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Predicting Financial Distress Within Indian Enterprises: A Comparative Study on the Neuro-Fuzzy Models and the Traditional Models of Bankruptcy Prediction

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Abstract

The financial distresses is of major importance in the financial management system particularly in the case of this competitive environs. There are several traditional methods existing for predicting the financial distress within the country. Major factors influencing the financial distress is the stock market, credit risk and so on. Hence there is a need of models which could make dynamic predictions with the use of dynamic variables. There are several machine learning and artificial intelligence based bankruptcy prediction models available. The neural network concepts and the computational intelligence based methods are highly acceptable in the prediction arena. This research presents a comprehensive review of the existing prediction approaches and suggests future research directions and ideas. Some of the existing methods are support vector machines, artificial neural network, multi-layer perceptron, and the linear models such as principal component analysis. Neuro-fuzzy approaches, Deep belief neural networks, Convolution neural networks are also discussed.

***Keywords*:** artificial intelligence; convolution neural network; deep belief networks; multi-layer perceptron; neuro-fuzzy approaches.

1. Introduction

Bankruptcy prediction is the art of predicting the bankruptcy and innumerable events of financial distress of the public firms. It is a massive area of finance and accounting research. The prominence of the area is owed in part to the consequence for creditors and investors in estimating the possibility that a firm might go bankrupt in nature. High rate of letdown in business could be distressing to several firm owner, share partners, society and the country's economy level and appropriate development in bankruptcy prediction model (BPM) for any such firms is found to be justified in an un-doubtful manner. The performance metrics of this models mainly depends on numerous factors such as the tool chosen for BPM studies. The tool is mainly selected by means of the acceptance level or professional environment since there does not exist any specified evaluation material for examining the relative performance of major tools with respect to the basic form of criteria which any bankruptcy should fulfill.

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This kind of evaluation material could assure guidelines and suitably it could support a justified tool selection for the BPM developers. Currently the chief focus is towards some of the statistical tools or the most advanced Artificial Intelligence (AI) based approaches. Multiple Discriminant Analysis (MDA) is one such essential tool which was basically introduced for developing a BPM popularity named as Z model. AI tools are predominantly the computer based technologies in which Artificial Neural Network (ANN) is the most common among them. Owing to its popularity, several studies incorporated the back-propagation algorithm of ANN for the bankruptcy prediction [1]. A neural network model is established for prediction of bankruptcy, and it is verified by using financial data from numerous companies. The same set of data is examined by using a further customary technique of bankruptcy prediction, multivariate discriminant analysis. An evaluation of the predictive capabilities of both the neural network and the discriminant analysis method is offered. The prediction of bankruptcy in enterprises is a problem that has disturbed industrialists, scholars and even governments for years, meanwhile perceiving timely symbols that a company is going to arrive bankruptcy obligatorily and being able to save it from that procedure, and it could aid in condensing the financial losses that bankruptcy causes.

Bankruptcy prediction model is mainly related with credit risk which has been a great threat to the recent financial crisis. To modify a bankruptcy prediction mode, the tools suggested must satisfy some of the general necessitates such as accuracy, result transparency, non-deterministic, sample size, data dispersion, variable election, and types of variables, update level, and the integration capability. Some of the financial institutions, governments, and budget market players aids to develop advanced models which could effectively evaluate the probability of the counterparty default [11]. One such effect is the credit risk that raised owing to the bankruptcy events. Another reason for the credit risk is the relegation of the debt ratings of the credit based imposts. Recently academics and the researchers are focusing on artificial intelligence approaches which and the machine learning methods for effective analysis of the prediction based applications. Even though several research works has been admitted in this regard, the outcomes were not considered as ideal. Furthermore, studies regarding strengths and weaknesses of the machine learning techniques has been conducted to develop a supreme model. The conventional methods available were supporting prediction efforts in corporate bankruptcy. Some of the machine learning methods available are support vector machines, bagging, boosting, random forest and artificial neural networks [2].

-The credit rating problem of the small and medium sized enterprises including deep understanding of the asymmetry information problem among the banks as well as selecting proper and efficient credit rating model was presented in [15] which describes specific values in practical and theoretical level. Practical means, this research could assure methods for the commercial banks to ascertain the credit risk and provide with effective credit rating tool for the audit work before loan in the commercial banks which desires to minimize the probability of the commercial banks management loss occurred due to the rupturing of the contract of a huge amount of loans and at the same time, it provides the practical functions for decreasing the operation cost in the commercial banks. And in theoretical means, this work could emphasize on the index selection of the credit rating in a small and medium sized enterprises as well as the construction method of the rating model and hopes to stimulate much more attention and discussion on the credit rating model. The index form of the credit risk rating needs to cover the basic information of the loan, the financial information of the borrowed enterprises,

and operation and the management situations. Risk is one of key features of an initiative as a marketplace entity and an economic organization. This ascends from managers' inadequate knowledge with esteem to forthcoming variations in the surroundings of supervision and their influence on the firm, competitors' behaviors, and the establishment and progression of consumers' prospects. The above-mentioned settings are detached and permanent.; thus, risk is measured to be the factor that endorses certain initiatives that derive additional assistances from it on the one hand and excludes incompetent objects from the market on the other (for the latter, it turn out to be only a negative factor). In this framework, risk should be professed both as an opening to attain extra assistances and a threat for the persistence of the activity of a business.

Initially there were linear methods which could attempt for the subspace learning approaches such as Principal Component Analysis (PCA), Singular Value Decomposition (SVD), etc. These kind of methods are found to be effective only when they lies in or adjacent to the linear subspace and produces advanced discriminant results incorporated with the classifiers. PCA was employed in several research works for enhancing the prediction accuracy of the learning methods, employed with various filter applications for feature selection so that the subsequent models could attain comparatively good performance to extent the business failure.

The linear systems predict whether the data lies in or near in a linear subspace, which does not fulfill in financial data along with the availability of complex nonlinear structures. The nonlinear subspace learning methods could overcome the drawbacks of the linear approach, and hence minimizes the generalization error of the classification. Among the nonlinear methods, the manifold learning describes the significant applicability in the financial analysis domain. This could examine the low –dimensional structures embedded in the high dimensional data space such that the classification and prediction approaches could be easily applied to relatively low-dimensional spaces. Isometric Feature Map (ISOMAP) is one of the manifold learning methods [3].The models that are deployed in machine learning were not used in the field of business for two major reasons such as initially the prediction accuracy does not exceed the statistical models and secondly, the results attained was not interpretable form. Solving the skewness were focused which is a characteristic of the financial data [22]. A new ensemble based model was introduced for the bankruptcy prediction which uses extreme gradient boosting as an ensemble of decision trees. New methods were employed [23] for generating the features to enhance the prediction. The major aim of the bankruptcy prediction is to assess the financial condition of a company and its future perspectives within the context of long term operation on the market.

This paper presents a comprehensive review on the financial distresses in the Indian enterprises and neuro-fuzzy approaches and other existing conventional prediction models for bankruptcy prediction.

The review paper is divided into six sections. The first section provided a background of bankruptcy prediction methods, and financial distresses in Indian enterprises due to the credit risk occurred. The second section presents the theoretical background of fuzzy models and neural networks. Third section describes some of the works on machine learning models; neural networks model like Artificial Neural Networks; Convolutional Neural Networks; Deep belief neural networks and so on, fuzzy models and other conventional models like Altman, Ohlson and other models will be reviewed from the aspects of techniques used, performance measures, merits and demerits. Fourth section portrays the research gaps available in this field and the purpose of this

research conducted. Last section, the fifth section describes conclusion of the current work.

2. Fuzzy model & Neural Networks - Fundamentals

This section presents the theoretical background of fuzzy models and neural networks. It portrays:

2.1 Neural Networks

In Artificial Neural Network based prediction models encompasses stock price forecasting and some of the other financial applications. Different implementations of ANN was examined including economics and management system including economic time series forecasting. Text mining surveys are also existing in financial applications that could extract market responses to news for prediction purpose. A deep belief networks consists of a stack of RBM networks which is a preferred generative model of latent variables. Deep belief networks are mainly used to find out the discriminate independent features in input set using unsupervised learning methods. When a deep belief network is trained in an unsupervised manner, it could probably learn to reconstruct input set in a reliable manner. While integrating the application of artificial neural network, the time series methods are well documented to their proneness to over fitting, convergence concerns, and the difficulty of the implementation raised problems. However the departure from the fundamentals of the financial econometrics isolated the financial econometrics research community and the finance holders. On the other hand, the algo-trading firms employs the computer scientists and the mathematicians who were capable of perceiving artificial neural networks as not only black-boxes but rather a non parametric approach to model based on the current resurgence in the method. Deep Neural network is a branch of artificial neural network which contains multiple hidden layers of the units between input and output layers. They have been popularized in the artificial intelligence community for the successful use in the image classification and speech recognition area termed as deep learning. Research in [9] deep neural network is been used to identify some of the deficiencies of artificial neural networks. Among the dependent and independent variables, non-linear relationships were modeled and further minimized the tendency to over fit. In case of financial forecasting area, particularly in multivariate prediction analysis system, feed forward method has achieved more attention. Gradient descent and the back propagation has been chosen as the preferred method to train these structures owing to the ease of implementation and the tendency to congregate to further local optima associated to other trained models. The distribution of the first time that the additional reaches a given level and the duration of the negative surplus in a Sparre Anderson risk process was executed in [10] by having their inter-claim times being Erlang distributed.

2.2 Fuzzy Model

Fuzzy neural network is the combination of the fuzzy systems theory and the back propagation neural network which possess the advantage of both the fuzzy systems and the neural network systems by incorporating learning, association, recognition and information processing. Fuzzy theory states that the basic characteristic feature of the things in the transitional stage were uncertain and their genera are found to be clear enough. Mainly the fuzzy logic types of uncertainty are divided into random uncertainty and vocabulary uncertainty.

Random uncertainty is the probability level that the things might happen. One of the supreme advantage of the fuzzy logic is that it permits the users to determine the expected behavior of the system with humble means of if-then relationship rules. By uniting the fuzzy logic system with the back propagation neural network system, which is one of the neural network, instantaneously processes the fuzzy information. The major difference between the fuzzy neural network and the back propagation neural network is given as follows:

Table 1: Comparison of Fuzzy Logic vs Back Propagation Neural Network System.

Fuzzy Logic system	Back Propagation Neural Network system
Knowledge is acquired from the experts	Knowledge is acquired form the algorithm
Uses membership function to represent knowledge	Uses distributed representation
Fuzzy reasoning rules are visible	Back propagation neural network is black box and the training process is invisible
Fuzzy system mainly uses input layer, fuzzy layer, rule layer, anti-fuzzy layer, and the output layer	Back propagation neural network includes input layer, hidden layer, and the output layer

The basic advantages of applying combined Fuzzy Neural system in the financial risk assessment process is that the fuzzy neural system possess strong parallel processing mechanism, hard adaptability and reasoning capability, and ability to process the fuzzy information [8].

The bankruptcy prediction issue has been extensively investigated for the past four decades. The improvement in the prediction accuracy was not adequate from previous research works to recent papers. This review will look at alternative modeling of the system, using neuro-fuzzy models that merge neural networks with fuzzy controllers. Classical modeling is based on statistical equations representing the company's behavior. While the key concept of fuzzy control is to create a paradigm of an expert in control, who can manage the operation without applying any statistical concept. This control specialist carries out his control steps in the form of linguistic rules. These control rules are interpreted into a fuzzy set theory which provides a calculus to stimulate the control expert's actions and improve his or her results. The current review paper will assess the accuracy of the model using information from the studies conducted by previous scholars. Furthermore, the strengths and weaknesses of the model will be highlighted in the context of bankruptcy prediction.

3. Other Models

3.1 Machine Learning Models

One of the major share of the prediction based methodologies are inspired by the machine learning approaches to learn from the initial price historic data to predict future prices. Even though the modeling and predicting of stock market is a technical analysis criteria, which relies on the historic data from the market, it could take up these as assumptions while in a machine learning approach. With regards to the computational intelligence there exist enormous studies assessing diverse methods in order to accomplish accurate predictions in stock market. They include evolutionary computation through genetic algorithms, static way of learning by using algorithms such as support vector machines, neural networks, and component modeling textual analysis based on the news

data and so on. By having a depth knowledge of the deep learning process in stock marker field, it could be understood for which place a study based on deep belief network is deployed which is composed of stacked Restricted Boltzmann Machines coupled to a Multi-level Perceptron (MLP) and using long range log returns from the stock prices to predict the above-median returns for each day. The historic price data for the particular stocks are collected in the format of a time series of candles such as open, close, high, low and volume [12]. A novel cost-sensitive boosted tree model is proposed for the loan evaluation in P2P lending [13].

A data mining approach was executed to predict the P2P performance loan before funded using the data from the lending club, the characteristic feature of loan and its applicant and random forest is been used to accomplish feature selection in the modeling phase. While compared to other risk based prediction models, this is mainly classified into three to four categories. The random forest could examine the significance of a variable in a prediction task and also could extract the relative essential features by means of importance ranking provided by random forest model. Decision trees are the powerful classification which have been widely used and in this approach, the acquisition of the training set is represented as a tree structure by a set of specific rules and it is used to approximate the basic target variable. 10-fold cross-validation approach was used to examine the prediction performance by employing two main criteria such as predictive accuracy and lift curve [14]. The Conditional Value-at-Risk (CVaR) is a coherent measure that could examine the risk for the different investing schemes and since the extreme value distribution has been revealed to furnish the better financial and economic data adjustment in contrast to the well-known normal distribution, this is widely used in examining the explicit formulas for two common risk measures such as VaR and CVaR for providing better tools in risk management [16].

Some of the machine learning models were employed for predicting the bankruptcy based on the performance measures of the classifiers and the best among them is chosen for the development of a decision support system in R programming language. The support system could be utilized by the stock holders and the investors to establish the performance of a company based on nature of the associated risk. The machine learning models might be either supervised or unsupervised way of learning. Supervised way of learning is deployed while in case an output of a function is already determined or well-known. In case of unknown functions, the unsupervised function is deployed [17]. The main aspects of the machine learning approaches include collection of data, preprocessing of data, model development and knowledge extraction. The classification algorithms used are logistic regression, naïve bayes classifier, random forest and so on. While detecting bankruptcy, mathematical and statistical models were initiated and the study focused on the univariate analysis of different financial factors to detect bankruptcy. An advancement in this arena was developed by the developing a multivariate Z-score model of five variables.

The Z-score model is mainly considered as a standard model for estimating the probability of the default in bankruptcy. Logistic regression was initiated to evaluate bankruptcy and these techniques were considered as the standard estimate for predicting the financial distress level. With the advent of current financial crisis and the European debt crisis, the corporate bankruptcy prediction has become an increasingly advanced issue for the financial institutions. Several studies has been instigated and intelligent techniques has been initiated and however there is no such efficient method for predicting the corporate bankruptcy. Some studies recommend

ensemble learning methods might possess potential applicability in the corporate bankruptcy prediction.

A novel ad improved form of boosting, FS boosting is proposed for estimating the corporate bankruptcy. For the purpose of testing and illustration purposes, two kind of real world bankruptcy datasets were elected to determine the efficiency and feasibility of FS-boosting [19]. Altman models were built by multiple discriminate analysis (MDA) from a set of candidate factors. Each of the accounting ratio puts forward as a potential explanatory variable is been assessed for its capability to explain the firm failure, only those making a noteworthy contribution being measured as the final model. The corporate failure resonates widely, leaving the practitioners searching for understanding of default risk. Managers seek to steer away from the trouble, credit providers to avoid the risky loans and investors to alleviate the losses. Research work conducted in [20] describes the basic models of Altman and its predictions of the default against the true cases of corporate failures. Topological Data Analysis Ball Mapper was used to produce an abstract 2-dimensional representation of the financial ratio space to predict when the failure might occur among the combinations of the firm characteristics. The performance of the Z-score model for the firm from 31 European and three non-European countries by using diverse modifications of the actual model were examined. Recent reviews were offered by the reviewers which mainly takes into consideration the performance of accounting based, market-based, and the hazard models. Though the Z-score was modified more than 45 years ago and numerous failure prediction models exist, the Z-score model continues to be deployed worldwide as a major supporting tool for the bankruptcy or financial distress prediction and analysis both in real world and research wise [21].

3.2 Deep Learning Models

Among the different prediction models available in determining financial distresses of the country, the stock market prediction is one such vital parameter. Precise estimation of the stock market estimation is the major challenge nowadays. In previous decades, the machine learning models like Artificial Neural Networks and Support Vector Regression models has been deeply accepted to estimate the financial time series and high gain predictable accuracy level. Current trend is the machine learning and pattern recognition approaches that contemplates a deep nonlinear topology application in to the time series prediction. This could mainly model the complex real-world data by extracting robust topographies which could capture the significant data. Apart from the convolution neural network and deep neural network, the stacked auto-encoders are one such deep learning approaches widely applicable. Long short-term memory is one of the variations of the recurrent neural networks architecture which could model RNN and its LSTM architecture for forecasting the closing price. A novel deep learning framework is presented in [5] in which wavelet transform, stacked encoders and the long short term memory wee combined for the stock price forecasting. The stacked autoencoders for hierarchically extracted deep features were instigated into the stock price forecasting for the first time which included three stages [5]. Several algorithms, and methodologies were proposed in previous research works for the feed forward network optimization. Previously, in feed forward network, only gradient based optimization methods were the most adoptable method. Gradually due to the drawbacks of this method, the requirement of a meta-heuristic based optimization approach was initiated which formulated the feed forward neural network components such as weights, structure, nodes into an effective optimization approach. The meta-heuristics accomplish several heuristics for locating the near-optimum solution. In addition, a multi-objective type meta-heuristic deals with

the diverse objectives in a simultaneous manner. Persistence of the multiple level objectives in feed forward network optimization is adoptable since minimization of feed forward network's approximation error is desirable at one hand and generalization and model's simplification factor stays as other. In feed forward based meta-heuristic treatment, the initial population of feed forward neural networks is directed in the direction of a final population in which basically the best feed forward network is chosen. Feed forward neural networks are a vibrant model that consists of several neurons interconnected using synaptic links and they are arranged in layer by layer basis. Meta-heuristic based feed forward neural network review is conducted in [6] which suggests interesting research challenges and future research ideas. Convolution neural network is a type of deep neural network which includes the convolution layers based on the particular function.

3.3 Deep belief neural networks

In last few years, the importance of deep learning has been evidently emerged as effective performing predictor class within the machine learning area of research field. The financial time series prediction is f no exception and as such, an augmented prediction measures were established based on countless deep learning approaches have been presented in several conferences and journals. Despite the numerous number of research surveys conducted which covers financial time series estimation and trading systems using traditional soft computing techniques, literature including deep learning is reviewed a lesser amount. Deep learning based implementations and distinctive characteristic features of deep learning cold assist in preventing the researchers to make substandard choices all through the system development. Research work in [4] measured the particular deep learning models suggested for financial time series forecasting, performance of deep learning models and its comparison with machine learning approaches and the future research scope of deep learning.

In practical applications, the success factor of reinforcement learning have been comprehensively established in numerous tasks which includes navigation of robots, game playing and aero plane control applications. Therefore trading is extended as an interesting area of research focused on training reinforcement methods. The question that; can a reinforcement training model be able to overcome an experienced human traders on the area of financial market trade. While related to some of the existing traditional reinforcement learning tasks, they were found to be tedious due to several reasons. Complications in financial background summarization and demonstration was one major problem. Financial data includes huge sum of noise, jump and the movement which leads to extremely non-stationary time series. For mitigating the data noise and the uncertainty, the handcraft financial features such as moving average or practical kind of pointers were basically extracted to frame the market criteria. The ideal indicator search for the technical analysis has been predominantly examined in the quantitative finance. Poor generalization capability is the main challenge in technical analysis. Moving average feature is quite good enough to exhibit the development but it might suffer substantial losses in the mean-revision market. Dynamic behavior of the trading action execution is another challenge and the placing of the trading orders is a systematic task allocation in which considers several practical factors [7].

Rapid development of the artificial intelligence techniques leads to the employment of data mining techniques in numerous domains. These data mining methods were used to filter the required amount of information from the financial basis for the prediction of bankruptcy. These data mining techniques include traditional approaches

and evolutionary methods such as inductive learning, neural networks and the genetic algorithm in bankruptcy prediction. Currently several quantitative methods combining quantitative methods were non-financial variables were proposed but none of them incorporated both the quantitative and qualitative approaches. Lack of a combined framework for both qualitative and quantitative systems leads to the future research directions in this field [18].

Environment fluctuations and the increasing competitiveness among the corporations are prominent to make the attainment of proper benefit more demanding. Hence, the financial decision making received more focus compared to past few decades and it forces the managers to apply new methodologies in order to make excellent decisions. The research work in [24] examines the application of Altman and Ohlson models. Economic methodology of the logistic analysis was chosen and the dependent variable was binomial and was defines as 1 if the firm was delisted and 0 if the firm was found to be non-delisted firm. After the prediction improvement by employing the neural network, several studies based on the computational intelligence were presented as the statistical approach and the computational intelligence technique have become two broad methods in the design of a bankruptcy prediction model [25].

A hybrid structure incorporating the statistical theory and the computational intelligence technique was employed for the classifier design. Fuzzy based clustering algorithm was used for the classifier design. Two financial ratio sets were used, one extracted from the suggestions of another studies and the other obtained by means of using genetic algorithm. For the classifier design, the developed fuzzy system was compared with the back propagation neural network classifier habitually used in other research works. The hybrid form of implementation was found to be effective by comparing with the other applied structures.

4. Research Gaps

Because of the ongoing global financial crisis, the present relevance of bankruptcy modeling has increased. This recession has seen a spike in the number of bankruptcies in many countries and has demonstrated that even the strongest businesses have to maintain their financial situation and attentively operate the position of the firms. The current analysis will aim to forecast the probability of Indian companies' bankruptcy using different predictive models. The current study will involve a review of literature in order to compare the neuro-fuzzy models and the traditional models of bankruptcy prediction. Furthermore, based on the previous literature, the limitations of the conventional models will be suggested that highlighted the need for the adoption of alternative neuro-fuzzy models. Additionally, several instances of the Indian companies will be mentioned to highlight the scope of modern and traditional bankruptcy models.

Different economic situations vary in their attributes; which further prohibits the use of the same bankruptcy forecast models under different circumstances. Objectively, the proliferation of bankruptcy prediction models gives rise to the notion that these models are not in accordance with the evolving business environments in the industry and do not satisfy the increasing sophistication of business activities. The goal of this analysis is to evaluate the adequacy of current prediction models for bankruptcy and identify the prospect of increasing their implementation efficacy. The current study will review the comparison between the modern methodologies

(neural networks analysis) and conventional methodologies (like multiple discriminant analysis, one-way analysis of variance, recurrent algorithm analysis, logarithmic analysis) of Bankruptcy Risk Modeling. Furthermore, an in-depth analysis will be employed to identify the benefits and limitations of each model and the reason for adopting an alternative model with special reference to the Indian companies. The current study will involve reviewing the previous literature in order to concise the findings of the different scholars and draw a conclusive result for the research conducted.

5. Conclusion

This review paper examined the existing research works on bankruptcy prediction models such as artificial intelligence, fuzzy systems, neuro-fuzzy systems, support vector systems and so on. The supervised and unsupervised learning methods are employed in this context in which the unsupervised learning methods are mostly discussed. Machine learning approaches and the computational intelligence based methods are quite familiar in predicting bankruptcy prediction models. Hybrid models by incorporating machine learning methods and neural network forms a good source of future research work. With upcoming advances in artificial intelligence and improvements in neural network models for solving precise problems for different sectors, the research would also aim to include more methods of comparison of bankruptcy prediction models and try to review innovative approaches to provide most accurate bankruptcy predictions possible.

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