

Prediction of Human Capital Performance Capability with a Data Mining Approach

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Abstract: The human capital as the most important factor in achieving competitive advantage is of a great importance for the organization, however, how this vital organizational factor should be attracted and preserved has been among the greatest challenges of the managers. Therefore, the current study has aimed at improving the hiring procedures by the use of data mining technique in the form of case study strategy. Through this approach, with the introduction of the variables effective on the immediate performance of people, capable forces appropriate to the organization could be employed, and the rate of displacement could be reduced. In this regard, 208 employees working in the Organization of Roads and Urban Development of Southern Khorasan Province were studied in terms of variables such as gender, education, marital status, working experience, age, and conformation of the major and the current performance. The current study, aimed at designing a data mining model based on the decision tree, and creation of an appropriate pattern for applied use of data mining technique to fill this gap, and provide a model for human capital data mining, so that the extraction of relationship between the staff's profile and their performance evaluation becomes viable. The results of the current study indicated that the conformation of the major and the job, the education, and the type of employment were among the important components in the examination of the people's performance.

Keywords: Performance capability, Human resources, Data mining, Prediction

Introduction

One of the most basic capitals in any organizations is the human resource. This resource is of a great importance in some organizations such as the Ministry of Education. In spite of the special importance that the human resource has in the organizations, it is seen sometimes that the employees are not inclined to stay in the organization and due to different reasons, they want to leave it. Clearly, it won't have positive results for the organization and losing the human resource, especially for the organizations, might be totally irrecoverable, or not recoverable in the short term. Therefore, the employees' intention to leave is one of the problems the organizations are faced with that they should take measures to prevent it.

Once, the organizational managers and brokers were expected to protect their organizations. Their responsibility was to identify the failures in fulfilling the legal commitments or the deviations from the organizational policies, and then punish the transgressors. The direct result of this orientation was that some organizational management administrators became cautious and some other have remained in the present form. The new role of organizational management required a vision greatly different from the former one (Behrad, 2015).

The organizational specialists have stated that inefficiency of the employees is one of the greatest organizational risks. Therefore, the exploration and research on the human elements in different aspects of the organizational performance is so important, and the data mining method can be very effective in this regard (Gupta, 2015). A method in which the combination of science and the complex analytical expertise, and the special knowledge in a specific field, is used for the identification of the latent patterns and processes. Different algorithms of data mining can explain these patterns and relations. Therefore, one of the important concerns of the organizational management, from the past up to now, is a process that can provide the optimal organizational performance of the employees. Thus, the necessity of studies on the factors that lead to the transformation of the organizational human capitals capabilities into the executive capabilities of these capitals is so important that has been one of the major concerns of the managers and organizations, and the current study has sought to deal with it.

Theoretical Framework

The Human Resources Performance

Recently, the discussion of the employees` performance evaluation has been replaced with the organization`s performance management. In other words, the performance is a behavior to achieve the organizational goals that have been measured or valued. The employee performance is the result of his activities in terms of fulfillment of the tasks assigned to him after a specified period. In terms of individual performance management, there have been different effective factors and components mentioned, among which the followings can be named: individual characteristics (personality traits), individual differences, individual needs, physical conditions governing the work, group effects and relationships with colleagues, position or environment, organizational structure, the way the individual adapts himself with the job, managers and their leadership style, ability, learning, perception, motivation, stress or psychological pressure, and ... (Khaefollahi et al., 2011).

Many believe that the performance is the organization`s profitability. The truth is that the firm`s performance is evaluated and measured depending on the type of the organization, the management thoughts, the existential philosophy and mission of the organization, the environmental conditions, and numerous other cases (Diwandari, 2008).

The performance is the actual and measurable result of efforts. In other words, the business performance and the output action of the organizational operation includes the achievement of the internal and external goals of the organization (Lin, 2008). Other scholars also, in order to measure the business performance, have used seven indicators in two groups as the marketing performance and financial performance (Diwandari, 2008).

The organizational effectiveness is the degree or level to which the organization is able to meet its objectives. Dwainy believed that the organizational performance is a part of the organizational effectiveness concept whose basis is the organization`s external objectives, i.e. the objectives of the beneficiary groups (Khodadad Hosseini et al., 2006). The organizational performance is the external aspect of the organizational effectiveness while the organizational effectiveness, in addition to the external factors, also includes the internal factors (Fattahi, 2007).

One of the requirements of any performance evaluation systems is the presence of a clear relationship between the performance indicators at the different hierarchical levels of the organization, in a way that each unit tries to achieve a common objective (Karimi, 2006).

The Factors Effective on the Performance

The factors effective on the performance at the organizational level are: the organizational structure, the organizational environment, the policies, and the organizational procedures and culture (Robbins, 2010). The factors effective on group performance are: the communications, leadership, power, policy, the group behavior, and the controversial behavior.

(Pal & Kent, 1992) have chosen seven variables in relation to the effective performance management, from among the other variables that are: motivation, ability, perception, organizational support, environmental adaptation, feedback, and credit.

Review of the Related Literature

(Mohammadian, 2016), conducted a study titled “identification and prediction of the employees` performance based on efficiency and innovation indices”, and stated that the employees performance is affected by different variables. The employees efficiency and innovation variable can be a useful parameter for the prediction of the employees performance, and meanwhile, the structural variables can be very effective, too.

(Taher, 2015), has dealt with the evaluation of the factors effective on the human resource productivity. He stated that all the elements of the productivity cycle such as the productivity measurement, the productivity improvement planning, etc. must be chosen based on the company’s conditions, objectives, and tasks, and the feasibility of implementation in the company. It should be noted that one of the factors which is highly effective on the productivity is the training, which is a kind of long-term investment and not a current cost. There is also a direct relationship between the human resource training and the productivity.

(Siadati et al., 2014) in their study titled “the use of data mining in human resources management of the ICT organizations” investigated the selection of the best strategy in human resources management by the use of data mining algorithms, in one of the biggest Information and Communication Technology organizations in the country.

(Alirezai et al., 2013) in a study titled “the relationship between the work ethics and the job performance” concluded that the work ethics` aspects (the reliability and success-orientation) have a positive and significant relationship with the job performance. The regression results also indicated that the work ethics` aspects could explain 32% of the job performance.

(Khaefollahi et al., 2011) dealt with the investigation of the effects of utilization of an employment model based on the data mining on the staff’s displacement. This study was conducted by the use of data mining method and the results showed that the appropriate indicators could lead to the decrease in displacements within the organization.

(Kirimi & Christopher, 2016) in a study titled “the use of data mining technique for prediction of the employee performance” stated that the employees performance is to a large extent affected by the experience, academic degree, professional training, gender, marital status, and the performance evaluation scores.

(Thakur et al., 2015) in a study titled “the use of data mining for the prediction of the software engineers` performance” showed that different factors and criteria should be considered for the measurement and selection of the experts. Consideration of the graduation average score is not a reliable criterion for selection, and paying attention to the programming skills, analytical knowledge, and expertise in the related field, are of a great importance.

(Sangita & Suma, 2014) dealt with the investigation of the importance of different variables considered for the students` selection, and noted that variables such as the academic scores, programming skills, the dominant knowledge assessment, deduction skills, the mental ability and math skills, and different decision trees such as ID3, CART, and C4.5 have been used. As the studies progressed, numerous other attributes were required to be evaluated besides the academic scores, in order to approve the employee quality.

(Suma et al., 2012) in a study titled “an approach for the prediction of the software projects` success by the data mining clustering” investigated different algorithms of machine learning and used them for predictions in the field of software.

Methodology

The current study was of applied type in terms of the objective and of data-centric and was of consistency correlation type in terms of the nature. Regarding the research nature that was the use of data mining techniques for the investigation of the relationship between employment and performance variables, the current study was data-centric and applied. The statistical population was related to the performance data of the employees working in the Organization of Roads and Urban Development of Southern Khorasan Province. The data were collected from the human resource department information system of the organization and the results of the periodical performance evaluation of the employee, the employment indicators, the results of the employment testing, and selection parameters as well as the other data that existed about the organization’s human resource, through the Personnel and Human Resources Units and Organizational Documents. The total number of the employees in the organization was 283 persons. Regarding the type of the intended data and presence of the related information, 208 valid samples were chosen from among 283 employees, for data analysis. The library-based and document reading methods were used for data collection. The supervisors and advisers, as well as a few aware persons such as the professors and Ph. D students approved the validity of the content of this questionnaire, and it had the sufficient validity. Since in most of the conducted studies in the field of human resource management, the decision tree technique has been used in the data mining method, in the current study also, the decision tree would be used for the analysis. The algorithms used in this technique included CART, C5.0, CHAID, and QUEST which have been investigated by the SPSS and Office (Excel).

Research Questions

- 1- What are the factors used for the prediction of the organization’s human resource capabilities in the employment process?
- 2- What is the dissociative effect of the identified indicators on the employee performance?
- 3- What is the weight of each of the identified indicators on the employee performance?
- 4- What are the most important indicators effective on the employee performance?
- 5- How is the priority of these factors` effectiveness on the success of the human capitals in the enjoyment of the optimal organizational performance?
- 6- To what extent do the identified indicators anticipate the human capitals` performance?

Research Hypotheses

Regarding the type of the current study, it had no hypotheses.

Findings

The objective variable in the current study was the performance.

Performance evaluation: This variable, based on a specified regulation in the Roads and Urban Development organization, was implemented for each employee, at least twice a year, by his direct manager, and the score was provided per a milestone of 100. For the ease of data mining conducting, the dependent variable of all the provided numbers was modified to the qualitative index, classified in 7 classes provided in the following (Table 1).

Table 1. The options and classification of performance evaluation

Criterion	Score
Great	100
Very good	99-100
Good	98-99
Average	96-98
Weak	93-96
Very weak	90-93
No efficiency	<90

Other variables in the current study have been expressed as follows:

Promotion Score: Regarding the employee ability in their job promotion during their working period, this variable was the difference of current job scores from the first job position of the employee at the time of employment. Clearly, in case the position of the employee was not changed during his working period, it would be zero. Also, the highest score among the employee belonged to this variable, which was equal to 1200 (Table 2).

Table 2. The options and classification of the promotion score

Criterion	Label	Promotion score
Great promotion	A	1200-800
Good promotion	B	800-400
Has had promotion	C	400-100
Without promotion	D	100-0

The other variables of the study have been codified as follows (Table 3):

Table 3. The options and classification of the research variables

Variable	Criterion
Gender	Male :1 'female :2
Marital status	married :1 'single 2
Age	Under 25:1, between 25 and 30:2, between 30 and 35:3, between 35 and 40:4, above 40:5
Educational degree	Associate degree and lower:1, bachelor degree:2, master's degree:3, Ph.D and higher:4
Conformation of the major and the job	Conforms: 1; does not conform:2
Working experience	Less than 5 years:1, between 5 and 10 years: 2, between 10 and 15 years:3, between 15 and 20 years:4, more than 20 years:5
Employment type	Formal:1, contractual:2, official: 3
Previous training (annual average)	10 hours:1, between 10 and 20 hours:2, between 20 and 30 hours:3, between 30 and 40 hours:4

Formation of the Tree

Step 1: Regarding the identification of the variables and presence of the objective variable of the performance evaluation, and on the other hand, presence of the different algorithms for the formation of the decision tree, firstly the evaluation of all possible models that could be formed by the existing database, was dealt with. Regarding the fact that there were 10 independent variables, one objective variable, and 6 types of algorithms for the decision tree, the possibility of tree formation was identified as follows (6144):

$$(2^x - 1) * y * A$$

Step 2: Based on the results obtained from the created tree, and investigation of the most important effective variables among all the trees (6136 trees), 14 trees were also created by the most important variables obtained from the existing trees. The conclusion of the errors obtained in each algorithm with regards to the existing 6136 trees, has been provided in the following (Table 4):

Table 4. The precision rate of each algorithm based on the results of each pattern

Algorithm's name	The average precision of the algorithm in tree generation	The average precision of total algorithms in tree generation
QUEST	%64.85	68.38%
CHAID	61.33%	
C5.0	82.67%	
CART	64.29%	
CART (Towing)	67.38%	
CART (Ordered)	66.98%	

The Initial Selection of the Trees Fit for the Rule Extraction:

For the selection of the trees among the other trees, some criteria have been determined based on the experts' opinions, as follows:

- 1- Selection of trees with a precision of more than 705.
- 2- Selection of the trees with a minimum level number higher than one (it means that definitely a rule has been created).
- 3- Selection of the trees with at least one of the independent variable groups.

Regarding the application of the mentioned conditions, finally 17 initial trees were chosen for the testing state, among which there were 3 trees with objective variable of "performance evaluation", in which the C5.0 algorithm has been used.

Testing of the Generated Trees

In order to test the 17 chosen models for rule extraction, the experimental data were used. Since based on the following table, the precision of the three generated trees with the objective variable of “performance evaluation” was greatly reduced, these trees were omitted before the rule extraction stage (Table 5).

Table 5. The precision rate of the trees generated with the objective variable

Tree's code	The precision rate with the primary data	Precision rate with the experimental data	The precision difference between the main and experimental modes
C5-A-3	65.62%	15.38%	40.24%
C5-A-7	82.33%	11.21%	71.11%
C5-A-10	96.11%	35.07%	61.04%

Finally, the number of the ultimate models for rule extraction reached 14, which regarding the homogeneity of the model and rules generated by the two CART (Ordered) and CART (Towing) algorithms, merely one of them has been considered. The results have been provided in the following (Table 6):

Table 6. The precision rate of each algorithm based on the results obtained from the 14 select trees

Tree's code	The precision rate with the primary data	Precision rate with the experimental data	The precision difference between the main and experimental modes
QUEST	69.43%	71.54%	-2.11%
CHAID	73.81%	76.93%	3.12%
C5.0	79.03%	75.63%	3.40%
CART	81.47%	82.78%	1.31%
CART (Ordered and Towing)	77.38%	69.36%	8.02%
Total average	75.25%	76.22%	0.98%

The conclusion of the provided analyses indicated that from among total select trees, the CART algorithm has had the highest precision.

Evaluation of the models obtained from the modelling phase, before being used to evaluate the quality and effectiveness (Kirimi & Christopher, 2016), were calculated for the definition of evaluation indices as f-measure, recall, precision, and accuracy. The cluster validation method has been used to increase the validity of the model of the study. In this method, all the data sets were used for both training and testing. Also, the primary data were randomly divided into k subsets with approximately similar sizes. In the i-th iteration, the Di section was used as the test set and the remaining sections were used for training, and the model was created based on them. Each of these sections have been equally used once for the training and testing (Lin & Tsang, 2008).

Normally, the k value was taken as 10. In the current study also, the k value has been considered to be 10. In this study, the modelling has been done by the use of cluster validation method. The best results of the evaluation parameters for modelling the decision tree for CART algorithm, which was known as the best algorithm, have been provided as follows (Table 7):

Table 7. The results of validation of the decision tree modelling on the CART data set

Accuracy	Precision	Recall	F-measure
93.67%	92.18%	88.35%	82.33%

The Rule Extraction

By rule extraction, evaluation of every single generated tree and definition of each rule by the mathematical and logical language understandable and inferable for the experts was meant. On the other hand, every determined rule would have a probability of occurrence that was obtained based on the number of records consistent with the defined rule, out of the total records of that branch.

$$P = n_c / N$$

In which: P is the probability of the occurrence of the rule out of the other records in the data set, N is the total number of the evaluated records, and n_c is the number of the records consistent with the rule.

Clearly, the deeper a branch, the lower it would be placed in the tree, and the lower the value of n will be. However, it does not necessarily mean the reduction in P value. As a result, the extraction rules can be trusted.

Finally, from among the 89 extracted rules, and with regards to the iteration of the rules in some trees, 68 trees were obtained from the data mining process. Also, the variables that based on the extracted rules had a correlation with the objective variable (performance evaluation), were: the promotion rate, the education level, the conformation of the major and the job, previous trainings, past performance evaluation, gender, working experience, and the marital status.

Selection of the Rules:

Since the analysis and evaluation of all these rules could be difficult and troublesome, the ultimate rules were determined based on the experts' opinions and the two following principles:

- The rules in which $n > 100$ and $P > 60\%$ at the same time.
- The rules in which $n > 50$ and $P > 70\%$ at the same time.

With the application of the above rules, and comments of the human resource experts about the rules selected by the above method, finally 11 rules out of the 68 remaining rules were chosen, a sample of which was as follows (Table 8):

Table 8. The final selected rules

The elaboration of the extracted rule	Probability (p)	Number of branch (n)	Rule's code
The employees whose working experience is equal or more than 2, their employment type is 2, their degree is 3, and their training is equal or more than 3, and their promotion score after 3 years is D, are classified under the 'very good' class	68%	102	R07
The employees whose gender is 2, their employment type is 1, their degree is 2, and their training is equal or more than 2, and their promotion score after 3 years is D, are classified under the 'very good' class	72%	98	R15
The employees whose major conforms to their job, their employment type is 1, and their promotion score after 3 years is D, are classified under the 'very good' class	77%	77	R23
The employees whose major conforms to their job, their employment type is 1, their degree is 3, and their training is equal or more than 3, and their promotion score after 3 years is D, are classified under the 'very good' class	66%	106	R30

The elaboration of the extracted rule	Probability (p)	Number of branch (n)	Rule's code
The employees whose major does not conform to their job, their employment type is 3, their degree is 1, and their training is equal or more than 1, and their promotion score after 3 years is A, are classified under the 'average' class	61%	79	R32
The employees whose major conforms to their job, their employment type is 1, their degree is 2, are married and female, are classified under 'good' class	53%	65	R40
The male employees whose training hours is equal to 2, and their employment type is 1, and their promotion score after 3 years is D, are classified under the 'very good' class	71%	121	R47
The single employees whose major does not conform to their job, their employment type is 3, their training is equal or more than 2, and their promotion score after 3 years is B, are classified under the 'weak' class	55%	69	R50
The employees whose major conforms to their job, their employment type is 2, their degree is 3, and their training is equal or more than 2, and their promotion score after 3 years is D, are classified under the 'very good' class	73%	83	R55
The employees whose major does not conform to their job, their employment type is 3, their degree is 1, and are female, are classified under the 'average' class	81%	69	R60
The employees whose major conforms to their job, their employment type is 1, their degree is 2, and their training is equal or more than 3, are classified under the 'good' class	77%	115	R65

The performance and organizational data were collected from the Organization of Roads and Urban Development of Southern Khorasan Province. Form among the total number of the employees, only for 208 persons, there were the required comprehensive information in the organization, and these employees were identified and analyzed. Finally, four performance clusters were identified and the output basis was based on the performance analysis including the evaluation in the scales of very good, good, average, and weak. The identified rules based on the data analysis were indicative of the effectiveness of the variables such as the conformation of the major and the job in the very good scale, the academic degree in the good scale, the non-conformation of the job and the past promotions scores in the average scale, and finally, the employment type as the most important predictive factors. In the (Tables 1-8), the rules on the performance evaluation have been shown as well as the probability of the occurrence of each, and the extent of the sample size included in each class.

Finally, after evaluation of the rules and elaborating them, it can be deduced that the type of employment, conformity of the major and the job, and the promotion score, were among the most important predictive indices for the performance of the employees in the Organization of Roads and Urban Development of Southern Khorasan Province.

Discussion and Conclusion

In the modern view of the human resource management, the man is considered as the most important element and not as a resource. Not only should he be administered in the organization, but also his cultural, social, economic, and political environment should be taken into consideration, so that his power can be put in favor of the organization's goals properly. The success of each organization depends on the allocation and proper utilization of the tools, equipment, money, raw materials, and human resources of that organization in its planning, and it would be viable if they can use the personal and collective skills, abilities, and attributes of the employees in favor of the organizational goals. One of the most important tools for human resource management to this purpose is the performance evaluation.

The literature related to the human resource include different methods and tools in this regard. What is important meanwhile is the correct identification of the evaluation indices, which are greatly varied for the human resource.

The current study, through focusing on the data existing in the in the Organization of Roads and Urban Development of Southern Khorasan Province, evaluated a group of the variables effective on the performance of the employees in the framework of demographic, occupational, and performance variables. Meanwhile, the conformation of the major and education of the employee, the type of employment, the training he has received, the working experience, the promotion conditions, and the education level were among the factors that, by the use of data mining, provide the possibility of performance prediction capability for the organization in the future. In this regards, and through the analysis of the related literature, it can be said that the previous studies also have emphasized on the importance of the education, working experience, and training. Studies such as those of (Armestranh et al, 1991; Khodadad Hosseini et al., 2006; Fattahi, 2007; Karimi, 2006; Sangita & Suma, 2014; Kirimi & Christopher, 2016) have also emphasized on such variables for employees` performance prediction. However, few studies have emphasized on the type of employment, conformation of the major and education, and promotion score of the employees, and the current study took a new step in studies on the performance prediction in our country. As is clear, the effects of the type of the working contracts was among the important factors that through affecting the job security, has greatly affected the employees` action capability in our country, and therefore, studies in this regard can be a proper operational facilitator for the performance in the country`s organizations and systems.

Conflict of interest

The authors declare no conflict of interest

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