed, then express it in the multileveled way that the AHP requires.

Step 2: Hierarchies defined.

A *hierarchy* is a system of ranking and organizing people, things, ideas, etc., where each element of the system, except for the top one, is subordinate to one or more other elements (Saaty, 1980). In this step, hierarchies are defined, which tell about the goal, criteria (sub criteria, if any), and alternatives.

Step 3: AHP hierarchies explained.

An AHP hierarchy is a structured means of describing the problem at hand. It consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal. In most cases the criteria are further broken down into sub criteria, sub-sub criteria, and so on, in as many levels as the problem requires. The hierarchy can be visualized as a diagram like the one below, with the goal at the top, the alternatives at the bottom, and the criteria filling up the middle (Holder, 1991). Figure 4 gives the details of a hierarchy consisting of *five* criteria and *three* alternatives.

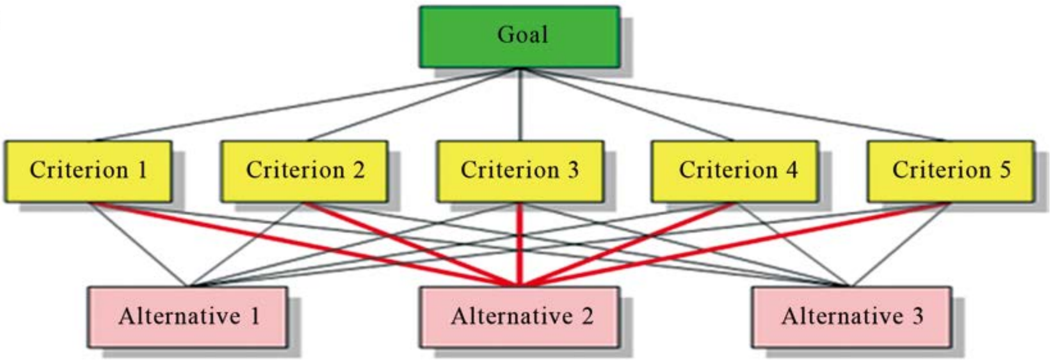


Figure 1
General AHP Hierarchy Structure (Saaty, 1980)

Step 4: Establishment of priorities.

Once the hierarchy has been constructed, AHP can be used to establish priorities for all its nodes. In doing so, information is elicited from the participants and processed mathematically.

Step 5: Priorities defined.

Priorities are numbers associated with the nodes of the hierarchy. By definition, the priority of the Goal is 1.000. The priorities of the criteria (which are the children of the goal) can vary in magnitude, but shall always add up to 1.000. The priorities of the children of any Criterion can also vary but shall always add up to 1.000, as will those of their own children, and so on down the hierarchy. If the priorities within every group of child nodes are equal then the priorities are called default priorities.

Step 6: Pair wise comparisons.

To perform judgments about the various elements in the hierarchy, pair wise comparison of the elements is made. For assigning numerical values to the compared results, a pair wise comparison scale is used which may be like the one shown below (please refer to Table 2).

Table 2
Pair Wise Comparison Scale (Saaty, 1980)

Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6 and 8 can be used to express intermediate values. Intensities 1.1, 1.2, 1.3, etc., can be used for elements that are very close in importance.		

After all the pair wise comparisons are completed, the consistency of the comparisons is assessed by using the Eigen value, λ, to calculate a consistency index, *CI*:

$$C.I. = \frac{(\lambda - 1)}{(n-1)} \quad , \tag{3}$$

where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (*C.R.*).

$$C.R. = \frac{(C.I.)}{(R.I.)} \, , \tag{4}$$

where *R.I.* stands for Random Consistency Index, the appropriate values of *R.I.* are given in Table 3. Saaty, (1980) suggests that the *C.R.* is acceptable if it does not exceed 0.10. If the *C.R.* is greater than 0.10, the judgment matrix should be considered inconsistent. To obtain a consistent matrix, the judgments should be reviewed and repeated.

Table 3
Average Random Consistency Index (Saaty, 1980)

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random Consistency Index (*R.I.*)	0.00		0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The AHP uses relative values instead of actual ones. Thus, it can be used in single or multi dimensional decision making problems (Saaty, 1977).

Step 6: Comparing alternatives.

Then we evaluate alternatives against their covering criteria in any order they choose.

Step 7: Make the decision.

In the end, the summation of priorities is evaluated. Their grand total should be equal to 1.000. Each alternative has a priority corresponding to its *fit* to all the family's judgments.

2.3.2 Simple Additive Weighting (SAW)

Simple additive weighting (SAW) is extremely simple to use. The advantage of this method is that it is a proportional linear transformation of the raw data which means that the relative order of magnitude of the standardized scores remains equal. Following are the procedural details of the technique:

The sum *Sj* of the weighted normalized values of all the criteria is calculated for the *j*-th object:

$$S_j = \sum_{i=1}^{m} \omega \tilde{r}_{ij} \ , \qquad (5)$$

$$= \left(\sum_{i=1}^{m} \omega_i = 1 \right) ; \tilde{r}_{ij} \ . \qquad (6)$$

where ω_i is weight of the *i*-th criterion normalized *i*–th criterion's value for *j*–th object; *i*=1,...,*m*; *j*=1,…,*n*; *m* is the number of the criteria used, *n*–is the number of the objects (alternatives) compared. The largest value of the criterion S_j corresponds to the best alternative. The alternatives compared should be ranked in the decreasing order of the calculated values of the criterion S_j. SAW may be used if all the criteria are maximizing. This is a drawback of this method, though minimizing criteria can be easily converted to the maximizing ones by the formula:

$$\bar{r}_{ij} = \frac{\min_j r_{ij}}{r_{ij}} \ , \qquad (7)$$

where *ij r* is *i*-th criterion's value for *j*-th alternative, min *j ij r* is the smallest *i*-th criterion's value for all the alternatives compared, *ij r* denotes the converted values. Thus, the smallest criterion value min *ij ij j r* = *r* acquires the largest value equal to unity (Afshari et al, 2010).

2.3.3 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

Among numerous MCDM methods developed to solve real-world decision problems, *Technique for Order Preferences by Similarity to Ideal Solution* (TOPSIS) continues to work satisfactorily in diverse application areas. Hwang and Yoon (1981) originally proposed TOPSIS to help in selecting the best alternative with a finite number of criteria. As a well-known classical MCDM method, TOPSIS has received much interest from researchers and practitioners. TOPSIS is a widely accepted multi criteria decision making technique due to its sound logic, simultaneously consideration of the ideal and the anti ideal solutions, and easily programmable computation procedure. This technique is based on the concept that the ideal alternative has the best level for all attributes, whereas the negative ideal alternative is the one with all of the worst attribute values. The basic principle of TOPSIS is that the chosen alternative should have the shortest distance from the ideal solution and the farthest distance from the negative ideal solution. This method considers three types of attributes or criteria:

a) Qualitative benefit attributes/criteria;
b) Quantitative benefit attributes;
c) Cost attributes or criteria (Hwang & Yoon, 1981).

Following is the stepwise procedure for implementing TOPSIS (Hwang & Yoon, 1981):

Step 1: Construct normalized decision matrix.

This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria. Normalize scores or data as follows:

$$\chi^2 = \Sigma \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \ , \qquad (8)$$

where *j* = 1,2,3,… , *J*, *i* = 1, 2, 3, …,*n*.

Step 2: Construct the weighted normalized decision matrix.

Assume we have a set of weights for each criteria w_j for *j* = 1,…,*n*.

Multiply each column of the normalized decision matrix by its associated weight.

The weighted normalized value is calculated as:

$$V_{ij} = (w_{ij} \times r_{ij}) \ . \qquad (9)$$

Where w_i is the weight of the i_{th} attribute or criterion, and it is calculated by AHP method.

$$w_i = 1 \ . \qquad (10)$$

Step 3: Determine the ideal and negative- ideal solution.

Ideal solution:

$$A^* = (v_1^*, v_2^*, \ldots, v_i^*) = \left((\max v_{iji} \ \ / i \in I') \times (\max v_{ij} / j \in I'')_j \right). \qquad (11)$$

Negative- Ideal Solution:

$$A^{-} = \left(v_1^{-}, v_2^{-}, \ldots, v_i^{-}\right) = \left((\max v_{iji} \quad / i \in I').(\max v_{ij}/j \in I'')_j\right). \tag{12}$$

Step 4: Calculate the separation measures, using the n dimensional Distance.

The separation of each alternative from the ideal solution is given as:

$$D_j^{*} = \sqrt{\Sigma_{i=1}^{n} (vij - vi*)^2}, \tag{13}$$

where j=1,2,3,…, j.

Similarly, the separation from the negative ideal solution is given as:

$$D_j^{-} = \sqrt{\Sigma_{i=1}^{n} (vij - vi-)^2};, \tag{14}$$

where j=1,2,3,..., j.

Step 5: Calculate the relative closeness to the ideal solution.

The relative closeness of the alternative a_j is defined as:

$$\mathrm{CC}^{*}_{j} = \frac{Dj*}{Dj* + Dj-}. \tag{15}$$

Step 6: Rank the preference order.

2.3.4 VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

The Serbian name VIKOR stands for *VlseKriterijumska Optimizacija I Kompromisno Resenje* means *multi-criteria optimization and compromise solution.* It was developed by Opricovic in last 1998. This method concentrates on ranking and selecting the best from a set of alternatives, which are associated with multi-conflicting criteria. Moreover, it makes it easy for the decision makers to reach the final decision by finding the compromise solution (closest to the ideal) of a problem. The basic principle of VIKOR is determining the positive-ideal solution as well as the negative-ideal solution in the first place. VIKOR is a helpful tool in multi criteria decision making, particularly in a situation where the decision maker is not able, or does not know, to express his/her preference at the beginning of system design. VIKOR ranks the alternatives according to conflicting criteria. It introduces the multi criteria ranking index based on the particular measure of *closeness* to the *ideal* solution (Opricovic, 1998).

VIKOR is a MCA based on outranking principle. It is used to find the compromise ranking list, the compromise solution and the weight stability intervals (Opricovic & Tzeng, 2004). The method was developed from the *Lp* – metric which is used in compromise programming as an aggregation function. The method uses *Lp* – metric concepts to find the compromise solution that is the closest to the ideal solution. The *Lp* – metric has the following form:

$$L_{p,j} = \left\{\sum_{i=1}^{n}\left[w_i\left(f_i^{*} - f_{ij}\right)/\left(f_i^{*} - f_i^{-}\right)\right]^{p}\right\}^{1/p}, \tag{16}$$

$$1 \le p \le \infty, \qquad j=1,2,3,\ldots, J. \tag{17}$$

The following steps are involved in VIKOR method (Opricovic & Tzeng, 2007):

Step 1: Representation of normalized decision matrix.

The normalized decision matrix can be expressed as:

$$F=[f_{ij}]m \times n. \tag{18}$$

Here,

$$f_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^{2}}} \quad i = 1,2,\ldots m; \tag{19}$$

and, X_{ij} is the performance of alternative A_i with respect to the j^{th} criterion.

Step 2: Obtain the maximum criterion function f_j^* and the minimum criterion function f_j^-, where j = 1,. . ., m.

Maximum Criterion Functions

$$f_j^{*} = {}^{\max}_{i} f_{ij} = \max\left[\left(f_{ij}\right) \backslash i = 1,2,3,\ldots n\right] \tag{20}$$

Minimum Criteria Functions

$$f_j^{-} = {}^{\max}_{i} f_{ij} = \max\left[\left(f_{ij}\right) \backslash i = 1,2,3,\ldots n\right] \tag{21}$$

Step 3: Calculation of utility measure and regret measure

The utility measure and the regret measure for each alternative are given as:

Utility Measure

$$S_i = \sum_{j=1}^{n} w_j \frac{\left(f_j^{*} - f_{ij}\right)}{\left(f_j^{*} - f_j^{-}\right)}. \tag{22}$$

Regret Measure

$$R_i = \max_j\left[w_j\right]\frac{\left(f_j^{*} - f_{ij}\right)}{\left(f_j^{*} - f_j^{-}\right)}. \tag{23}$$

Step 4: Computation of VIKOR index.

The VIKOR index can be expressed as follows:

$$Q_i = \mathrm{v}\left[\frac{S_i - S^{*}}{S^{-} - S^{*}}\right] + (1-\mathrm{v})\left[\frac{R_i - R^{*}}{R^{-} - R^{*}}\right]. \tag{24}$$

Q_i represents the VIKOR index value of I^{th} alternative . i=1,2,…, n.

$$S^{*} = \min_i S_i = \min\left[(S_i)/i = 1,2,3,\ldots n\right], \tag{25}$$

$$S^{-} = \max_i S_i = \max\left[S_i/i = 1,2,3,\ldots n\right], \tag{26}$$

$$R^{*} = \min_i R_i = \min\left[R_i/i = 1,2,3,\ldots n\right], \tag{27}$$

$$R^- = \max_i R_i = \max\left[R_i / i = 1,2,3,\dots n\right], \quad (28)$$

where v is the weight for the maximum value of group utility and 1-v is the weight of the individual regret. V is generally set to 0.5.

3. CASE STUDY

In the present research work different manufacturing industries located in *five* different cities are being compared on the anvil of different knowledge management evaluation criteria. The target is to rank the industries located in different cities according to their knowledge management levels. Targeted industries for the research work are the manufacturing industries belonging to different cities of of Malwa region of Madhya Pradesh. The cities are Pithampur, Ujjain, Dewas, Ratlam and Mandsaur. Reasons behind selection of these cities are as follows:

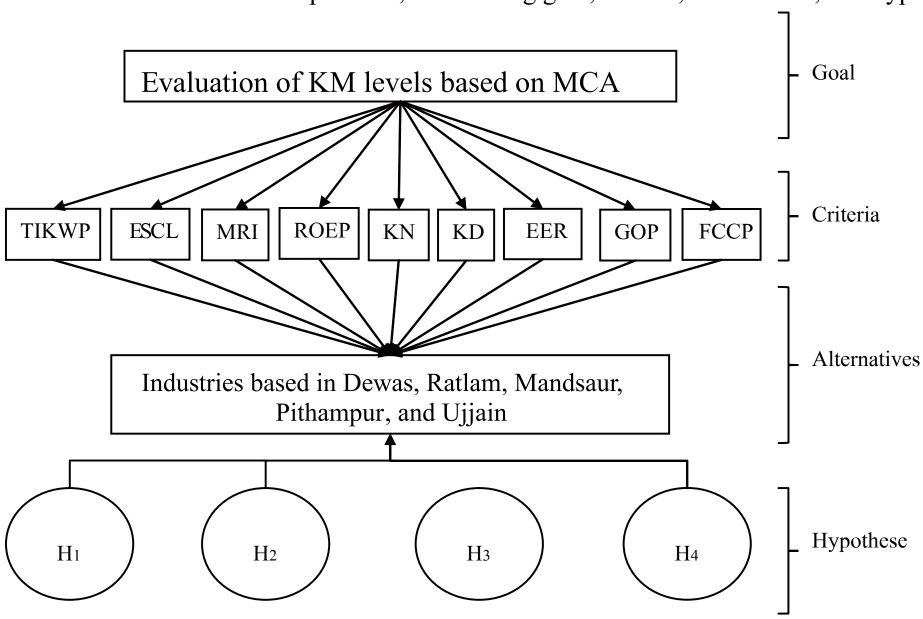
- These cities have enough manufacturing industries for the purpose of comparison;
- Sufficient manpower; and
- A wide range of products.

On comparing the research parameters with MCA procedures, the observations shown in Table 4 can be drawn.

Table 4
Equivalency of Research Work Terminology and MCA terminology

S.No	Research work Terminology	Equivalent MCA Terminology
1	Evaluation of knowledge management levels based on multi criteria analysis	Goal
2	Knowledge management evaluation criteria (obtained by applying *principal component analysis*)	Attributes and Criteria
3	Manufacturing industries in five cities	Alternatives

Figure 2 shows the model formulation for problem, considering goal, criteria, alternatives, and hypothesis.



where,
TIKWP = Technological impact on K worker performance; **ESCL** = Employee satisfaction, commitment, and loyalty; **MRI =** Management related issues; **ROEP** = Role of organizational in employee participation; **KN** = Knowledge nurturing; **KD** = Knowledge deployment; **EER** = Efficient employee retention; **GOP** = Growth oriented performance; **FCCP** = Focus on customer and cost perspectives.
$\mathbf{H_1}$= Better knowledge management leads to the prosperity of the organization; $\mathbf{H_2}$ = Different organizations have different levels of knowledge management; $\mathbf{H_3}$ = Better knowledge management leads to the development of employees; $\mathbf{H_4}$ = Organizations can enhance the level of their knowledge management.

Figure 2
Model formulation for the Research Problem

Following are the main stages of solution methodology for the problem:

a) Criteria collection;
b) Criteria finalization;
c) Hypothesis testing and prioritization of criteria;
d) Evaluation of alternatives.

Details of above mentioned stages are given as follows:

3.1 Criteria Collection

In this stage, a list of criteria was prepared by the candidate with the help of detailed survey of available literature, and expert opinion. With the help of an expert, that list was sorted to *forty four* criteria and classified into *three* classes, *organization based factors*, *knowledge cycle elements*, and *KM output*, as follows:

Table 5
Distribution of Criteria

S.No	Identified category	Components
1		Knowledge carrier performance
2		Knowledge receiver performance
3		Technological infrastructure
4		Employee commitment
5		Employee satisfaction and loyalty
6		Interpersonal trust
7	Organization based factors	Vision and goals
8		Top management commitment, encouragement and support
9		Efficient employee participation
10		Organizational structure and culture
11		Internal performance analysis
12		External performance analysis
1		Knowledge utilization
2		Recognizing K
3		Knowledge development
4		Knowledge acquisition
5		Maintenance of K
6		Knowledge creation
7		Knowledge absorption
8	Knowledge cycle elements	Knowledge accumulation
9		Knowledge protection
10		Knowledge transferability
11		Knowledge sharing and devotion
12		Knowledge capture and storage
13		Applying K
14		Knowledge identification
15		High quality of K
1		Improved learning or adaption capability
2		Better staff attraction/retention
3		More innovation
4		Improved business processes
5		Enhanced collaboration
6		High productivity
7		Improved employee skills
8		Better decision making and supervision
9	KM Outputs	Better planning
10		Enhanced quality of product or service
11		Intellectual capital
12		Improvement in market share
13		Increased profits
14		Faster response to key business issues
15		Reduced costs
16		More value to customers
17		Improved communication

3.2 Criteria Finalization

The next stage in solution methodology is *criteria finalization*. From the review of available literature, it was realized that with the help of long list of criteria, it was quite impracticable to use *multi criteria analysis* techniques. So, therefore, in order to reduce the criteria multivariate technique *principal component analysis* was used. For this purpose, a systematically designed was sent to respondents, and responses are collected. Following are the details of responses obtained.

Table 6
Details of Responses Collected for Criteria Finalization

S.No	Item	Output
1	Type of scale used	5-point Likert scale
2	Total number of questionnaire sent	400
3	Number of industries covered	105
4	Type of industries covered	Manufacturing and service industries
5	Number of responses obtained	232
6	Number of complete responses obtained	232
7	Response ratio	58%
8	Regions covered	Different provinces of country

Following are the results:

Table 7
Identification of Principal Components

S.No	Identified categories	Principal component	Component variables	Factor loadings	Corrected Item to total correlation	α
1	Organization based factors	Technological impact on K worker performance	Knowledge carrier performance	0.906	0.757	0.846
			Knowledge receiver performance	0.899	0.772	
			Technological infrastructure	0.740	0.617	
2		Employee satisfaction, commitment and loyalty	Employee commitment	0.802	0.337	0.504
			Employee satisfaction and loyalty	0.744	0.337	
3		Management related issues	Vision and goals	0.818	0.417	0.589
			Top management commitment, encouragement and support	0.780	0.417	
4		Role of organizational in employee participation	Efficient employee participation	0.837	0.538	0.700
			Organization structure and culture	0.815	0.538	
5	Knowledge cycle elements	Knowledge nurturing	Knowledge utilization	0.895	0.887	0.912
			Recognizing k	0.870	0.834	
			Knowledge development	0.853	0.844	
			Knowledge acquisition	0.798	0.752	
			Maintenance of k	0.768	0.666	
			Knowledge creation	0.767	0.675	
			Knowledge absorption	0.721	0.674	
			Knowledge accumulation	0.631	0.523	
			Knowledge protection	0.511	0.469	
6		Knowledge deployment	Knowledge sharing	0.896	0.879	0.908
			Knowledge capture	0.879	0.866	
			K storage	0.872	0.710	
7	KM outputs	Efficient employee retention	Improved learning or adaption capability	0.854	0.681	0.882
			Better staff attraction/retention/retirement/deflection	0.835	0.735	
			More innovation	0.834	0.782	
8		Growth oriented performance	Improved business processes	0.818	0.780	0.683
			Enhanced collaboration	0.719	0.453	
			High productivity	0.704	0.496	
			Improved employee skills	0.696	0.487	
			Better decision making and supervision	0.605	0.427	
9		Focus on customer and cost perspectives	Reduced costs	0.908	0.704	0.826
			More value to customers	0.891	0.704	

3.3 Hypothesis Testing and Prioritization of Criteria

In next stage, *hypothesis testing* and *prioritization of criteria* was accomplished. The purpose of hypothesis testing was to check the suitability of the manufacturing industries for the purpose of evaluation. For, this purpose, a systematically designed questionnaire was sent to industries personnel. The same questionnaire was used for evaluation of alternatives. Following are the details of responses obtained:

Table 8
Details of responses Collected for Hypothesis Testing, Prioritization of Criteria, and Evaluation of Alternatives

S.No	Item	Output
1	Type of scale used	5-point Likert scale
2	Total number of questionnaire sent	310
3	Number of industries covered	110
4	Type of industries covered	Manufacturing industries
5	Number of responses obtained	171
6	Number of complete responses obtained	171
7	Response ratio	55.1%
8	Number of industries covered	83
9	Regions covered	Five districts of Madhya Pradesh

Following are the demographic details of respondents:

Table 9
Demographic Details of Respondents

S.No	City	Industries covered	Responses collected
1	Ujjain	25	37
2	Indore	27	57
3	Dewas	27	44
4	Ratlam	15	18
5	Mandsaur	9	15
	Total	**103**	**171**

(a)Hypothesis testing

For the purpose of hypothesis testing, a systematically designed questionnaire was sent to industries personnel. The same questionnaire was used for evaluation of alternatives. Following are the results of hypothesis testing:

Table 10
Results of Hypothesis Testing

S.No	Hypothesis	No. of respondents	Chi-square value (calculated)	Chi-square value (obtained from table)
1	Hypothesis 1	171	6.988304	9.488
2	Hypothesis 2	171	11.97076	12.592
3	Hypothesis 3	171	4.415205	5.991
4	Hypothesis 4	171	7.093567	9.488

Significant level : 0.05

Inferences of results obtained from hypothesis testing are as follows:

Hypothesis 1

H_0: Better knowledge management does not lead to the prosperity of the organization**:** ***Rejected***.

H_1: Better knowledge management leads to the prosperity of the organization**:** ***Accepted.***

Hypothesis 2

H_0: Different organizations have same levels of knowledge management**:** ***Rejected***.

H_2: Different organizations have different levels of knowledge management**:** ***Accepted.***

Hypothesis 3

H_0: Better knowledge management does not lead to the development of employees**:** ***Rejected***.

H_3: Better knowledge management leads to the development of employees**:** ***Accepted.***

Hypothesis 4

H_0: Organizations cannot enhance the level of their knowledge management**:** ***Rejected***.

H_4: Organizations can enhance the level of their knowledge management**:** ***Accepted.***

(b) Prioritization of criteria

In order to prioritize the criteria (*principal components*), average value of responses scored by different criteria from all the respondents were recorded and were sent to a group of experts in the form of systematically designed questionnaire to get pair wise comparisons. For the purpose of prioritization of criteria, a renounced MCA technique, *analytical hierarchy process* (AHP) was used. Following are the details of results obtained:

Table 11
Priorities of Criteria

S.No	Criteria	Abbreviation	Priority value
1	Focus on customer and cost perspectives	FCCP	0.111
2	Efficient employee retention	EER	0.111
3	Employee satisfaction, commitment and loyalty	ESCL	0.111
4	Growth oriented performance	GOP	0.111
5	Knowledge deployment	KD	0.111
6	Knowledge nurturing	KN	0.111
7	Management related isssues	MRI	0.111
8	Role of organizational in employee participation	ROEP	0.111
9	Technological impact on K worker performance	TIKWP	0.111

C.R. = 0 < 0.10

3.4 Evaluation of Alternatives

In the last stage of solution methodology, evaluation of alternatives is accomplished by using various MCA approaches. The MCA approaches used are *analytical hierarchy process* (AHP), *simple additive weighting* (SAW), *technique for order preference by similarity to ideal solution* (TOPSIS) and *višekriterijumsko kompromisno rangiranje or compromise ranking* (VIKOR), all combined with AHP. Following are the results:

Table 12
Details of Scores for Different Industries

Industries based in (city-wise)	MCA techniques			
	AHP	SAW	TOPSIS	VIKOR
	Score			
Dewas	0.140	0.746	0.409	0.784
Pithampur	0.563	0.999	1.000	0.000
Mandsaur	0.089	0.648	0.203	0.977
Ratlam	0.132	0.733	0.385	0.868
Ujjain	0.074	0.627	0.107	0.985

4. RESULT AND DISCUSSION

Figure 3 shows the graphical representations of scores obtained by industries from different cities.

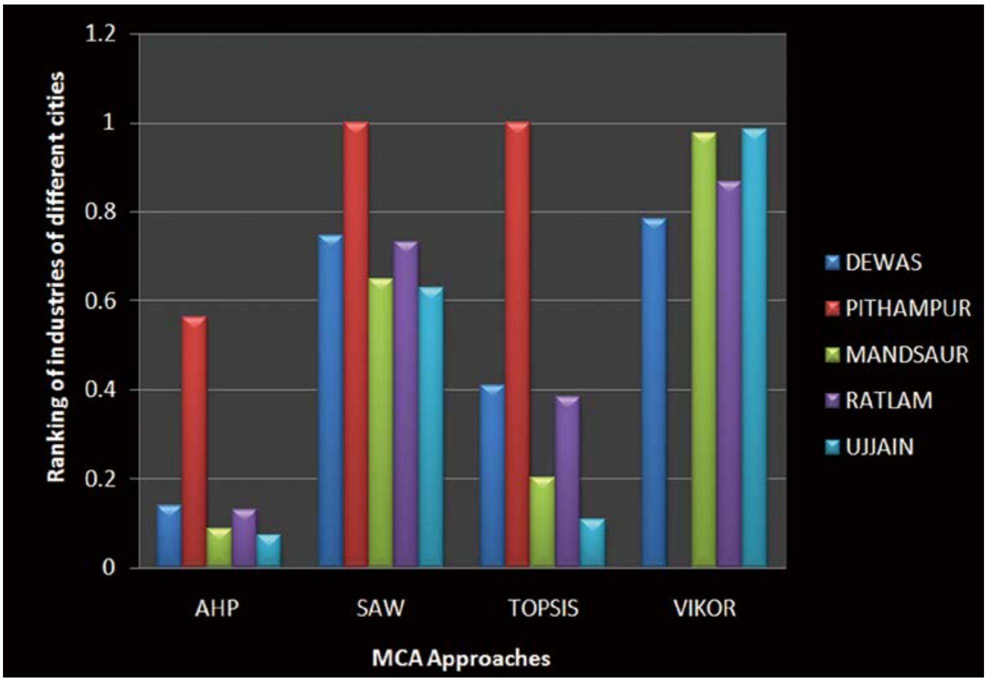


Figure 3
Scores Obtained by Industries From Different Cities Using MCA Approaches

But in order to evaluate KM levels, above Table and Figure seems inappropriate. For the purpose of evaluation of KM levels following stages are being involved:

a) Selection of proper knowledge management maturity model;

b) Investigation about maximum and minimum values obtained by different MCA techniques according to KM levels;

c) Investigating the KM level to the values obtained to the industries from different cities by different MCA approaches;

d) Declaration of levels using the principle of affinity of values to different KM levels.

Details of above mentioned stages are as follows:

a) First of all, different knowledge management maturity models available in the literature were analyzed. For different models, model known as ***General Knowledge Management Maturity Model (G-KMMM)*** proposed by Vanini and Bochert in the year of 2014, is being adopted. According to G-KMMM, there are *five* KM maturity levels, namely, ***initial, aware, defined, managed*** *and* ***optimizing*** (from lower to higher).

b) In the next stage, investigations about maximum and minimum values obtained by different MCA techniques according to KM levels were made. Range for SAW was obtained manually, whereas, ranges for other three methods were referred from literature. Following are the details of ranges:

Table 13
Ranges for Different MCA Techniques

S.No	Range				Level
	AHP	SAW	Topsis	Vikor	
1	0-0.2	0-0.1998	0-0.2	0.81-1.0	1 – initial
2	0.21-0.4	0.1999-0.3996	0.21-0.4	0.61-0.8	2 - aware
3	0.41-0.6	0.3997-0.5994	0.41-0.6	0.41-0.6	3 – defined
4	0.61-0.8	0.5995-0.7992	0.61-0.8	0.21-0.4	4 – managed
5	0.81-1.0	0.7993-0.999	0.81-1.0	0-0.2	– optimized

c) In next stage, KM levels were allocated to industries based in different cities according to their scores. Following are the details:

Table 14
Investigation on KM Levels to Industries

Industries (city-wise)	MCA Techniques							
	AHP		SAW		TOPSIS		VIKOR	
	Score	Level	Score	Level	Score	Level	Score	Level
Dewas	0.14	1	0.746	4	0.409	2	0.784	2
Pithampur	0.563	3	0.999	5	1	5	0	5
Mandsaur	0.089	1	0.648	4	0.203	1	0.977	1
Ratlam	0.132	1	0.733	4	0.385	2	0.868	1
Ujjain	0.074	1	0.627	4	0.107	1	0.985	1

Figure 4 shows the details of KM level allocation in graphical manner, below:

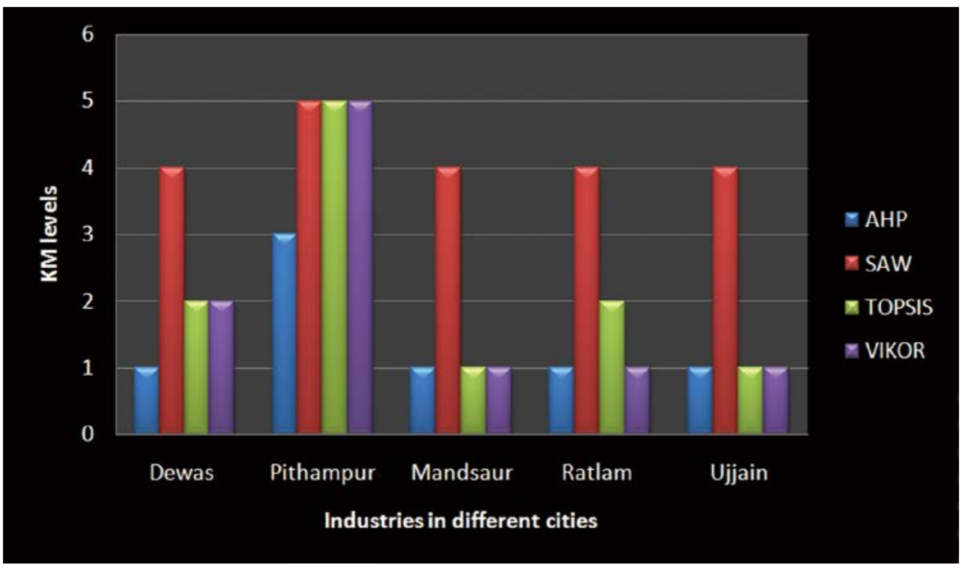


Figure 4
Graphical Representation of KM Levels' Investigation

Table 14 and Figure 4 indicate following key points:

- Different *multi criteria analysis* techniques yield different results;
- There is no multi criteria analysis technique, which shows obtainment of all the KM levels by industries form different cities;
- All the techniques vote Pithampur based industries for *KM level 5*. Score of Pithampur based industries is much more as compared to the scores of other industries;
- There is little difference between scores obtained by Ratlam based industries and Dewas based industries. In the similar manner, difference in scores obtained by Mandsaur based industries and Ujjain based industries is very little.

After analyzing Table 14 and Figure 4, one can find that combination of AHP-VIKOR and TOPSIS-VIKOR show *three* common KM levels. In the similar manner, combination AHP-SAW shows *none* of common KM levels showed by the industries. Rest combinations show single common KM levels, details of which are given below, in Table 15.

Table 15
Repeatability of KM levels Scored by Industries of Different Cities

S. No	Pair of MCA techniques	Number of common KM levels scored by industries of different cities
1	AHP- SAW	0
2	AHP-TOPSIS	2
3	AHP-VIKOR	3
4	SAW-TOPSIS	1
5	SAW-VIKOR	1
6	TOPSIS-VIKOR	3

Figure 5 shows the graphical representation of above facts, below:

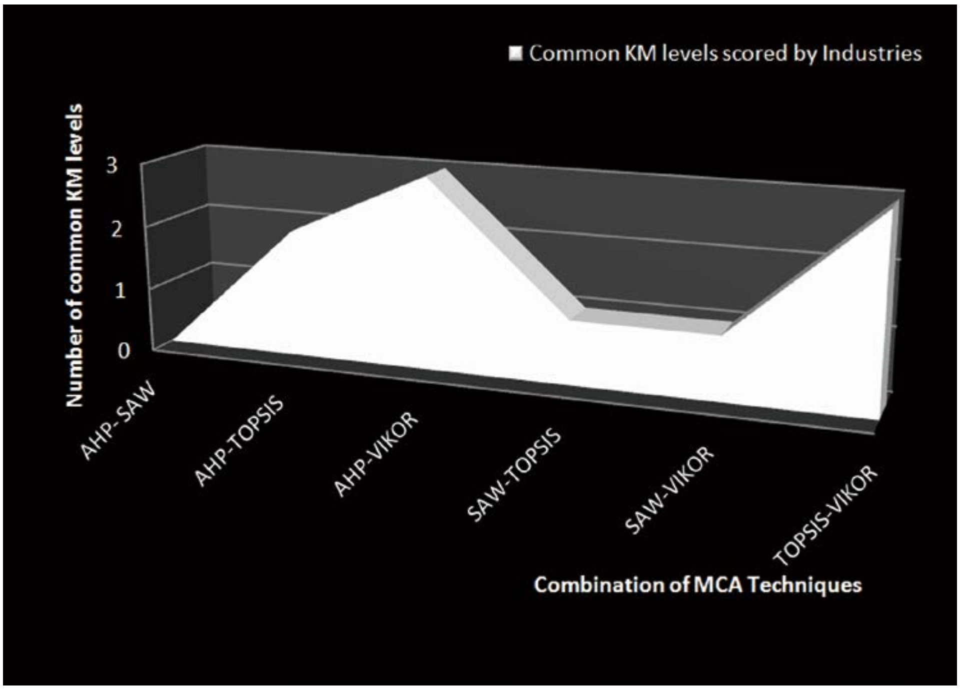


Figure 5
Repeatability of KM Levels Scored by Different Industries

Also, due to varying nature of MCA techniques, industries from different cities scored in such a manner that no two MCA techniques yield same results. It is being found that, for same levels more than one industry are eligible. Moreover, within a MCA technique, industries are fighting for KM level. Table 5 shows the details, below:

Table 16
Common KM Levels Earned by Industries

S.No	Industries (city wise)	KM level earned	MCA approaches
1	Dewas	2 - Aware	TOPSIS, VIKOR
2	Pithampur	5 – Optimizing	SAW, TOPSIS, VIKOR
3	Mandsaur	1 - Initial	AHP, VIKOR
4	Ratlam	1 - Initial	AHP-VIKOR
5	Ujjain	1 - Initial	AHP,TOPSIS, VIKOR

Based on above results, Pithampur based industries prove themselves most eligible for the KM level – 5, *optimizing level*. In similar manner Dewas based industries are proving themselves for KM level – aware level, and industries from Ratlam, Mandsaur and Ujjain find their places for KM level – 1, *initial level*. Diagrammatical representation of different KM levels scored by industries is shown in Figure 6.

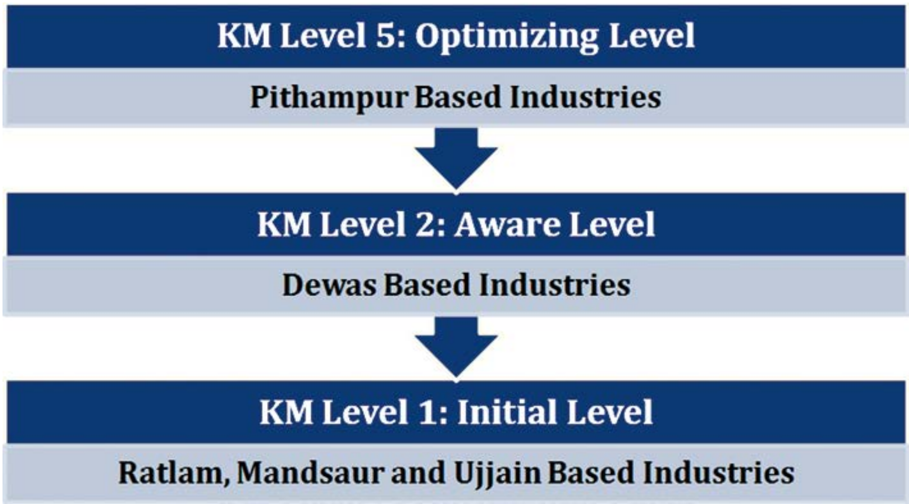


Figure 6
KM Levels Shown by Industries

Above results show the considerable differences in knowledge management levels of different industries belonging to different cities of Malwa reason. Table 17 presents a summary of comparison among industries situated in different cities.

Table 17
Comparison Among Industries Belonging to Different Cities

S.No	Industries (city wise)	Parameters					
		Expansion	Type of industry	Extent of industrialization	Salary structures, increments, and employee retention	Use of IT	Facility from government side
1	Pithampur	Broad (at national and international level)	All classes of industries	Rich industrialization	Proper. Employee turnover rate is low.	Extensive	Rich facilities provided from Government
2	Dewas	Mainly at local and national level	Some large scale industries, and vendor industries	Lesser as compared to Pithampur	Lesser salaries as compared to Pithampur. Turnover rate of employees is high as compared to Pithampur	Limited	Lesser facilities provided
3	Ratlam, Mandsaur and Ujjain	Local	Local product industries, and vendor industries	Very limited industrialization	Improper. Employee turnover rate is quite high.	Almost NIL	Almost NIL facilities provided

CONCLUSION

Details of overview of research work along with the conclusions drawn at each stage are as follows:

a) First of all, a detailed survey of available literature was conducted. The purpose of this survey was to identify the research problem. From the survey, it was concluded that in the manufacturing industries of Madhya Pradesh, very less emphasis is being given to knowledge management, and there are many companies which are still unaware about the importance of knowledge management principles, which ultimately guide for evaluation of knowledge management levels of manufacturing industries.

b) In next stage, for the purpose of evaluation of knowledge management levels, a list of *forty four* KM evaluation parameters was identified. With the help of expert opinion, the list was modified under three categories, namely, organization based factors, knowledge cycle elements and KM outputs which made the task of segregation of set of criteria into manageable headings. The purpose behind this modification was to get a compact set of criteria for easeful operations and understandable results. At this point it was concluded that there should be a compact set of identifiable categories of criteria for proper management of a large set of criteria responsible to solve a problem.

c) In spite of having a list of KM evaluation criteria under manageable categories, next stage was to find out the most favorable KM evaluation criteria. For this purpose, a systematically designed *criteria survey sheet* was designed and circulated to various manufacturing and service industries in the country and abroad. The results obtained were analyzed by using *principal component analysis* (PCA), which, after elimination of less favored criteria, assembled *thirty one* criteria into *nine* principal components. For validity of results, cronbatch's alpha value based on corrected *item to total correlation* was calculated for each principal component. At this point, it was concluded that for efficient questionnaire design, manageable set of criteria should be considered, considering only favored set of criteria.

d) Next stage of research was dedicated to hypothesis testing, prioritization of criteria and evaluation of alternatives. The purpose of hypothesis testing was to analyze the importance of knowledge management in manufacturing industries, and its recognition by industry personnel. At this stage, it was concluded that industries know about the importance of knowledge management.

e) In the next stage, with the help of systematically questionnaire design and expert opinions, scores of industries situated in different cities were evaluated, with the help of *multi criteria analysis* techniques. With the help of expert opinions, knowledge management levels of industries were identified with the help of scores. After that, with the help of principle of affinity, KM levels of different industries are being identified. Following are the conclusions drawn at this stage:

Table 18
KM Levels of Different Cities

S.No	Industries (city-wise)	KM level earned
1	Pithampur	5 – optimizing
2	Dewas	2 - aware
3	Mandsaur	1 – Initial
4	Ratlam	1 – Initial
5	Ujjain	1 – Initial

LIMITATIONS OF THE RESEARCH

Following are the limitations of the present research work:

a) The research work is limited to the evaluation of knowledge management levels only;
b) The research work is based on a particular set of Indian industries,;
c) The results obtained are limited by time. We cannot expect similar results with large time span for sample industries;
d) The research is also made limited with given set of KM evaluation criteria; and
e) The research work is limited by gave set of multi criteria analysis techniques.

FUTURE SCOPE OF THE RESEARCH

The present work has been carried out with an idea of evaluation of knowledge management levels for a particular set of industries. On the basis of reviewed literature and experience of the candidate, he indicates following as future scope of research:

a) A detailed research in this field using establishment of knowledge management systems and their progress monitoring is still awaited;
b) Extensive research on knowledge management levels for a broader set of Indian as well as foreign industries is still awaited;
c) Research on the basis of generalized set of KM evaluation criteria is also awaited;
d) A detailed research with inclusion a comprehensive set of *multi criteria analysis* techniques is still awaited; and
a) A more detailed research on evaluation of KM levels is still awaited.

REFERENCES

Afshari, A., Mojahed, M., & Yusuff, R. M. (2010). Simple additive weighting approach to personnel selection problem. *International Journal of Innovation, Management and Technology, 1*(5), 511-515.

Bamgboje- Ayodele, A., & Ellis, L. (2015). Knowledge Management and the Nigerian Culture–A round peg in a square hole? *The African Journal of Information Systems*, *7*(1), 1.

Bhatt, G. D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques and people. *Journal of Knowledge Managemen, 5*(1), 68-75.

Binney, D. (2001). The knowledge management spectrum - Understanding the KM landscape. *Journal of Knowledge Management, 5*(1), 33-42.

Buchholz, T., Rametsteiner, E., Volk, T. A., & Luzadis, V. A. (2009). Multi criteria analysis for bioenergy systems assessments. *Energy Policy*, *37*(2), 484-*495*.

Cao, M., Fan, J. J., Lü, H. P., & Chen, J. L. (2010, June). Evaluation of enterprise knowledge management performance based on gap analysis. In *Management of Innovation and Technology (ICMIT), 2010 IEEE International Conference on* (pp. 894-897). IEEE.

Chawla, D., & Joshi, H. (2010). Knowledge management initiatives in Indian public and private sector organizations. *Journal of Knowledge Management*, *14*(6), 811-827.

Davenport, T. H., De Long, D. W., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan Management Review*, *39*(2), 43-57.

Girard, J., & Girard, J. (2015). Defining knowledge management: Toward an applied compendium. *Online Journal of Applied Knowledge Management, 3(1), 1-20.*

Guilford, J. P. (1954). *Psychometric methods* (2nd ed.). McGraw Hills. NY.

Holder, R. D. (1991). Response to Holder's comments on the analytic hierarchy process: Response to the response. *Journal of the Operational Research Society,* 914-918.

Hsieh, P. J., Lin, B., & Lin, C. (2009). The construction and application of knowledge navigator model (KNM™): An evaluation of knowledge management maturity. *Expert Systems With Applications*, *36*(2), 4087-4100.

Hubert, C., & Lemons, D. (2010). *APQC's levels of knowledge management maturity*. Retrieved 2015, July 3 from http://www.apqc.org_

Hwang, C. L., & Yoon, K. (1981). *Multiple attribute decision making: Methods and applications, a state of the art survey*. Sprinnger-Verlag, New York, NY.

Ilin, A., & Raiko, T. (2010). Practical approaches to principal component analysis in the presence of missing values. *The Journal of Machine Learning Research*, *11*, 1957-2000.

Khatibian, N., Hasan gholoi pour, T., & Abedi Jafari, H. (2010). Measurement of knowledge management maturity level within organizations. *Business Strategy Series*, *11*(1), 54-70.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Levett, G. P., & Guenov, M. D. (2000). A methodology for knowledge management implementation. *Journal of Knowledge Management*, *4*(3), 258-270.

Linkov, I., Wenning, R. J., & Kiker, G. A. (2007). *Managing critical infrastructure risks* (pp.445-469). Springer: Springer Science & Business Media.

Lorenzo-Seva, U. (2013). *How to report the percentage of explained common variance in exploratory factor analysis.* Retrievceed from http://psico. fcep. urv. Es/utilitats/factor/documentation/Percentage_of_explained_common_variance. pdf

Meihami, B., & Meihami, H. (2014). Knowledge management a way to gain a competitive advantage in firms (evidence of manufacturing companies). *International Letters of Social and Humanistic Sciences*, (03), 80-91.

Minonne, C., & Turner, G. (2009). Evaluating knowledge management performance. *Electronic Journal of Knowledge Management, 7(5), 583-592.*

Mohanty, S., & Chand, M. (2005). 5iKM3 knowledge management maturity model. *Tata Consulting Services White Paper.* Retrieved from http://www.tcs.com/NAndI/default1.aspx

Niu, D., & Li, J. (2010). *Evaluation on the level of generation enterprise knowledge management based on AHP and gray relational analysis*. In IEEE International Conference.

Opricovic, S. (1998). Multicriteria optimization of civil engineering systems. *Faculty of Civil Engineering, Belgrade, 2*(1), 5-21.

Opricovic, S., & Tzeng, G. H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *European Journal of Operational Research, 156*(2), 445-455.

Opricovic, S., & Tzeng, G. H. (2007). Extended VIKOR method in comparison with outranking methods. *European Journal of Operational Research, 178*(2), 514-529.

Paliszkiewicz, J. (2007). Knowledge management: An integrative view and empirical examination. *Cybernetics and Systems: An International Journal*, *38*(8), 825-836.

Pee, L.G. and Kankanhalli, A. (2009). A model of organisational knowledge management maturity based on people, process, and technology. *Journal of information & knowledge management*, *8*(2), 79-99.

Pinkscan Assesment Report. (2012). Pink Elephant Inc., University of Alaska Office of Information Technology.

Poh, P., & Wee, Y. G. (2004). Improving Supply Chain Performance Through Strategic Knowledge Management. *Business Briefing Global Purchasing and Supply Chain Strategies*, 1-4.

Recchia, L., Boncinelli, P., Cini, E., Vieri, M., Pegna, F. G., & Sarri, D. (2011). *Multicriteria analysis and LCA techniques: With applications to agro-engineering problems*. Springer Science & Business Media.

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. *Journal of mathematical psychology, 15*(3), 234-281.

Saaty, T.L. (1980). *The analytic hierarchy process*. McGraw Hill, New York.

Siemens (2004). *Knowledge management maturity model (KMMM)*. Retrieved 2014, November 23 from http://www.w4.siemens.de/ct/en/technologies/ic/beispiele/kmmm.html

Singh, M. D., & Kant, R. (2008). Knowledge management barriers: An interpretive structural modeling approach. *International Journal of Management Science and Engineering Management*, *3*(2), 141-150.

Storey, J., & Barnett, E. (2000). Knowledge management initiatives: Learning from future. *Journal of Knowledge Management*, *4*(2), 145-156.

Tissayakorn, K., Akagi, F., & Song, Y. (2013). A Model of organization knowledge management maturity. *International Journal of Bioscience, Biochemistry and Bioinformatics*, *3*(6), 614.

Tiwana, A. (2002). *The Knowledge management toolkit: Orchestrating IT, Strategy and knowledge platforms*. Pearson Education India.

Tong, Y. (2009, December). *Summary research of risk identification in the process of knowledge management* (pp.210-213). In Future Information Technology and Management Engineering, 2009. FITME'09. Second International Conference on. IEEE.

Tong, Z. H., Chen, P., & Yao, W. (2011, September). *Research on the evaluation of enterprise knowledge integration capability based on Fussy-GRNN* (pp.347-351). In Industrial Engineering and Engineering Management (IE&EM), 2011 IEEE 18th International Conference on. IEEE.

Vanini, U., & Bochert, S. (2014). An empirical investigation of maturity levels in knowledge management. *Electronic Journal of Knowledge Management*, *12*(4), 221- 231.

Wang, X., Cao, X., & Zhang, X. H. (2011, September). *Knowledge management performance evaluation based on triangular fuzzy number and the theory of knowledge cycle* (pp.323-328). In Industrial Engineering and Engineering Management (IE&EM), 2011 IEEE 18th International Conference on. IEEE.

Wenzhi, P. (2010, August). *Research on the evaluation of knowledge management performance of enterprise* (Vol.2, pp.68-71). In Information Science and Management Engineering (ISME), 2010 International Conference of. IEEE.

Wu, Y. L., Wang, X., & Wu, H. S. (2009, May). *Research on the performance measurement of knowledge management based on principal component analysis* (pp.1-4). In Intelligent Systems and Applications, 2009. ISA 2009. International Workshop on. IEEE.

Zhu, X. Y., & Wu, Y. L. (2010, May). *Research on the evaluation method for enterprise knowledge management performance based on triangular fuzzy number* (pp.1911-1914). In E-Business and E-Government (ICEE), 2010 International Conference on. IEEE.

