I.J. Intelligent Systems and Applications, **2014, 01, 36-44**
Published Online December 2013 in MECS (http://www.mecs-press.org/)
DOI: 10.5815/ijisa.2014.01.05

An Analysis on Qualitative Bankruptcy Prediction Rules using Ant-Miner

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***Abstract*—** Qualitative bankruptcy prediction rules represent experts' problem-solving knowledge to predict qualitative bankruptcy. The objective of this research is predicting qualitative bankruptcy using ant-miner algorithm. Qualitative data are subjective and more difficult to measure. This approach uses qualitative risk factors which include fourteen internal risk factors and sixty eight external risk factors associated with it. By using these factors qualitative prediction rules are generated using ant-miner algorithm and the influence of these factors in bankruptcy is also analyzed. Ant-Miner algorithm is a application of ant colony optimization and data mining concepts. Qualitative rules generated by ant miner algorithm are validated using measure of agreement. These prediction rules yields better accuracy with lesser number of terms than previously applied qualitative bankruptcy prediction methodologies.

***Index Terms*—** Ant-Miner, Qualitative Bankruptcy Prediction, Experts Decision Analysis, Data Mining, Kappa Test, Measure of Agreement, Bankruptcy

I. Introduction

Bankruptcy is financial failure of a business [1] and when an organization not able to pay its debts is called as bankruptcy. Impact of bankruptcy has shown disastrous outcomes and its affects whole community [2]. The impact of bankruptcy clearly states the need for an efficient model to predict bankruptcy. Bankruptcy prediction (BP) refers to prediction of business failure through financial [4-12] and non-financial variables [13-18, 43]. BP is one of the most important decisions in financial decision making [19]. BP is studied extensively in the accounting and finance literature [20] Different approaches [42] have been applied for bankruptcy prediction. Statistical Approaches in which univariate analysis (Beaver, 1966) [22], multivariate discriminant analysis (Altman, 1968) [21], logistic regression approach (Ohlson, 1980) [23] and factor analysis technique (West, 1985) [24] have been applied. Another approach is artificial intelligence and soft computing approaches in which artificial neural networks [25], Support vector machines [26] Bayesian network models [27] and many other AI techniques have been applied. Other then these approaches swarm intelligence approaches [28-29, 35, 37] and hybrid methods and ensemble methods [8], [25] [43] have been applied to predict bankruptcy.

In all these approaches bankruptcy has been predicted by using two kinds of parameters such as quantitative parameters and qualitative parameters. Many quantitative bankruptcy prediction methods are available. These methods have improved the prediction accuracy of quantitative bankruptcy. Many organizations have applied these methodologies to predict bankruptcy. Irrespective these proven methodologies for quantitative bankruptcy prediction, organizations have tended to fail very often. When organizations starts give importance for indirect parameters, the occurrence of failure may be reduced [28] and these indirect parameters which cause bankruptcy called as qualitative bankruptcy parameters [18]. We have found very limited work on qualitative parameters which causes the bankruptcy. In this qualitative bankruptcy prediction method, we are applying 14 outer risk parameters and 68 inner risk parameters [18], [30], [32]. This research induces qualitative bankruptcy rules using Ant-Miner algorithm.

Ant-Miner is an application of ACO in data mining [34-35, 38, 42]. Ant Miner algorithm is a combination of both Ant colony and data mining concepts. It is an ant-based algorithm for the discovery of classification rules. Ant-Miner has proved to be a very promising

technique for classification rules discovery. Ant-Miner generates a fewer number of rules, fewer terms per each rule and performs competitively in terms of performance compared to other classification algorithms [33, 43-44].

The rest of the paper is organized as follows, section 2 describes the prior research on qualitative bankruptcy prediction, section 3 describes list of qualitative parameters, section 4 describes the ant miner algorithm, section 5 describes the experimental design, section 6 describes the results and section 7 concludes the paper.

II. Literature Survey

2.1 Ant-Miner Algorithm and its Applications

Ant-Miner is an application of ACO with the classification task of data mining. It has been introduced as an ant-based algorithm for the discovery of classification rules [34-35] Ant-Miner has proved to be a very promising technique for classification rules discovery. Ant-Miner generates a fewer number of rules, fewer terms per each rule and performs competitively in terms of performance. There are many researches undergone in the area of bankruptcy prediction. There are many studies regarding the analysis of qualitative and quantitative bankruptcy prediction. These studies include statistical techniques as well as intelligent techniques to predict bankruptcy. This literature survey describes about various studies on qualitative bankruptcy prediction [37-41].

The research on data mining with an ant colony optimization proposes an algorithm for data mining called Ant-Miner (ant-colony-based data miner). It compares the performance of Ant-Miner with CN2, a well-known data mining algorithm for classification, in six public domain data sets. The results provide evidence that the rule lists discovered by Ant-Miner are considerably simpler (smaller) than those discovered by CN2. The conclusion on this research indicates that Ant-Miner obtained better results in four data sets, whereas CN2 obtained a considerably better result in one data set. Therefore, Ant-Miner minimizes the number of discovered rules and rule terms (conditions) in order to improve clarity of the discovered knowledge [33-34, 41].

The research on an ant colony algorithm for classification rule discovery, proposes an algorithm for rule discovery called Ant-Miner (ant colony-based data miner). The result indicates that rule sets discovered by Ant-Miner are simpler (smaller) than the rule sets discovered by C4.5 [35]. A research on new classification-rule pruning procedure for an ant colony algorithm proposes a new rule pruning procedure for Ant-Miner. The results indicates that the rules which are generated by new pruning procedure is considerably shorter, and so simpler (more easily interpretable by the users) than the rules discovered by the original ant-miner [41]. The thesis on ant colony optimization and the ant miner algorithm describes premature converge on solutions obtained by ant-miner [44]. This literature study indicates the efficiency and suitability of ant-miner algorithm for the development qualitative bankruptcy prediction rules using ant-miner algorithm.

2.2 Qualitative Bankruptcy Prediction

The research on discovery of qualitative bankruptcy rules using Genetic Algorithm (GA) demonstrated the genetic based data mining approach to discover qualitative prediction rules from experts' decision process. This study is the first work on GAs for the purpose of discovering experts' qualitative knowledge on bankruptcy. The fitness function of the GA is the composite measure to discover decision rules that satisfy accuracy and coverage. This work has generated expert decision rules for qualitative bankruptcy, but it has redundant and overlapping structure. Since GA is applied to construct rules, learning approach was not applied in this methodology. In this approach only six external factors have been considered to generate the rules and the performance of this method is limited traditional genetic approach [18]. The qualitative factors which are applied in this work have been collected from various firms which are applied to analyze its qualitative performance [30-32].

III. Qualitative Bankruptcy Parameters

Bankruptcy prediction is the art of predicting financial distress of a business, an organization or an individual. Bankruptcy is a legal status of a person or an organization that cannot repay the debts it owes to its creditors. Bankruptcy prediction is an active area of research in finance as well as in any business. The qualitative parameters that are included in the paper are described in Table 1.

Table 1: List of qualitative bankruptcy parameters

MAIN PARAMETERS	SUB PARAMETERS
Industry Risk(IR) (Myoung and Ingoo,2003)	▪ Governmental Policies and International Agreements (GPI) ▪ Cyclicality (CY) ▪ Degree of Competition (DEG) ▪ Price and Stability of the Market Supply(PSM) ▪ Size and Growth of Market Demand (SGM) ▪ Sensitivity to changes in Macroeconomics (SEN) ▪ Domestic and International competitive Power (DOM-POW) ▪ Product Life Cycle (PLC)

Management Risk(MR) (Myoung and Ingoo,2003)	▪ Ability and Competence of management (ACM) ▪ Stability of Management (SM) ▪ Relationship between Management/Owner (REL-MO) ▪ Human Resource Management (HRM) ▪ Growth Process/Business Performance (GP/BP) ▪ Short and long term Business Planning, Achievement and Feasibility (SL-TERM AF)
Financial Flexibility (FF) (Myoung and Ingoo,2003)	▪ Direct Financing (DF) ▪ Indirect Financing (IF) ▪ Other financing [Affiliates, Owner, Third Parties] (OF)
Credibility(CR) (Myoung and Ingoo,2003)	▪ Credit History (CH) ▪ Reliability of Information (RI)
Competitiveness (CO) (Myoung and Ingoo,2003)	▪ Market Position (MP) ▪ Differentiated Strategy (DIFF-S)
Operating Risk (OR) (Myoung and Ingoo,2003)	▪ Stability and Diversity of Procurement ▪ Stability of Transaction ▪ Performance of Production ▪ Prospectus for Demand for Product and Service ▪ Sales Diversification ▪ Sales Price and Settlement Condition ▪ Effectiveness of Sales Network
Common Business Performance Analysis Parameters (CBP) (Yi-Chung, 2009)	▪ Managerial Experience (ME) ▪ Number of Years in Business (NYB) ▪ Competition (COM) ▪ Level of Service (LoS) ▪ Price Level (PL) ▪ Location of the firm (LOC) ▪ Training of the employees (TE) ▪ Quality (QUA) ▪ Awareness of Market Trends (AMT) ▪ Opening Hours (OH) ▪ Number of Different Goods/Services (SER)
Firm Default Parameters(FD) (Kasirga and Omur,2009)	▪ Non-Performing Loan Volume (NPL) ▪ Rediscounts of Accrued Interest (RAI) ▪ Issuing of Bad Cheque (BC) ▪ Credibility and Reputation of the firm and its Shareholders (CRE-REP) ▪ Relationships with other banks and financial institutions (REL-BFI) ▪ Property Holding of the firm and its Shareholders (PRO-FS) ▪ Ownership and situation of head office and other offices (OWN-HEAD) ▪ Working Conditions with banks and other financial institutions (WC) ▪ Demand conditions for the products (DEM-PRO) ▪ Maturity matching of Purchases and Sales (MM)
Reorganization Parameters(RP) (Nesi et.al, 2009)	▪ External Environment (EE) ▪ Quality of Enterprise (QE)
Pricing (PP) (Nesi et.al, 2009)	▪ Deposit Rate (DR) ▪ Transaction fee (TF)
Differentiation Parameters(DP) (Nesi et.al, 2009)	▪ International Linkages (IL) ▪ International Image and Reputation (IIR) ▪ Company Privilege (CP) ▪ Penetration Rate of a Market (PRM) ▪ Working Hours (WH)
Marketing Parameters(MP) (Nesi et.al, 2009)	▪ Service Quality (SQ) ▪ Quality of the Employees (QE) ▪ Responding to the Customer Needs (RCN) ▪ Market Dimension (MD)[Market Share, Newly added Customer]
Delivery Parameters(DEP) (Nesi et.al, 2009)	▪ Transaction Duration (TD) ▪ Internet Banking (IB)
Productivity (PRP) (Nesi et.al, 2009)	▪ Productivity

Table 1 describes about various qualitative parameters which have been applied in various business to analyze qualitative bankruptcy performance. Qualitative parameters are subjective in nature as it can be measured as low, medium and high. To evaluate qualitative parameters, we need help from experts. Experts will be evaluating the parameters based on their decision and this analysis depends on the history, the values will not be accurate but approximate. The scores and ranks to indicate the importance of the parameters are High (100-66), Medium (65-46) & Low (45-0). Expert analyses have been conducted for these

parameters from various banks using questioner. The questioner which is applied for industry risk has been depicted in figure 1.

I. Industry Risk (IR)

IR is measured by the stability and the growth of the industry, the degree of competition over the industry, and the overall conditions of the industry.

1. Do Governmental Policies and International Agreements (GPI) affect the Bankruptcy?
□ High □ Medium □ Low Score
2. Does Cyclicality (CY) Affect Bankruptcy?
Sensitivity towards worldwide economic fluctuations. These fluctuations occur around a long-term growth trend, and typically involve shifts over time between periods of relatively rapid economic growth.
□ High □ Medium □ Low
Score
3. Does Degree of Competition (DEG) affect Bankruptcy?
□ High □ Medium □ Low
Score
4. Does the Price and Stability of the Market Supply (PSM) affect Bankruptcy?
□ High □ Medium □ Low
Score
5. Does the Size and Growth of Market Demand (SGM) affect Bankruptcy?
□ High □ Medium □ Low
Score

Fig. 1: Questioner applied for Industry Risk

In the same way questioner which is applied for management risk has been described in figure 2.

II. Management Risk (MR)

MR is concerned with the efficiency and stability of management and organization structure. It is measured by the ability of management, the stability of top management, the stability of organization structure, management performance, and the feasibilities of business plans.

1. Does Ability and Competence of management (ACM) affect Bankruptcy?
□ High □ Medium □ Low
Score
2. Does Stability of Management (SM) affect Bankruptcy?
□ High □ Medium □ Low
Score
3. Does the Relationship between Management/Owner (REL-MO) affect Bankruptcy?
□ High □ Medium □ Low
Score
4. Does Human Resource Management (HRM) affect Bankruptcy?
□ High □ Medium □ Low
Score
5. **Do Growth Process/Business Performance (GP/BP) affect Bankruptcy?**
□ High □ Medium □ Low
Score

Fig. 2: Questioner applied for Management Risk

The next section describes the ant-miner algorithm with its working procedure.

IV. Working Model of Ant-Miner Algorithm

Ant Miner is an ACO based rule induction algorithm [33-34,42]. The first application of ACO for the classification task was reported in where the authors introduce the Ant Miner algorithm for the discovery of classification rules. The aim of this algorithm is to induce simple rules of the form if rule antecedent then rule consequent, where the rule antecedent is a conjunction of terms. Ant miner algorithm is a rule induction algorithm by which the qualitative bankruptcy rules are framed. Each classification rule is of the form:

If <Term1 And Term2 And Term3…..> Then <Class>

Each term is a triplet *<attribute, operator, value>*,

Where,

Value is the value belonging to the domain of the attribute.

The operator element in the triplet is the relational type.

Usually the operator element is always '='

In this algorithm the rules are generated and the generated rules are pruned. The pruned rules are considered as the optimal rules. After the pruning process the pheromone updating is done both locally and globally. The steps of Ant-Miner algorithm [33-34] have been described in figure 2,

procedure Ant-miner
  $TS \leftarrow$ InitializeTrainingSet
  $rule\_list \leftarrow [\ ]$
  while $(|TS| > uc)$ **do** % uc is the number of uncovered cases
    $\tau \leftarrow$ InitializePheromones
    $i \leftarrow 1$
    $rule_{best} \leftarrow \emptyset$
    while (termination condition not met) **do**
      $rule_i \leftarrow$ ConstructRule
      $rule_i \leftarrow$ PruneRule$(rule_i)$
      UpdatePheromones
      if $(f(rule_i) > f(rule_{best}))$
        $rule_{best} \leftarrow rule_i$
      end-if
      $i \leftarrow i + 1$
    end-while
    $rule\_list \leftarrow [rule\_list, rule_{best}]$
    $TS \leftarrow TS \setminus CoveredCases(rule_{best})$
  end-while
end-procedure *Ant-miner*

Fig. 3: Ant-Miner Algorithm

The working procedure of ant-miner has been described as follows,

Initiation of training set; training set will contain all the values of parameters (i.e) all training cases. An empty rule list is initiated namely DiscoveredRuleList[].

While(training set > Max uncovered cases)
Step i: t=1 / ant index*/*
*Step ii: j=1/*convergence test index*/*
Step iii: Initiate the pheromone for all the parameters

Repeat
Step i: Ant_t starts with empty rule and constructs a classification rule R_t by adding one term at a time to the current rule

Step ii: Prune rule R_t

Step iii: Update the pheromone contents of all trails by increasing the pheromone in the trail followed by Ant_t, and decreasing in other trails

Step iv: if (R_t=R_{t-1}) then increment j; j=j+1/ update convergence test*/*

Step v: else j=1

Step vi: Increment the ant index; t=t+1 Until(t ≥ No.of Ants) Or (j ≥ No of Rules Converge); Choose the best rule R_{best} among all rules R_t constructed by all ants

Step viii: Add rule R_{best} to DiscoveredRuleList

Step ix: TrainingSet= TrainingSet-{set of cases correctly covered by R_{best})

Step ii in Repeat loop is for pruning the generated rules. There is an original ant miner pruning for freshly generated rule by the current ant and tries to improve its quality by removing irrelevant terms from the rule antecedent [40]. This process is done iteratively by removing one term at a time. The iterative process will stop when there is no more improvement in the quality of the generated rules while there is removal of terms.

Execute_Pruning=true / A Boolean variable */*

While(Execute_Pruning=true)&& (No.of rules in current antecedent is greater than 1)

Step i: For each term t_i in the current rule to be pruned, temporarily remove the term t_i and evaluate the quality

Step ii: Reinstate term t_i in the rule antecedent

If Rule quality is improved with respect to original rule's quality in some iteration of For loop

Then permanently remove the term whose removal improves the quality of the rule

Else Set Execute_Pruning=False

The time taken by the ant mining pruner is sensitive to the number of attributes added. This is due the fact that the larger the number of attributes in the data being mined, in general the larger the number of terms in the constructed rule before pruning, and so the larger number of iterations in the loops. The quality of the rule can be calculated by the formula below:

Rule Quality =

$$\text{Sensitivity} \times \text{Specificity} = \frac{TP}{TP+FN} \times \frac{TN}{TN+FP} \quad (3)$$

Where,

TP = true positives, the number of cases covered by the rule that have the class predicted by the rule.

FP = false positives, the number of cases covered by the rule that have the class different from the class predicted by the rule

FN = false negative, the number of cases not covered by the rule but have class predicted by the rule

TN = true negative, the number of cases not covered by the rule and that do not have class predicted by the rule

After the pruning method, the best among the rules will be found and the performance analysis of the predicted rules will be known. Finally, the comparisons of rules generated by both the algorithms are done and the performance will be calculated.

V. Experimental Design

5.1 Data Design

The value for these qualitative parameters has been collected from various experts belongs to banks. These parameters are framed as questionnaire and the data have been collected from the experts. Table 2 describes the parameters with its values have been collected from various banks.

Table 2: Qualitative bankruptcy prediction parameters with expert analysis

BANKS	IR	MR	FF	CR	CO	OR	CBF	FD	RP
Syndicate Bank	mid	mid	mid	mid	mid	mid	mid	mid	mid
Karnataka Bank	mid	mid	High	mid	mid	mid	mid	mid	mid
Indian Overseas Bank	mid	mid	High	mid	mid	High	High	mid	mid
Indian Overseas Bank	High	mid	High	mid	mid	mid	High	mid	High
Karur Vysya Bank	High	High	mid	High	High	High	mid	High	mid
UCO Bank	low	mid	low	mid	low	mid	mid	mid	mid
Vijaya Bank	high	high	high	mid	low	high	high	mid	mid
ING Vysya Bank	mid	high	mid	high	low	mid	mid	mid	high
Axis Bank	mid	high	mid	mid	mid	high	mid	mid	mid
Vijaya Bank	mid	high	mid	low	mid	mid	high	high	low
Vijaya Bank	high	mid	high	mid	mid	high	high	mid	mid

Qualitative parameters with its values have been described in Table 2. To generate qualitative bankruptcy prediction rules using ant-miner we have selected parameters from the expert analysis. According to expert analysis the six parameters have been considered as most important parameters to induce rules such as Industry Risk (IR), Management Risk (MR), Financial Flexibility (FF), Credibility (CR), Competitiveness (CO) and Operating Risk (OR). Among the 14 qualitative bankruptcy parameters six parameters have been considered to generate bankruptcy prediction rules. The next section describes about experimentation design of ant-miner algorithm to induce rules for qualitative bankruptcy prediction.

5.2 Experimentation of Ant-Miner

The ant miner algorithm is internally split into two parts for convenient implementation. First is for the generation of rules and second part is for the pruning of the generated rules. Ant-Miner algorithm applied for the discovery of classification rules. The first application of ACO for the classification task has been applied on Medical Data set retrieved from UCI repository. The applied data set are Wisconsin breast cancer, Cleveland heart disease and Hepatitis [33-34]. From these dataset classification rules have been generated using ant-miner. In this experiment we are consideration bankruptcy data which are collected from various banks to induce bankruptcy prediction rules. For this experiment we have applied GUI Ant-Miner. GUI Ant-Miner is a tool for extracting classification rules from data.

VI. Results and Discussion

Qualitative bankruptcy prediction rules are generated using Ant-Miner algorithm. The generated rules have been described in figure 4.

- Rule1 IF FF is high and CR is high and CO is mid THEN Nonbankrupt
- Rule2 IF FF is low and CR is low and CO is low and OP is low THEN Bankrupt
- Rule3 IF FF is high and CO is high THEN Nonbankrupt
- Rule4 IF IR is mid and CR is mid and CO is high THEN Nonbankrupt
- Rule5 IF IR is mid and MR is mid and FF is mid and CO is mid and OP is mid THEN Nonbankrupt
- Rule6 IF MR is high and CR is high and CO is high THEN Nonbankrupt
- Rule7 IF MR is low and FF is low and CR is low CO is low THEN Bankrupt
- Rule8 IF IR is high and MR is high and CO is high THEN Nonbankrupt
- Rule9 IF IR is mid and CO is high and OP is mid THEN Nonbankrupt
- Rule10 IF MR is low and FF is low and CR is low and CO is low and OP is mid THEN Bankrupt

Fig. 4: Qualitative bankruptcy rules induced by Ant-Miner

From this experiment we have obtained different rules to predict the qualitative performance of the business. These generated rules have been applied to predict bankruptcy qualitatively. Rule 1 indicates that financial flexibility is high and credibility is high and Competitiveness is high then the business would not bankrupt. Whereas Rule 2 indicates that financial flexibility is low and credibility is low and Competitiveness is low and operating risk is medium then the business may bankrupt. Rule 3 indicates that financial flexibility is high and competitiveness is high then the business would not bankrupt. These rules can be applied various organizations and bankruptcy status can be identified by using these rules. The qualitative performance of business or any organization can be predicted using these rules. These generated classified rules can reveal the state of the organization.

6.1 KAPPA TEST – Measure of Agreement

It is important to measure the agreement between the classification made by expert and the classifier. This measure indicates the degree to which the subjectivity of experts is incorporated in the model [18]. We adopt Cohen's kappa (1960) as the "measure of agreement". Cohen's kappa measures the agreement between two rater (e.g. an expert and a data mining technique) classifying the same set of cases. Cohen's kappa defines the "measure of agreement" - It depends upon the percentage of matches in each class. A kappa value of 1 indicates a perfect agreement and a kappa value of 0 indicates that agreement is no better.

The result of this experiment has been verified with kappa test to evaluate measure of agreement. The measure of agreement obtained using kappa test for ant-miner is 0.9042 which is very near to perfect agreement. The measure of agreement obtained for ant-miner is compared with previous methodologies which have been applied for qualitative bankruptcy prediction. The comparative analysis of ant-miner with other techniques for kappa test has been depicted in figure 5.

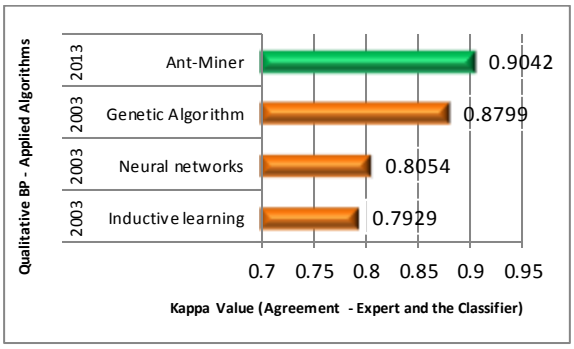

Fig. 5: Ant-Miner & Other Methodologies for Qualitative Bankruptcy Classification

The graph which is depicted in figure 4 indicates that expert decision making knowledge has been incorporated by ant-miner is high compared to other methodologies. Thus the rules generated by ant-miner can be applied to predict bankruptcy qualitatively.

VII. Conclusion

In this research the qualitative bankruptcy prediction rules have been induced by classifying bankruptcy into different classes. For this classification task ant-miner has been applied. The validation of the results has been verified using kappa test based on the factor measure of agreement. In this research data has been validated using 10 fold cross validation. The quality of generated rules has been verified by using rule pruning. The quality of rules can be enhanced by using different rule pruning methodologies. In ant-miner the accuracy of rules can be improved by conducting experiment with larger data set.

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How to cite this paper: A. Martin, T. Miranda Lakshmi, V. Prasanna Venkatesan,"An Analysis on Qualitative Bankruptcy Prediction Rules using Ant-Miner", International Journal of Intelligent Systems and Applications(IJISA), vol.6, no.1, pp.36-44, 2014. DOI: 10.5815/ijisa.2014.01.05

