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Logistic Regression for Employability Prediction

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Abstract: ***Prediction is a conjecture about something which may happen. Prediction need not be based upon the previous knowledge or experience on the unknown event of interest in the future. But it is a necessity for mankind to foresee and make the right decisions to live better. Every person does predictions but the quality of the predictions differs and that differentiates successful persons and unsuccessful persons. In order to automate the prediction process and to make quality predictions available to every person, machines are trained to make predictions and such field comes under machine learning and later on deep learning algorithms. Various fields such as health care, weather forecasting, natural calamities, and crime prediction are some of the applications of prediction. The researchers have applied the field of prediction to see whether a model can predict the employability of a candidate in a recruitment process. Organizations use human expertise to identify a skilled candidate for employment based on various factors and now these organizations are trying to migrate to automated systems by harnessing the benefits of the exponential growth in the area of machine learning and deep learning. This investigation presents the development of a model to predict the employability by using Logistic Regression. A set of candidates was tested in the proposed model and results are discussed in this paper.***

Keywords: Machine Learning Algorithm, Support Vector Machine, Decision Trees, Clustering, K-Means Classification, Logistic Regression Model, Artificial Intelligence.

I. INTRODUCTION

Dr. A. P.J. Abdul Kalam, former Indian president has opined that there doesn't exists any problem of unemployment but only un-employability.

Nowadays highly professional candidates are required for extremely technical and sophisticated jobs to increase productivity and such types of candidates are necessary to enhance productivity which will subsequently result in enhancement of the value of an organization [1].

Various modes of the recruitment process have been adopted by the organizations so an organization can ensure better talent among its personnel [2]. The best choice for the organization is to select a candidate with sound knowledge in technology, proficiency in communication skill and personality with pleasant appearance [3].

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The problem of choosing a skilled candidate for employment in an organization is a big issue of the Human Resource Information System (HRIS). The employability skill focuses on attributes like Aptitude skills(β1), Communication skills(β2), Technical skills(β3) and Personality skills(β4)[4]. These skills assist the candidates to achieve the goal.

After analyzing these factors, the HRIS has to take a decision on whether to choose that candidate or not, based on his/her score in skill factors. However, this process can be automated with the help of a machine learning algorithm. This investigation explores the application of the Logistic Regression machine learning technique to predict the employability opportunity in an organization.

A Supervised Learning in Machine Learning, in which the computer program learns from the input given to it, and then uses this learning to classify new observation. Human expertise can be automated with the help of classification algorithms in machine learning [5].

The idea behind machine learning is if the machine could learn from its experiences, its value gets increased. This leads to automatic predictions of value based on the experiences handled by the machines. It leads to an accurate prediction of data [6].

The objective of this investigation is to automate the recruitment process which adopts the logistic Regression method to forecast the probability of employability because the result is assessed with a dichotomous variable. Hence it is useful to develop an analytical model to assess the employability of candidates.

II. RELATED WORK

A. Machine Learning

Machine Learning is used to make exact decisions based on observations and predictions. Machine Learning examines the areas of algorithms that can make high-end predictions on data [7]. The learning process in Machine Learning is classified into Training and Testing. If the model is to be built, the training data has to be utilized and this model will also be validated using testing data.

Four distinguished Machine Learning Techniques based on the essence of learning and the various algorithms in Machine Learning is given in Table I.

Table I. Machine Learning Algorithms

S.No.	Machine Learning Techniques	Machine Learning Algorithms
1	Supervised Learning	Linear Regression
		Logistic Regression
		Stepwise Regression
		Support Vector Machine
		Naive Bayesian
		Decision Tree
2	Unsupervised Learning	Clustering
		K-Means Clustering
3	Semi-Supervised Learning	Generative Model
		Graph-Based Methods
4	Reinforcement Learning	Q learning
		State -Action –Reward- State-Action (SARSA)

B. Supervised Learning

Supervised Learning is executed in assistance with a teacher. Let us analyze how a small child learns. Certainly, there is a learning process.

The Child doesn't possess the ability to read and write initially. It is taught at home by the parents and by the teachers in educational institutions. There are teachers who supervise the activities of a child very consciously.

The child tries steadfastly with respect to the output that is expected of the child to yield [8].

Correspondingly, Supervised Learning is to train a particular set and get the corresponding answer to it. It is used to predict the values for the target function and the desired output is known. The purpose of this method is to find by analyzing the original output along with the "learned" output in order to find out the flaws and to carry out the modifications subsequently with the help of the learning algorithm. Fig. 1 depicts the blueprint of Supervised Learning.

a. Linear Regression

Linear Regression is the prime method of machine learning. Linear Regression accomplishes the model to find the dependency among two variables by furnishing the linear regression for the data which are recognized.

The first variable denoted as 'X' is a supplementary variable and another variable denoted as 'Y' is the dependent variable. Here the dependent variables are to be explained or focused. Linear Regression can be applied in two ways: to find out whether there is any relationship between two variables and to find out whether they have a statistically significant relationship.

Y=a + bX is the equation form of a Linear Regression Line. Here X is supplementary variable and Y symbolizes the dependent variable, 'b' denotes the ramp of the line and 'a' signifies the intercept. Linear Regression applications are used effectively in analyzing market strategy, stock market pricing, promotion of sales of a product, forecasting the business strengths and weather data.

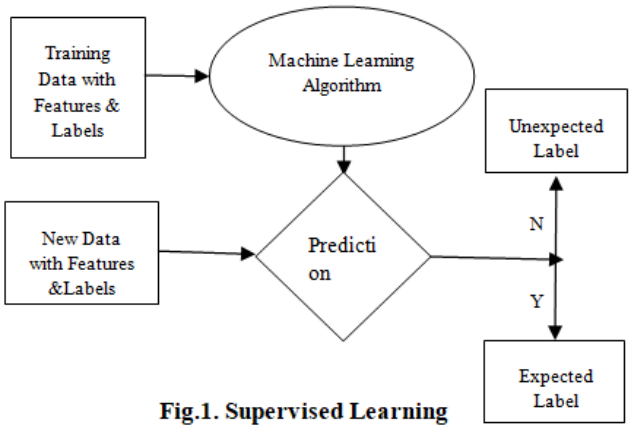

Fig.1. Supervised Learning

b. Logistic Regression

Logistic Regression statistical method is used for analyzing the dataset and produces a binary outcome. One or more autonomous variables may have consisted of the dataset. The result is determined by these variables that are dichotomous in nature. Which means only two results are possible [9]. It is a specific category of regression and it is used in the best way to predict the binary and categorical output.

Logistical Regression method is used to regulate the impact of numerous autonomous variables which are conferred at the same time. This method also predicts any one of the two independent categories of variables. Logistic regression designs the best-fitting function with the help of the maximum likelihood method in order to maximize the probability of classifying the recognized data into the proper division [10].

Various appliances of logistic regression are forecast market trends, to find the success and failure rates in results, the true or false category in recruiting employees based on their performance in need of employment in a company, image categorization, health care and analyze a group of people affected by Myocardial Infarction [11].

c. Stepwise Regression

In this regression model, there is an opportunity to select the predictive variables. This selection process is accomplished by a self-regulating strategy. Variable is constructed in an individual manner. It is carried out by adding a set of explanatory variables or to subtract from it especially in some pre-specified criteria. It is a way to build a model by including or subtracting predictor variables by applying a series of F-Tests and T-Tests. The selection of the variable to be summated or discarded is normally depended upon the test statistics of the predicted coefficient [12].

The stepwise regression is used to deal with multiple independent variables which are the most essential variables to be considered.

The goal of stepwise regression is to come out with a model that is able to predict the variables which were considered to be the fewest variables.

The disadvantage of the stepwise regression is that there is a chance of selecting unimportant variables for prediction.

d. Support Vector Machine (SVM)

This algorithm helps in solving problems that are linear and non-linear binary classification in nature. It constructs a hyper-plane, especially in hyper-dimensional space. The primary aim of this construction is to achieve class separation. If the distance to the closest training data point of any class in the hyperplane is longer then a good separation process will be carried out. That is, if the margin value is larger then, the rationalization fault of the classifier is reduced.

In SVM the range of the data is between [0, 1] [13]. The main benefit of SVM is good in large dimensional spaces and efficient in handling memory.

The disadvantage of SVM is less perfection when features are more than samples, probability estimates could not be reached.

SVM can be applied in Medical emerging, Medical classification doubts, Time series predictions, financial analysis, Pattern Recognition for medical diagnosis, Page Ranking in Google and Object Recognition.

e. Naive Bayesian

Because of simplicity and good performance Naive Bayes becomes a popular technique in classification. [14]. Naive Bayes technique performs the classification with the belief that all the variables are autonomous to each other and depends upon the probabilities arrived. The classifier can measure the Mean and Variances of the variables with the minimum amount of training data. These variables may be real and discrete data which are inevitable for doing classification [15].

The important logic that motivates one to use Bayes' rule in machine learning is given below.

$X \rightarrow Y$ is a target function to be trained, which is similar to the probability of Y with respect to X. The assessment of probability over X with respect to Y and the probability of Y are utilized by the training data in order to learn. New samples X can be classified by these probability distributions and Bayes' rule [16].

f. Decision Trees

Decision Trees are used to predict the possible target values from the observed data. The branches in a tree represent the observed data and the leaves represent the targeted values. This method can be deployed in statistics, data mining and machine learning [17].

Decision Trees are applied to the situations to find out the possible solutions to a problem based on certain constraints. Decision Tree algorithms results are quick and precise. Nodes and the leaves represent the entities. The output is represented in leaves and the data observation is represented in nodes.

Decision Tree (DT) classifications are simple to read and realize [18].

The commonly used algorithms in DT are

- Classification And Regression Tree - CART
- Chi-Squared Automatic Detection
- Reduction in Variance
- Conditional Decision Tree
- C4.5 and C5.0
- Decision Stump and M5

Decision Trees are used in calculating, taking population census, predicting the percentage of gender and price prediction of housing loans. Decision Trees are utilized effectively when they are used with advanced machine learning algorithms like Random Forest and Gradient Boosting.

C. Unsupervised learning

In unsupervised learning, learning is achieved beyond the support of a tutor. A tadpole imbibes itself to swim without any training. Thus, learning is self-reliant and is not supervised by a parent. In unsupervised learning, there is a deficiency of training data. Along with unlabeled data, the learning algorithm is utilized to find out the resemblance among the objects from the input data. The system creates clusters at the time of the training process when it receives the key in pattern and organizes the same.

When a new pattern is applied, the system provides an output response revealing the class to which the new pattern is matched. Otherwise, one more fresh class is created if that pattern is not matched with the input pattern.

In this method, the system must identify the pattern, features from the key in data and the association for the new data with the output. The system will go through the parameter modification while discovering all these features. This is known as self-organizing work in which perfect clusters are composed by identifying the resemblance among the entities. The block diagram of unsupervised learning is depicted in Fig. 2.

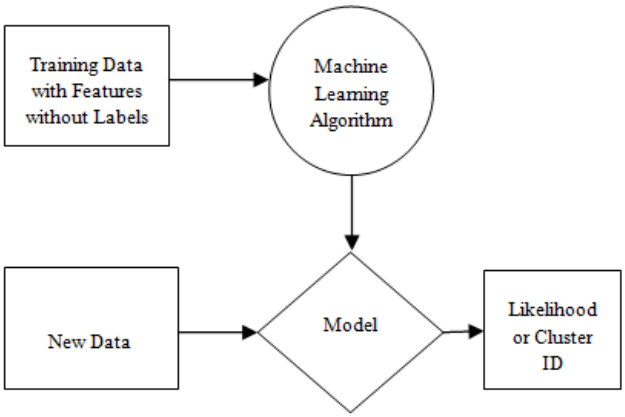

Fig.2.Unsupervised Learning

a. Clustering

Clustering means a form of grouping objects into similar groups. Clustering performs the identification of smaller groups of data in a data set.

Clustering is classified as hierarchical clustering and partition clustering. Clustering is used in the field of Marketing,

Medical imaging of blood cell relationships, streaming analysis in IoT (Internet of Things), Financial Transactions, Anomaly detection of fraudulent activities in Insurance and in analyzing the earthquake-affected areas.

b. K – Means Clustering

K – Means clustering is the Partitive Clustering algorithm which requires prior knowledge. The data chosen in this type of algorithm is not grouped or categorized. The number of clusters in the data is denoted by K. It acquires the Euclidean distance between the two clusters.

1. K is the given cluster and initializes the K clusters by picking one point near to the cluster.
2. The random selection could be done for picking the K point.
3. Place the nearest cluster whose centroid is closer.
4. Find the available data point in the cluster.
5. Find the cluster whose centroids are closest to the data point and assign it to the cluster.
6. Repeat from step to step 5 for each point.

When all the data points are assigned to the K- cluster, the possibility of changing the centroid to another cluster could arise due to the arrival of new data points in the concentrates. Update each location of the centroid by taking into count whenever a new data point is added to the K – cluster. Reassign all the points to the closest centroid.

The processes are repeated until the convergence takes place. At the stage of convergence, the point does not make a move between the centroid and makes to stabilize [19].

The K-means algorithms can be applied in the field of behavioral segmentation of the customer like the customer purchase history, to classify the customer or use website search or the application which user-preferred most and to predict the sensor measurement, to use in audio separation and healthcare monitoring.

D. Semi-Supervised Learning

The supervised learning technique utilizes the labeled data but the unsupervised learning technique concentrates more on unlabeled data[20].

But a combination of both formatted data and unformatted data are utilized in semi-supervised learning. The expected result that is derived from semi-supervised learning is more satisfactory than using any one-labeled data set.

This technique will be implemented in the field of classification, regression, and prediction. Google Expander is the progression of semi-supervised learning [21].

Identifying human face through the web camera is also an example of this type of learning. Fig. 3 depicts the block diagram of semi-supervised learning.

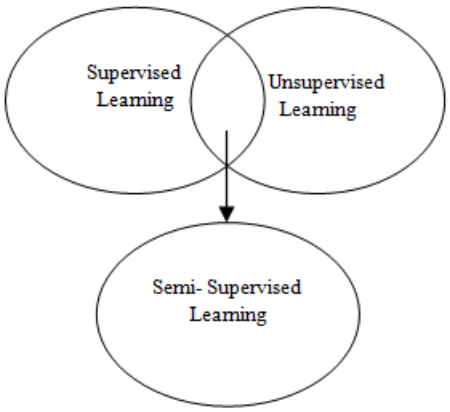

Fig.3. Semi-Supervised Learning

a. Generative Models

Generative models can be helpful in the construction of a model that can learn representations that are extraordinarily predictive of a huge-level perception like the sentiment form of a text, the digit of the human handwritten number by a human. Often in supervised learning, such information will be given by only human reviewers who are a scarce resource. But in the generative model yield, even more, performance gains than supervised tasks and it can promote the efficient results in classification by utilizing very small amounts of labeled data [22].

This model is used to develop a new model that permits effective generalization from small labeled data sets too large unlabeled data[23].

b. Graph-Based Methods

Graph-based learning methods place a vital role in classification. In this method, the correlation between formatted data and unformatted data influences the formation and pursuance of the classifier. Hence, semi-supervised learning is adopted [24].

E. Reinforcement Learning

This learning is empowered by behaviorist psychology, regard with the action taken by a software agent for a given situation to maximize certain assumptions of accumulative reward[25]. In this learning, the action taken by an agent in an environment is translated into a reward and a depiction of the reward is delivered onto the agent. The algorithm is competent to map actions according to the situations. [26].

Reinforcement learning has three main components: the learner, environment, and action. The application of reinforcement learning includes game board like chess, transportation car games, and robotics. When playing chess, the computer cannot be trained to move all the stages. The only possible explorer is the right to move or wrong move.

a. Q Learning

The objective of Q Learning is to gain a strategy that what action has to be implemented under which situation by an agent. It does not prerequisite a model of the environment.

It can provide a solution for the problems with vague conversions and rewards, without demanding transformations.

Certainly, Q Learning finds an excellent strategy for any Finite Markov Decision Process (FMDP)[27]. "Q" stands for the "quality" of an action taken in a given state [28].

b. State-Action-Reward-State-Action (SARSA)

(SARSA) is a reinforcement learning algorithm in order to know about Markov Decision Process (MDP) policy. The name **SARSA** means

"**S**"-Current State of an agent

"**A**" - Action was taken by an agent

"**R**" -Reward an agent received for choosing that action

"**S**" - State of an agent enters into subsequent action

"**A**" – Consequent Action of an agent chooses in the advanced state.

III. DEVELOPMENT OF THE MODEL

This research paper focuses on the Supervised Learning Method to predict the employability of a candidate using the Logistic Regression Method since the Logistic Regression is helped to predict the binary result such as either 1 or 0, yes or no and true or false. The probability in Logistic Regression is more easily interpretable than the real number outcome [19].

There are two motives to use Logistic Regression [10].

- Group membership prediction in an efficient manner. Logistic Regression measures the probability of success over the probability of failure.
- It can also contribute to the knowledge of-relation and robustness among the variables.

To predict employability, various factors like Aptitude, Communication, Technical and Personality skills of a candidate have been taken as input and weights have been assigned and the summation is also calculated. Then Threshold/ Cutoff value has been calculated for all candidates with the help of the Logistic Regression equation. If the p-value is above the threshold value then the probability of employability of the candidate is set as "Yes". Otherwise, it is set as "No".

The bottom line equation of the universal linear model is [29]

$$g(E(y)=\alpha+\beta_n+yx2 \quad (1)$$

Where g() represents the link function. E(y) represents the expectation of the target variable. Where α is initial value, β_n are various skill factors, y is the outcome. The role of the 'link' function is to associate the expectation variable y to linear predictor.

The elementary Logistic Regression equation with dependent variable enfolded in a link function

$$g(y) = \beta_0 + \beta_i w_i \quad (2)$$

Here, w_i represents weights assigned for various skill factors as input variables.

Let p is the probability of employability and 1-p is the probability of unemployability.

p should satisfy the following conditions:

- p must consistently a positive value (since, p>=0)
- And p must always be less than or equal to 1 (since, p <= 1)

So change the linear equation into the exponential form, because the probability must always be positive. For any slope and dependent variable, the exponent will never be negative. Hence,

$$p = \exp(\beta_0 + \beta_i w_i) \quad (3)$$

$$p = e^{(\beta_0 + \beta_i w_i)} \quad (4)$$

In order to satisfy the probability conditions, that is, to constitute the probability of less than 1, a number greater than p should divide p. This can be accomplished in the equation – (5)

$$p = \frac{e^{(\beta_0 + \beta_i w_i)}}{1 + e^{(\beta_0 + \beta_i w_i)}} \quad (5)$$

Using equations (2), (3), (4), (5) by reconsidering the probability , equation –(6) is derived as

$$p = \frac{e^y}{1 + e^y} \quad (6)$$

If q = 1- p then, equation - (6) can be written as

$$1 - p = 1 - \frac{e^y}{1 + e^y} \quad (7)$$

Equation-(8) is obtained by dividing equation-(6) by the equation- (7)

$$\frac{p}{1-p} = e^y \quad (8)$$

By taking log on both sides, equation – (9) is derived

$$\log\left(\frac{p}{1-p}\right) = y \quad (9)$$

The log is the link function because logarithmic transformation on the output variable permits the model with a nonlinear association in a linear approach.

The four skill factors (β1, β2, β3, β4) are identified, which are responsible for providing employability for the candidates as shown in Table II.

Weights have been assigned (at the maximum of 25) to each skill factor to the candidates. These data were collected from the interview process for candidates of the Department of Computer Applications (UG) of Sacred Heart College, which is depicted in Table III.

Table II. Factors which are responsible for Employability [10]

FACTORS	SKILLS
Aptitude: β1	Problem-solving, Analytical, Mathematical, Business Awareness, Logical Thinking, Visualizing
Communication : β2	Oral Communication , Written Communication , Reading, Listening, Presentation
Technical: β3	Basic Computer Knowledge, Subject Concept Knowledge, Application of Technical Knowledge
Personality: β4	Team Working, Leadership Initiative, Flexibility, Creative / Innovative, Self Confidence, Self-Motivated, Positive Attitude, and Goal Setting

Logistic Regression also contributes to the knowledge of co-relation and robustness among the variables. This can be verified by finding the rank for skill factors from the sum value of each factor $\sum w_j$, where **0<j>=10** from Table III.

The Grade Points have been given based on a rank obtained for each skill factors as shown in Table IV.

Table III. Factor Weights of each Candidate

Candidates/Factors	β1	B2	β3	β4
Candidate 1	21	20	23	22
Candidate 2	19	20	21	22
Candidate 3	22	18	19	22
Candidate 4	22	20	20	20
Candidate 5	14	12	13	10
Candidate 6	11	10	11	10
Candidate7	21	18	17	16
Candidate 8	10	08	07	08
Candidate 9	04	05	05	04
Candidate 10	23	23	23	23
$\sum w_j$, where 0 < j >= 10	**167**	**154**	**159**	**157**

Table IV. The Rank of Input Variables

Factors	Rank	Grade Points
Aptitude: β1	I	4
Technical: β3	II	3
Personality: β4	III	2
Communication: β2	IV	1

Logistic Regression in Supervised Learning method can be represented with the help of input data as trained data and the corresponding weights given to the input data as a feature vector which have been passed for prediction as shown in Fig.4.

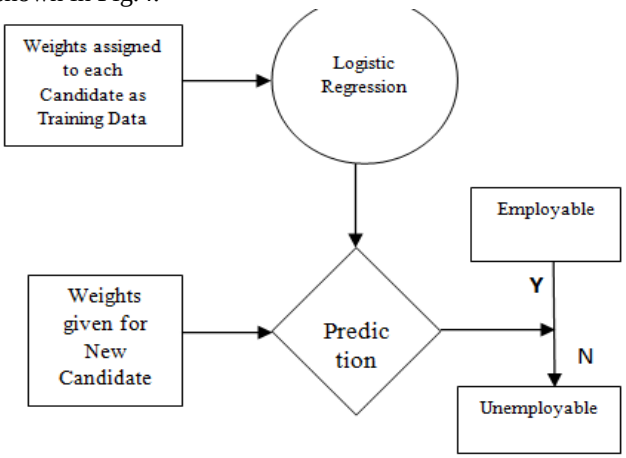

Fig.4. Employability Prediction Model

The input vector to the Logistic Regression classifier is the four skill factors β1, β2, β3, β4, and their corresponding weights w1, w2, w3, w4. The expected output will be the probability of getting employment over unemployment. This can be carried out by the following algorithm.

1. Start the process.
2. Consider all four factors as input and assign weights to each factor.
3. Prepare the dataset from Table III.
4. Do the classification using the Logistic Regression method as shown in Table V.

a. Find the sum of $\beta_i w_i$

b. Calculate **Sum= (β1*4+ β2*1+ β3*3+ β2*2)** that is, multiply each factor value with grade points as shown in Table IV.

c. Ave = Sum / 400

d. Find the exponent value for Ave.

e. Add 1with exponent value.

f. Calculate **p = e^ Ave / 1+ e^ Ave** using eqn. - (6).

g. Calculate the Threshold or Cutoff value by finding the average value for p.

h. If p> 0.598944 then assign y = 1 else assign y = 0.

5. If y = 1 then, set Scope for Employability as **"Yes ".** If y = 0 then set Scope for Employability as **"No".**
6. Repeat from step 2 to step 5 for N number of candidates.
7. Stop the process

IV. RESULTS AND DISCUSSION

The results of ten samples were analyzed using Logistic Regression and the scope for employability is predicted. Table IV furnishes the knowledge of the rapport among the input variables that is the rank of input variables and the grade points given to each skill factor.

Scope for Employability using Table V is shown in Fig. 5. The threshold/ Cutoff value has been calculated for all candidates with the help of the Logistic regression technique. The probability of the employability of the candidate is set as "Yes" whenever the p-value is greater than the threshold value. Otherwise, the employability of the candidate is set as "No". All the candidates other than candidates 5,6,8 and 9 can be employed based on the decreasing order of p which is given in Table V.

V. CONCLUSION

The novel contribution of this investigation is to develop a predictive model and authoritative model using logistic regression, which was validated on the recruitment process for ten candidates of the Department of Computer Applications (UG) of Sacred Heart College to predict employability.

The processing and classification of data were performed using the logistic regression technique. Automation of prediction using a machine is a challenging task. Many researchers use various techniques to make machine prediction, a reliable one. In the future, such systems are bound to substitute humans in the domain of prediction and also may excel humans in it. An attempt was made in this investigation to show the application of machine prediction to the employability of a candidate in a recruitment process. This research can be easily translated into other domains of predictions like health care, weather forecasting, natural calamities, crime prediction, etc., where the results will be a dichotomy in nature by changing the independent variables.

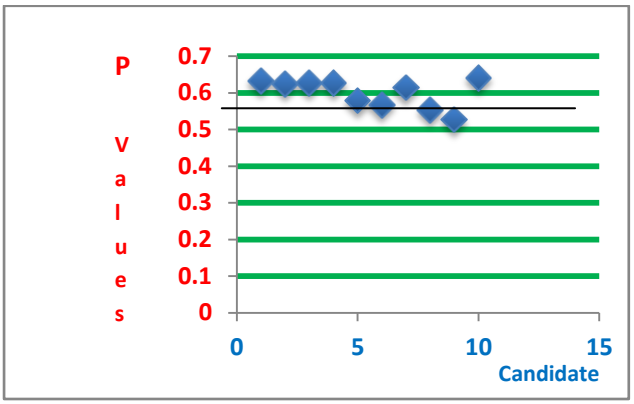

Fig.5. Scope for Employability

Table V. Probability of Employability using Logistic Regression

	Sum	Ave	e^ Ave	1+e^Ave	p	Scope for Employability
Candidate 1	217	0.5425	1.720302	2.720302	**0.632394**	**Yes**
Candidate 2	203	0.5075	1.661133	2.661133	**0.62422**	**Yes**
Candidate 3	207	0.5175	1.677828	2.677828	**0.626563**	**Yes**
Candidate 4	208	0.52	1.682028	2.682028	**0.627148**	**Yes**
Candidate 5	127	0.3175	1.373689	2.373689	0.578715	No
Candidate 6	107	0.2675	1.306694	2.306694	0.566479	No
Candidate7	185	0.4625	1.588039	2.588039	**0.613607**	**Yes**
Candidate 8	85	0.2125	1.236766	2.236766	0.552926	No
Candidate 9	44	0.11	1.116278	2.116278	0.527472	No
Candidate 10	230	0.575	1.777131	2.777131	**0.639916**	**Yes**
Threshold Value = 0.598944						

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