



# Going-concern prediction using hybrid random forests and rough set approach



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## ABSTRACT

Corporate going-concern opinions are not only useful in predicting bankruptcy but also provide some explanatory power in predicting bankruptcy resolution. The prediction of a firm's ability to remain a going concern is an important and challenging issue that has served as the impetus for many academic studies over the last few decades. Although intellectual capital (IC) is generally acknowledged as the key factor contributing to a corporation's ability to remain a going concern, it has not been considered in early prediction models. The objective of this study is to increase the accuracy of going-concern prediction by using a hybrid random forest (RF) and rough set theory (RST) approach, while adopting IC as a predictive variable. The results show that this proposed hybrid approach has the best classification rate and the lowest occurrence of Types I and II errors, and that IC is indeed valuable for going-concern prediction.

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## 1. Introduction

The going-concern principle is one of the most important accounting assumptions in the preparation of financial statements. According to this principle, an entity or organization will continue its operations into the foreseeable future, at least, or in perpetuity. A going-concern opinion implies that the entity is not at risk of liquidation or even of reducing the scale of its operations substantially, whether voluntarily or involuntarily. Although auditors are not responsible for predicting bankruptcy or future events, according to Chen and Church [15], "going-concern opinions are useful in predicting bankruptcy and provide some explanatory power in predicting bankruptcy resolution." Thus, going-concern prediction has been the focus of rigorous research efforts for decades. In particular, several researchers have suggested prediction models to aid auditors in conducting going-concern assessments of firms.

Prior studies on going-concern prediction are based primarily on conventional statistical techniques [22,34] such as univariate statistical methods, multiple discriminant analysis (MDA), and logit and probit analyses. These conventional statistical methods, however, have some restrictive assumptions such as the linearity, normality, and independence of predictor or input variables. Considering that the violation of these assumptions occurs frequently within financial data [18], the methods have intrinsic limitations in terms of effectiveness and validity. Recently, Bellovary et al. [6] had undertaken an extensive review of going-concern prediction.

Artificial intelligence (AI) approaches such as inductive learning are less vulnerable to these violations. Moreover, AI aims to identify valid, novel, potentially useful, and understandable correlations and patterns in data [6]. AI can be an alternative solution to classification problems, given that data mining has shown to have better predictive capability than conventional

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statistical methods of going-concern prediction [2,23,26,35,37,40]. Although the above-mentioned AI techniques have generally been shown to be effective in going-concern prediction, they are not without limitations.

First, since McKee [42] used financial ratios for going-concern prediction, most studies have primarily used financial ratios as independent variables. Financial ratios, originating in the financial statements of firms, can reflect some characteristics of a corporation. However, in the current knowledge era, the core competences of firms are derived from the knowledge and skills of their employees, and the value of intellectual capital (IC) now exceeds that of some tangible assets. Moreover, numerous researchers have recognized that the nature of a firm's IC plays an important role in its risk of bankruptcy [57,59]. Despite the growing importance of IC for firms in the knowledge era, it is usually excluded from early prediction models. Therefore, in this study, we believe that IC, which reflects the status of the corporation in going-concern predictions, will be a decisive factor that influences the predictive capability. Second, the studies mentioned above show that different researchers have used different independent variables as inputs for going-concern prediction. However, a few of the researchers used independent variables as a module of their going-concern prediction. These researchers did not pay much attention to finding and selecting important independent variables. Moreover, few studies employed these variables to generate the appropriate rules for going-concern decisions.

Recently, rough set theory (RST) [48–51] is a relatively new approach in AI that has been extensively used for knowledge reasoning and knowledge acquisition. Using the concepts of lower and upper approximations in rough sets, the knowledge hidden in the information systems can be unraveled and expressed in the form of “if ..., then ...” decision rules [1,47,50,51,60,62]. The extracted rules are easily interpretable, permitting complex relationships to be represented in an intuitive and comprehensible manner. The rules establish a relationship between descriptions of objects based on attributes and their assignment to specific classes. Moreover, the rules can be used for the classification of new objects [36]. Recently, it has found its application in a wide variety of fields including credit rating [17,64], business failure [7,61], knowledge acquisition [60], market decision-making [48], and early warning [7,54], etc. Therefore, we attempt to investigate the effectiveness of RST approach in conducting the going-concern prediction tasks and to predict the characteristics of going-concern so decision-makers can understand the rules of going-concern.

Moreover, to determine and select important independent variables in the development of a going-concern prediction model, the random forest (RF) method is used in this study. RF is a relatively newer ensemble method that combines trees grown on bootstrap samples of data and a random subset bagging of predictor variables [10]. During the randomization of features, RF can provide an importance index of independent variables by calculating accuracy and the Gini index. Furthermore, the importance index captures the interactions among predictors through the randomizations of predictors [40]. In terms of robustness to outliers and noise, and calculation time, RF is superior to other machine learning methods such as bagging or boosting.

In order to make great use of the advantages of RF in preprocessing the business data, and further improve the classification accuracy of the RST predictor model, RF + RST is proposed to predict the going-concern in this work. Moreover, we examine whether an assessment of a corporation's IC conveys any useful additional predictors in going-concern prediction. First, we use IC as a predictive (independent) variable. Second, RF is used to conduct variable selection because of its reliability in obtaining the significant independent variables. Third, the obtained significant independent variables from RF are used as inputs for the RST model. Fourth, we generate meaningful rules using RST for going-concern prediction. Fifth, to validate the effectiveness of our model, comparative experiments are conducted. Finally, to examine the effect of IC, we also compare the obtained results to see whether the model including IC gives better classification accuracy.

The remainder of this paper is organized as follows: In Section 2, we conduct a literature review about going-concern prediction and IC. In Section 3, we present the methodologies used in previous research, which are relevant to our paper for RF and RST. In Section 4, we describe the experimental design of this study. In Section 5, we summarize and discuss the empirical results. Finally, in Section 6, we present the conclusions of this study and discuss the future research directions.

## 2. Literature review

### 2.1. Going-concern

Going-concern prediction as a concept remains one of the most controversial areas of the auditing profession and has received much criticism since its origin in the eighteenth century. Lenard et al. [37] state that the auditor must provide the annual audit report on the financial condition of a company, which is consolidated with the company's financial statements. One of the important things that an audit report should address is the likelihood of the survival of the company (remain a going-concern). A modified audit report on going-concerns indicates that an auditor's evaluation can show whether the survival of the company is under threat or not.

There is substantial literature on going-concern prediction. We categorized the methods extensively used in prior research into statistical methods and AI methods.

### 2.2. Statistical methods

In light of the difficulty of going-concern assessment, numerous prior studies on going-concern prediction using publicly available information have employed statistical techniques such as univariate statistical methods, multivariate discriminant

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