Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

Special Issue

DECISION TREE OPTIMIZATION FOR SUKUK RATING PREDICTION

M. Kartiwi[1,*], T. S. Gunawan[2], T. Arundina[3], M. A. Omar[4]

[1]Department of Information Systems, Faculty of Information and Communication Technology, International Islamic University Malaysia, Malaysia

[2]Department of Electrical and Computer Engineering, Faculty of Engineering, International Islamic University Malaysia, Malaysia

[3]Faculty of Economic and Business, Universitas Indonesia, Indonesia

[4]Islamic Research and Training Institute (IRTI), Saudi Arabia

Published online: 01 February 2018

ABSTRACT

Sukuk, an Islamic finance framework for securitization, has increasingly popular in the last few years. The fast growth of Sukuk as Shariah-compliant financial instruments alternative to conventional bond has raised the issue of rating the Sukuk issuance. Recent trade and academic literature show that predicting Sukuk rating has been of interest to potential investors as well as to the firm. Unfortunately, in the current practice, often conventional bond and Sukuk were rated using similar method, hence ignore the fact that these two instruments are different in nature. It is the aim of this research to develop an optimum model to predict Sukuk rating using decision tree approach. Several models were produced using different attribute selection measures, namely gain ratio, Gini index and information gain. The effectiveness of the proposed models were evaluated using dataset on Sukuk issuance for domestic from 2006 to 2015. The results indicate that the decision tree model with Gini index as the criterion performs significantly better than the model produced using decision tree algorithm.

Keywords: Sukuk, rating, prediction, neural network

Author Correspondence, e-mail: mira@iium.edu.my

doi: http://dx.doi.org/10.4314/jfas.v10i2s.25

1. INTRODUCTION

Rating is essential for corporate that issue Sukuk as well as for investors as it will give a general picture of credit worthiness of particular Sukuk. The rating is also valuable for the investor, especially for financial sectors such as banks. It allows the investor to measure the capital charge for such investment, as it shows the risk and expected performance of the Sukuk. However, due to lack of rigorous study had been done to evaluate the best methods and model to predict rating of the Sukuk, often the bond rating prediction model is adopted to assess credit scoring of a particular company.

The high cost associated with performing credit assessments has impelled the necessity to acquire a model for Sukuk rating prediction. This is due to large amount of time and human resources to conduct comprehensive analysis on the risk status of the company based on various aspects needed by the rating agencies. As a result, many businesses are not able to regularly update their Sukuk ratings through rating agencies. Hence, this highlight how valuable Sukuk rating prediction for investment market. In recent years, there has been significant increase in the use of data mining techniques in financial sector. For example, the use of data mining to forecast the financial market or rating of corporate bond. However, little has been done to examine how such techniques could contribute to the landscape Islamic financial sector. Hence, it is the aim of this paper to address such gap in the literature. One of the renown techniques in data mining, decision tree, is used in this study to predict Sukuk rating by incorporating various Sukuk structures.

2. LITERATURE REVIEW

2.1. Conventional Bonds versus Sukuk Bonds

In the secondary market, Sukuk often refers as the Islamic equivalent of bonds. Unlike conventional bonds, however, Sukuk gives investors an asset part along with equal cash flows and risks as opposed to debt ownership. Such securities observe the Islamic law, often referred as Shari'ah principles, which prohibit the collection or payment of interest. Through the release of Sukuk, companies are able to raise capital in a Shariah-compliant fashion. It also allow the companies to expand the investor base and offering investment opportunities for new groups[1].

Table1 provides simple definition and comparison between conventional bonds and Sukuk bonds.

Table 1. Sukuk Bonds vs. Conventional Bonds

	SUKUK BONDS	CONVENTIONAL BONDS
Definition	A fixed income certificate that represents an ownership of underlying assets, services or investments.	Debt security in which borrowed money is repaid in an agreed amount at a specified time.
Expected cash flows	Profit sharing	Interest payments
Concept	• Proof ofownership • Income derived from asset/ service/investments based on original contractual commitment	• Proof ofdebt • Pre-determined periodic repayment of cash flows with pre-setamounts
Structure and principles*	• Profit and losssharing • Leasing	• Zero couponbond • Coupon bearingbonds • Convertible bonds,etc.

Source: www.bpam.com.my

According to Accounting and Auditing Organization for Islamic Financial Institutions (AAIOFI) Standard no.17 [2], Sukuk are 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. As such, the investors as the Sukuk holder, has entitlement to the underlying assets. Consequently, Sukuk holders are entitled to share in the revenues generated by the Sukuk assets.

Another major notable difference between Sukuk and conventional bond is in terms of the investment risks. Sukuk is associated with a risk termed as Shariah compliance risk, which is essential during the structuring stage based on the available Islamic finance 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 payment of profits on the Sukuk. According to AAOIFI [2], Sukuk are 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. Those structures will affect the coupon payment method as well as the risk characteristics. The different nature of bonds and Sukuk in terms of their respective credit risk exposure causes the need for different ratings assessment.

2.2. Data Mining in Financial Sectors: Application of Decision Tree

Decision tree has become a renowned method in data mining. The increasing use of such 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 [3]. There are two main purposes when using decision tree. These are to analyze tree classification and to analyze the regression tree analysis.

Previous research found that decision tree algorithms are relatively stable and accurate [4, 5]. It also produce excellent visualizations of results and their relationships. Another advantage of constructing decision tree is that it does not require any domain knowledge or parameter setting, and therefore is appropriate for exploratory knowledge discovery. Decision tree method is rather new in bond rating prediction studies. However, some studies applied this method to build credit scoring model such as Bastos [7], Frydman, Altman and Kao [6], Novotna [8], Soltan and Mohammadi [9].

Despite there are numerous specific decision tree algorithms, it is noted that the algorithms that most commonly adopted are ID3, C4.5, and C5.0 [10]. The major differences in decision tree algorithms include how the attributes are selected in creating the tree. The attribute selection measure provides a ranking for each attribute describing the given training tuples. There are three popular attribute selection measures, i.e. information gain, gain ratio, and Gini index. Han, Pei and Kamber [11] provides an extensive explanation and examples of how each of these measures can be applied in real-life application. Below are the brief details of these measures [11]:

a. *Information gain attribute selection.* In this measure, the attribute with the highest information gain is chosen as the splitting attribute for node.

Expected information (entropy) needed to classify a tuple in *D*:

Expected information (entropy) needed to classify a tuple in *D*:

(1)

$$Info(D) = -\sum_{i=1}^{m} p_i \log_2(p_i)$$

Information needed (after using *A* to split *D* into *v* partitions) to classify *D*:

$$Info_A(D) = -\sum_{j=1}^{v} \frac{|D_j|}{|D|} \times I(D_j) \quad (2)$$

Information gained by branching on attribute *A*:

$$Gain(A) = Info(D) - Info_A(D) \quad (3)$$

b. *Gain Ratio attribute selection.* It is a modification of information gain in order to reduce its bias. This method takes the number and size of branches i nto account when choosing an attribute.

$$SplitInfo_A(D) = -\sum_{j=1}^{v} \frac{|D_j|}{|D|} \times \log_2\left(\frac{|D_j|}{|D|}\right) \quad (4)$$

$$GainRatio(A) = \frac{Gain(A)}{SplitInfo\ A} \quad (5)$$

c. *Gini Index attribute selection.* The Gini index measures the impurity of the data partition.

$$gini(D) = 1 - \sum_{j=1}^{n} p_j^2 \quad (6)$$

3. Data Pre-processing

3.1. Sukuk Issuance Dataset

The training sample is based on historical rating of the Sukuk announced by several rating agencies from 2006 to 2015. In this study, the data used in the training and validation was collected from Bond Pricing Agency Malaysia database and Bloomberg. Whereas, for Sukuk structure, the data were collected from MARC website and Rating Agency Malaysia (RAM). All Sukuk with ratings from AAA to BBB were included in the study.

It is noted that the technique chosen in this study, i.e. decision tree, is prone to over fitting problem [11]. In other words, if the training set to measure the model accuracy, the estimate generated would likely be optimistic, because the classifier tends to overfit the data. To address such issue, this study performed a stratified 10-fold cross-validation technique was selected to estimate the accuracy of the model generated using each attribute selection criterion.

3.2. Variable Selection

In this study, the variable selection was based on previous study conducted by Altman [12]. The most common variables used in previous studies which important and relevant to Sukuk rating were included in the building the prediction model. According to previous research, liquidity, profitability and leverage ratios are also constantly used and considered to be some important indicators for bond rating prediction. Some studies consider qualitative variable as additional information of the company, such as subordination, guarantee status, or tax burden.

Market variables such as credit spread, stock price volatility, or GDP are rarely used by bond rating previous studies. However, Niklis, Doumpos, and Zopounidis [14] and Hajek and Michalak [13] believe that a market variable is an important indicator to capture the situation of the company or particular security. As such, the market variable is included in the prediction model.

4. RESULTS AND FINDINGS: COMPARISON ON DECISION TREE MODELS

In this section, the performance of the three decision tree models constructed using information gain, gain ratio and Gini index as the criterion for attribute selection will be discussed.

The decision tree models were built with confidence level of 0.3 and minimal gain of 0.4. As mentioned earlier in this paper, in testing the model, stratified 10-fold cross validation technique was selected in this study. Table 2 shows summary of the model performance constructed in this

study.

Table 2. Class Precision and Overall Model Performance

Model	Attribute Selection Criterion	Class Precision (Percentage)				Overall Model Performance (Percentage)	Attribute at the Root Node
		AAA	AA	A	BBB		
A	**Information Gain**	85.29	88.33	90.79	50.00	88.28	Guarantee Status
B	**Gain Ratio**	78.38	86.67	88.59	50.00	85.71	Guarantee Status
C	**Gini Index**	86.84	89.83	94.59	50.00	90.45	Industrial Sector

As can be seen in Table 2, the results indicated that the decision tree with Gini index (Model C) is the best predictor with 90.45% accuracy. This model also has a better class precision, particularly in predicting Sukuk with AAA, AA and A rating. The decision tree model built using information gain criterion (Model A) came out to be the second with 88.28% accuracy. The model built using gain ratio as the attribute selection measure (Model

B) came out to be the worst of the three with 85.71% accuracy.

It is also interesting to note that guarantee status is the attribute selected as the root node for Model A and B, whereas industrial sector is selected as the root node in model C when Gini index criterion isused.

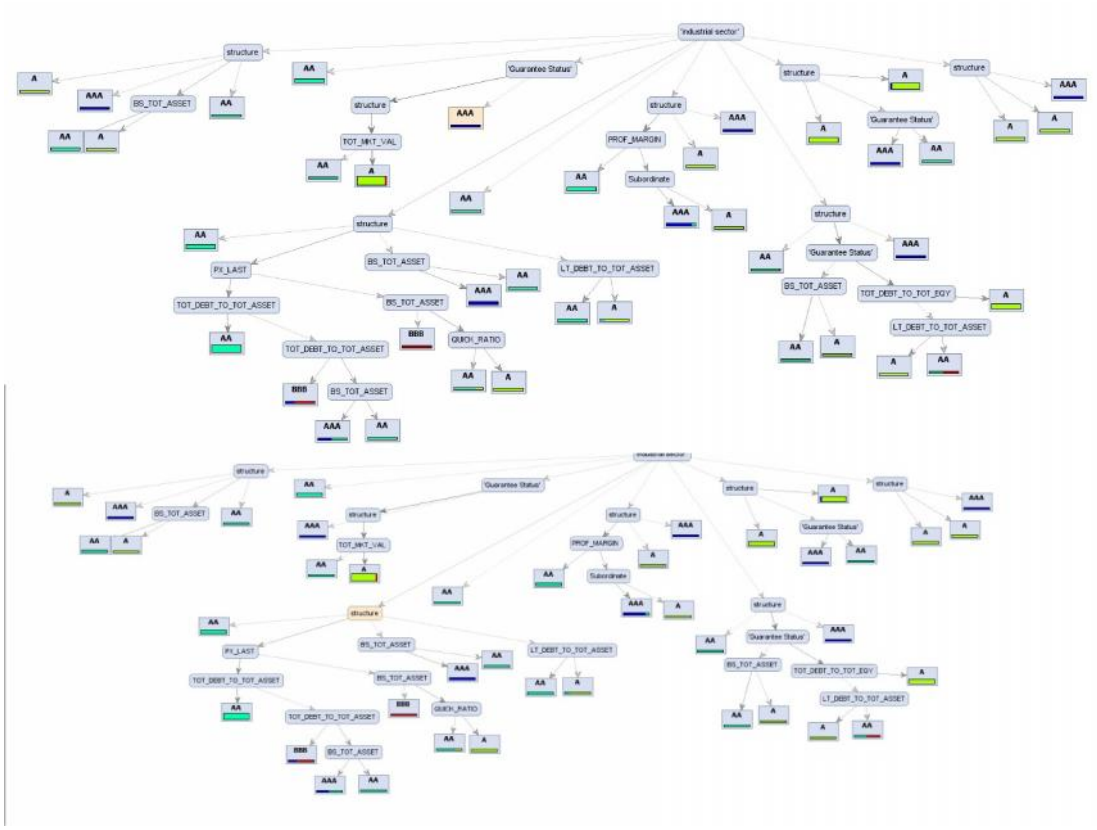

Fig.1. Structure of decision tree using Gini index attribute selection measure

One of the benefits of adopting decision tree in knowledge discovery is to visualize the path to each decision, or often called as rule induction. For every path from the root node of the tree to one of its leaves can be translated into a rule by connecting the tests along the path to form the antecedent part, and selecting the leaf's class prediction as the class value. For example, one of the paths in Figure.1 can be articulated into the rule: "If industrial sector is property, and the structure is murabahah, then the rating of the sukuk is A". Such set of rules can then be simplified to improve its comprehensibility to a human user, and possibly its accuracy[15].

CONCLUSIONS AND FUTURE RESEARCH

This study compares three models generated using decision tree based on three different attribute selection measures to predict corporate Sukuk ratings. From the classification accuracy, it can be concluded that in this study, the model generated using Gini index provides better performance as compared to other criterion. It is also interesting to note that in this model, the industrial sectors

variable was selected as the topmost decision node in a tree which corresponds to the best predictor (root node). These findings are expected to enrich the literature and have practical implications. This model is expected to be useful for the rating agencies to perform a shadow rating, for issuing companies and fund managers to conduct their own credit analysis for risk management and trading purposes. In addition, these models can be of use to banks that rely on rating systems in order to improve the risk-assessment techniques, pricing strategies, and provisioning levels as require in BaselIII.

Empirical results are also expected to contribute a wealth of knowledge to the development of Islamic finance while encouraging analysts and academic researchers to develop other potential research related to this topic. Future research is needed to compare the asset-backed Sukuk and the asset based Sukuk. In addition, it is noted that the issue of guarantee status has not been extensively explored in this study. Yet, there are various types of guarantee status or binding agreements in accordance with the structure of Sukuk. Hence, future research is needed to further study the role of various types of this guarantee status so as to give a better picture with regard to Sukuk credit risk profile.

5. ACKNOWLEDGEMENTS

The researchers in this study would like to acknowledge the International Islamic University Malaysia (IIUM) for the financial funding of this research through the Research Initiatives Grant Scheme (RIGS) RIGS15-070-0070.

6. REFERENCES

[1] A. A. Tariq, "Managing Financial Risks of Sukuk Structures," Loughborough University, Leicestershire, United Kingdom,**(2004)**.

[2] AAOIFI., *Accounting and Auditing Organization of Islamic Financial Institutions*,2005.

[3] I. H. Whitten, and E. Frank, *Data Mining: Practical Machine Learning Tools and Techniques*, 2nd ed ed.: Morgan Kaufman,**(2005)**.

[4] K. S. Kim, and K. H. Kim, "A prediction model for internet game addiction in adolescents: using a decision tree analysis," *Journal of Korean Academy of Nursing*, vol. 40, no. 3, pp. 378-388,**(2010)**.

[5] R. K. Lai, C.-Y. Fan, W.-H. Huang, and P.-C. Chang, "Evolving and clustering fuzzy decision tree for financial time series data forecasting," *Expert Systems with Applications,* vol. 36, no. 2, pp. 3761-3773,**(2009)**.

[6] H. Frydman, E. I. Altman, and D. L. KAO, "Introducing recursive partitioning for financial classification: the case of financial distress," *The Journal of Finance,* vol. 40, no. 1, pp. 269- 291,**(1985)**.

[7] J. A. Bastos, "Forecasting bank loans loss-given-default," *Journal of Banking & Finance,* vol. 34, no. 10, pp. 2510-2517, **(2010)**.

[8] M. Novotná, "The use of different approaches for credit rating prediction and their comparison," **(2012)**.

[9] A. Soltan, and M. Mohammadi, "A hybrid model using decision tree and neural network for credit scoring problem," *Management Science Letters,* vol. 2, no. 5, pp. 1683-1688,**(2012)**.

[10] D. Delen, C. Kuzey, and A. Uyar, "Measuring firm performance using financial ratios: A decision tree approach," *Expert Systems with Applications,* vol. 40, no. 10, pp. 3970-3983, **(2013)**.

[11] J. Han, J. Pei, and M. Kamber, *Data mining: concepts and techniques*: Elsevier,**(2011)**.

[12] E. I. Altman, "Financial ratios, discriminant analysis and the prediction of corporate bankruptcy," *The journal of finance,* vol. 23, no. 4, pp. 589-609,**(1968)**.

[13] P.Hajek,andK.Michalak,"Featureselectionincorporatecreditratingprediction," *Knowledge-Based Systems,* vol. 51, pp. 72-84, 2013/10/01/, **(2013)**.

[14] D. Niklis, M. Doumpos, and C. Zopounidis, "Combining market and accounting-based models for credit scoring using a classification scheme based on support vector machines," *Applied Mathematics and Computation,* vol. 234, pp. 69-81,**(2014)**.

[15] J. R. Quinlan, "Simplifying decision trees," *International Journal of Human-Computer Studies,* vol. 51, no. 2, pp. 497-510, 1999/08/01/, **(1999)**.

How to cite this article:
Kartiwi M, Gunawan T S, Arundina T, Omar M A. Decision tree optimization for sukuk rating prediction. J. Fundam. Appl. Sci., 2018, *10(2S), 323-332.*