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Original Article

An Application in Islamic Financial Sector using Data Mining

Hassabelrasul Yousuf AL Tom Shihabeldeen
Prince Sattam Bin Abdul-Aziz University, College of Science & Humanities Studies at Al-Aflaj, KSA

Abstract *- Islamic finance and capital market are one of the fastest-growing segments of international financial markets. Recent innovations in Islamic finance and the capital market have changed the terrain of the landscape of the financial industry. One of them is Islamic securities which are known as Sukuk. The use of Sukuk as the alternative to the existing conventional bond has become increasingly popular in the last few years. They are used as a means of raising government finance through sovereign Sukuk issues and means through which companies raise funds by issuing corporate Sukuk. In addition, theoretically, there should be some differences in rating methodologies for bond and Sukuk because these two instruments are different in nature. Thus, it is the aim of this study to identify the important determinants in Sukuk Rating using a data mining approach. The final model is then implemented into the web application called HZ-RateR.*

Keywords *- Data mining, Decision tree Applications, Sukuk, Islamic financial sector*

I. INTRODUCTION

The development of the Sukuk market has ascended the issue of Sukuk rating. Rating is essential for corporate that issue Sukuk as well as for investors as it will give a general picture of the creditworthiness of a particular Sukuk. The rating not only reflects the risk and expected performance of the Sukuk but also benefits and assist the investor, specifically banks that invest in that particular security, in measuring capital charge for this investment.

Unfortunately, however, there is limited research have been conducted to evaluate the best methods and model in predicting Sukuk rating. As a result, the bond rating prediction model is utilized as a reference as well as the financial distress model, which assess the credit scoring of a particular company. Though these two approaches are considered to have some similarities in rating prediction, the demand for specific studies in Islamic finance, such as Sukuk, is critical [1].

The use of data mining in the financial sector has risen significantly in recent years. Among the examples would include the use of data mining in the marketing sector to predict the likelihood of buyers to purchase certain products or services. The other main use of data mining is to forecast the financial market. Despite the increasing use of data mining in the financial sector, little has been done to examine how such methods could contribute to the landscape Islamic financial sector. Therefore, it is the aim of this paper to improve the previous study on Sukuk rating prediction by incorporating various Sukuk structures through the use of data mining, particularly decision trees. The final model is then implemented into the web application called HZ-RateR.

II. LITERATURE REVIEW

A. Sukuk Rating

Sukuk (plural of sack) had been extensively used by Muslims in the Middle Ages as papers representing financial obligations originating from trade and other commercial activities. However, Sukuk, as applied in the capital markets, pertains to the process of securitization. According to AAOIFI [2], Sukuk is certificates of equal value that represent an undivided interest in the ownership of an underlying asset, usufruct and services or assets of particular projects or special investment activity.

Sukuk certificates are unique in the way that the investor becomes an asset holder. Therefore, he should bear the risk of its underlying assets. Sukuk certificate holders carry the burden of these unique risks. Unlike a bond that is confined to the loan upon interest, Sukuk can be structured from various applications of Islamic financial contracts. Nonetheless, Sukuk has some similarities to conventional bonds because they are structured with physical assets that generate revenue. The underlying revenue from these assets represents the source of income for the payment of profits on the Sukuk. AAOIFI [2] also highlighted that Sukuk is issued on various transaction contracts. These Sukuk are Ijara, Murabaha, Salam, Istisna, Mudaraba and Musharaka, Muzara'a (sharecropping), Muqasa (irrigation) and Mugharasa (agricultural partnership). However, the last three types are rarely used in the market.

In assigning ratings, the rating agencies provide special methodologies and rating scales to accommodate Islamic debt instruments, although the structure of these bonds is rather complex. In addition, the rating agencies also provide opinions on the credit risk associated with such instruments and often do not comment on Shariah issues unless it affects credit risk [3-5].

In relation to credit risk, the rating agencies divide the Sukuk modes based on the recourse over the underlying assets. Currently issued Sukuk can be classified into asset-based and asset-backed Sukuk, which are semantically similar descriptions but mask significant differences in credit risk, thus affecting the rating methodology.

The performance of the underlying asset is the key driver for asset-backed Sukuk, whereas a corporate rating methodology applies to asset-based Sukuk. This implies that the special methodology only utilizes Asset-backed Sukuk. In contrast, to rate asset-based Sukuk, rating agencies adopt a common method to rate conventional bonds. RAM [5] states that the methods employed in rating Islamic debt securities are only slightly different from evaluating the default risk of conventional debt instruments. In the case of a company having an unsecured financial commitment and the company does not make a distinguishable payment priority over the Sukuk investor, then rating agencies apply Corporate Credit Rating (CCR) of the originator or general credit rating methodology.

In the case of financial institutions as the Sukuk originator, the rating assessment will be focused on the financial institution's capability to fulfil the Sukuk obligation.

As most Sukuk issuances are based on an asset-based model, a study in predicting Sukuk rating, therefore, can utilize similar variables used in predicting bond rating.

B. Previous Studies on Bond Rating Predictions

Numbers of studies have been done in predicting the bond rating model. Among early studies tried to formulate alternative approaches in bond rating prediction, including OLS regression such as West [6] to predict Moody's and S&P bond rating.

Pinches and Mingo [7] started to apply Multiple Discriminant analyses (MDA) to improve the statistical fit to develop a model. This attempt was followed by Belkaoui [8], who developed a bond rating model using 8 variables representing the three general variables; firm, market and indenture.

After the era of Belkaoui [8], researchers tried different statistical methods in predicting bond ratings during the 1980s, such as multiple regression analysis, discriminant analysis, logistic regression analysis, and n-dichotomous multivariate probit or logit model. Since the late 1980s, especially during the 2000s, researchers have started to use artificial intelligence models for predicting bond ratings.

Artificial Intelligence Neural Network was introduced for the first time by Dutta and Shekhar [9]. The paper applied a neural network to predict ratings of corporate bonds due to a lack of theory on the bond rating model. A neural network does not require a priori specification of a functional domain model. It rather attempts to learn the underlying domain model from the training input-output examples [9,10]. Dutta and Shekhar compared neural networks with regression using selected six financial variables based on the result of Horrigan [11] and Pinches and Mingo [7].

After the mid-nineties, most of the bond rating prediction studies proposed a modified method to get better performance in terms of accuracy. Subsequently, those studies compared the statistical analysis with their proposed method.

One approach is undertaken by Singleton and Surkan [12], who used a backpropagation neural network to classify bonds of the 18 AT&T Bell Telephone companies and compared a neural network model with MDA. Subsequently, Kwon, Han, and Lee [13] compared a Conventional Neural Network method to their new neural network training approach, namely, Pairwise Ordinal Partitioning. This proposed method is designed to capture the ordinal rating nature of bond rating. At the same period, Chaveesuk, Varee-Ratana, and Smith [10] also compared the prediction rate and accuracy of three Neural Network methods; Radial Basis Function (RBF), Learning Vector Quantization (LVQ) and Back Propagation (BP), with three different logistic regression models (first-order logistic, second-order logistic and stepwise logistic regression methods).

Huang et al. [14] introduced a new machine learning technique, namely support vector machine (SVM). This paper tried to compare the backpropagation neural network as a benchmark with the new technique. Later, Cao et.al [15],

Lee [16]and Hajek and Olej [17] compared SVM with the backpropagation (BP) neural network and traditional statistical methods such as; logistic regression (LR) and ordered probit regression (OPR) with Support Vector Machine (SVM). Hajek and Michalak [18] tried another effort to find the best classifier and performed credit rating prediction. The study was conducted using the following classifier; Multilayer Perceptron (MLP), RBF, SVM, Naïve Bayes (NB), Random Forest (RF), Linear Discriminant Classifier (LDC) and Nearest Mean Classifier (NMC). The result shows RF and NB classifiers were selected as the best prediction.

The only study that predicts Sukuk rating is Arundina and Omar [19]. This study used Ordered Logistic Regression and Multinomial Logistic Regression to create a model of Sukuk rating, which is one from several theoretical variables adapted from C. The result shows 70% for Ordered Logistic and 78.3% for Multinomial Logistic of all valid cases are correctly classified into their original rating classes.

Because of a limited number of samples, this study could not validate the model by having trained and holdout samples. Another limitation was this study did not take into account the different Sukuk structures, which theoretically have different credit risks.

Hence, the current study tries to extend this previous study on Sukuk rating prediction incorporating

various Sukuk structures as well as industrial categories.

III. DATA MINING APPLICATIONS IN THE FINANCIAL SECTOR

The decision tree has become a renowned method in data mining. The increasing use of such a method is due to a number of benefits, among others, is the fact that it is easy to be understood and interpreted. Decision tree also requires a minimum effort of data preparation, able to handle numerical data and categorical, and they perform very well with large data sets in rather a short time [20].

There are two main purposes when using the decision tree. These are to analyze tree classification and to analyze the regression tree analysis. In addition, the decision trees produce excellent visualizations of results and their relationships. Despite there being numerous specific decision tree algorithms, it is noted that the ID3, C4.5, and C5.0 algorithms are the most commonly adopted ones [21].

The decision tree method is rather new in bond rating prediction studies. However, some studies applied this method to build credit scoring models, such as Frydman, Altman and Kao [22], Bastos [23], Novotna [24], Arzy Soltan and Mehrabioun [25].

IV. METHODOLOGY

It is the goal of this study to identify and use a large and feature-rich dataset in order to derive a Sukuk rating. Hence, the data had to be collected from multiple sources as there is only a limited number of Sukuk issuance available even at a global level as compared to conventional securities like a bond.

This study uses both training and holdout samples from Malaysia Sukuk to build the model. Malaysia is chosen as a sample area because 68.75% of Sukuk are issued in Malaysia [26]. This fact confirms Malaysia is the largest Sukuk issuance country in the world.

However, this study only utilizes domestic Sukuk as the rating of International Sukuk is very much influenced by the rating of the issuer country. Rating of International Sukuk cannot exceed the rating of issuer country. This nature of International Sukuk will make a data noise in the prediction model. This limitation will drop the sample size and minimize the scope of the study.

Furthermore, due to confidentiality issues, asset-backed data is not publicly available and accessible. Hence, this study should take out asset-backed Sukuk from the sample as well. However, the number of Sukuk with asset-backed modes is very small in the market. Therefore, it is believed that this sample reduction is not really affecting the sample size.

The training sample is the historical rating of the Sukuk announced by several rating agencies from the first issuance up to the current rating. In order to increase the number of the data, this study will use all rating samples to build the model, predict original cases and test the significance of the variables. A holdout sample will be utilized to test the consistency of the models. Figure 1 shows the number of instances and variables used as the training samples.

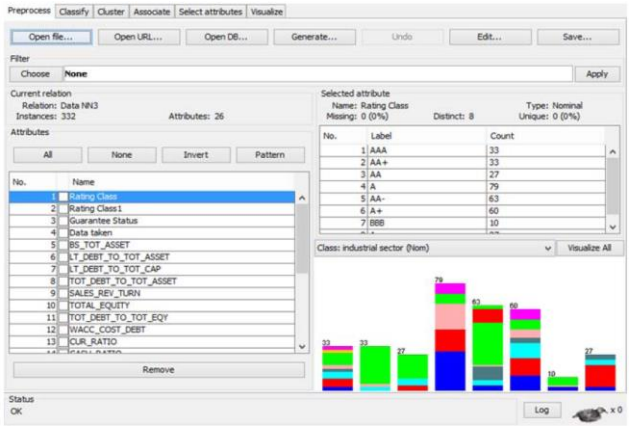

Fig. 1 Details of instances and variables of the training data

Furthermore, it is noted that often important data is missing, thus requiring a 'data cleansing' process to be carried out. The data were then analyzed using the data mining technique (in WEKA explorer application) and statistical analysis. The detail of the research framework is illustrated in Figure 2.

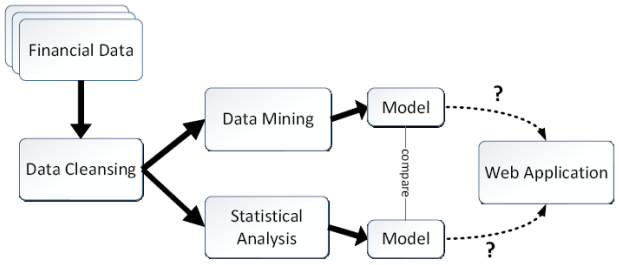

Fig. 2 HZ-RateR Framework

V. RESULTS AND FINDINGS

In this study, the C4.5 algorithm, which is equivalent to the J4.8 algorithm in WEKA explorer, was adopted to analyze the training dataset. Whitten and Frank [20] highlight that the J4.8 algorithm implemented in WEKA is the slightly improved version of the C4.5 algorithm before the commercial implementation C5.0 was released.

In order to determine how well the model developed in this study worked with data in the real world, a subset of records was held back for the testing and validation process. The data set was split, that is 66 per cent for training and generates the model, whereas another 34 per cent is reserved for testing it. For performance analysis, the test data sets were used for assessment.

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=== Summary ===

Correctly Classified Instances         264               84.0764 %
Incorrectly Classified Instances        50               15.9236 %
Kappa statistic                          0.7413
Mean absolute error                      0.0867
Root mean squared error                  0.2667
Relative absolute error                 28.2082 %
Root relative squared error             68.1475 %
Total Number of Instances              314

=== Detailed Accuracy by Class ===

               TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
                 0.771     0.05       0.659     0.771     0.711      0.932    AAA
                 0.875     0.108      0.833     0.875     0.854      0.898    AA
                 0.86      0.079      0.908     0.86      0.884      0.916    A
                 0.333     0.007      0.6       0.333     0.429      0.739    BBB
Weighted Avg.
                 0.841     0.085      0.843     0.841     0.84       0.906
```

Fig. 3 Summary of decision tree result

As can be seen in Figure 3, the overall accuracy rate shows that the model developed in this study has demonstrated a higher performance level (84.08%) compared to the earlier model on Sukuk rating developed by Arundina and Omar [19] using statistical methods, namely Ordered Logistic Regression and Multinomial Logistic Regression.

In addition, through the use of the decision tree technique, the researchers found the influence of a few additional variables to the model, such as GDP, which was not identified previously through the statistical methods. Figure 4 shows the structure of the decision tree.

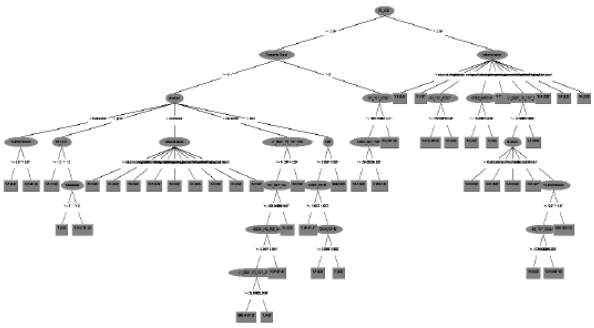

Fig. 4 Structure of decision tree result

The model was then implemented into a web-based application called HZ-RateR. The web application allows financial experts as well as investors to test the model with more recent data. As a result, the data supplied by the experts and public can then be used to continuously improve the existing model. Figure 5 shows the screenshot of the HZ-RateR application.

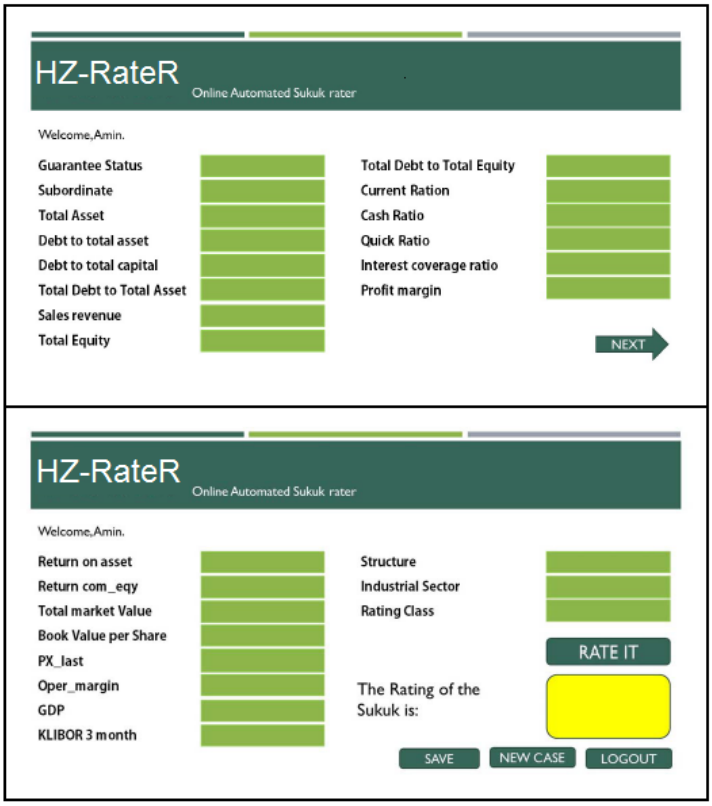

Fig. 5 The interface of the HZ-RateR Web Application

VI. CONCLUSION

The use of Sukuk as the alternative to the existing conventional bond has become increasingly popular in the last few years. It is the aim of this paper to improve the previous study on Sukuk rating prediction by incorporating various Sukuk structures through the use of data mining, particularly decision trees.

The result of the decision tree shows that the model developed in this study demonstrated a higher

performance level (84.08%) compared to the earlier model on Sukuk rating prediction. The final model was then implemented into the web application, called HZ-RateR, to allow financial experts and investors to test the model using more recent data. Finally, our findings corroborate the potential use of data mining analysis in studies related to the Islamic financial sector.

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