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Evaluation of clustering algorithms for financial risk analysis using MCDM methods

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ABSTRACT

The evaluation of clustering algorithms is intrinsically difficult because of the lack of objective measures. Since the evaluation of clustering algorithms normally involves multiple criteria, it can be modeled as a multiple criteria decision making (MCDM) problem. This paper presents an MCDM-based approach to rank a selection of popular clustering algorithms in the domain of financial risk analysis. An experimental study is designed to validate the proposed approach using three MCDM methods, six clustering algorithms, and eleven cluster validity indices over three real-life credit risk and bankruptcy risk data sets. The results demonstrate the effectiveness of MCDM methods in evaluating clustering algorithms and indicate that the repeated-bisection method leads to good 2-way clustering solutions on the selected financial risk data sets.

1. Introduction

Financial risks are uncertainties associated with any form of financing, including credit risk, business risk, investment risk, and operational risk. Financial data analysis, which is also called business intelligence [38], can help companies to detect financial risks in advance, take appropriate actions to minimize the defaults, and support better decision-making [22,63]. Supervised and unsupervised learning methods are two major techniques used in financial risk analysis. Though supervised learning may achieve high prediction accuracy (see for examples, [46]), they are inapplicable when financial data have no predefined class labels. Unsupervised learning methods can not only find underlying structures in unlabeled data, but also provide labeled data for supervised methods.

As one of the most important types of unsupervised learning methods, clustering algorithms have been widely used in financial risk analysis [58]. Brockett et al. [9] presented a study using Kohonen's Self Organizing Feature Map (SOM) to uncover automobile bodily injury claims fraud. Cox [16] developed a fuzzy system for detecting anomalous behaviors in healthcare provider claims based on unsupervised neural network and fuzzy logic. Moreau et al. [45] applied unsupervised neural networks to identify fraud in mobile communications. Williams and Huang [69] combined k-means clustering method and supervised method for insurance risk analysis. Yeo et al. [72] used hierarchical clustering technique for risk predicting in the automobile insurance industry.

Performance evaluation of learning methods is an important topic in financial risk management. The algorithm evaluation problem in general is a central issue in fields like artificial intelligence, operations research, machine learning, and data

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mining and knowledge discovery [28,32,55,66]. Whereas supervised learning methods can be assessed using measures such as accuracy and precision, the evaluation of clustering algorithms is much harder due to the very nature of cluster analysis [70] and has been studied for years (e.g. [26,31,40–44,68]).

In 2010, Rokach [62] suggested that the algorithm selection can be considered as a multiple criteria decision making (MCDM) problem and MCDM techniques can be used to select the best ensemble method for a problem in hand. Since evaluation of clustering algorithms involves more than one criterion, such as entropy, Dunn's index, and computation time, it can also be modeled as a MCDM problem. The objective of this paper is to propose an MCDM-based approach for clustering algorithms evaluation in the domain of financial risk analysis. Though there are many studies assessing the qualities of clustering methods, few, if any, have analyzed this problem using a combination of multiple criteria. The experimental study of this paper, which selects six clustering algorithms, eleven selection criteria, three MCDM methods, and three real-life financial data sets, is designed to validate the proposed approach.

The rest of this paper is organized as follows: Section 2 describes the research approach, clustering algorithms, performance measures, and MCDM methods; Section 3 presents details of the experimental study that evaluates the clustering algorithms using three financial risk data sets; Section 4 concludes the paper with summaries and future research directions.

2. Research methodology

This paper proposes an MCDM-based approach to evaluate the clustering results in financial risk analysis. The empirical study chooses six clustering algorithms, eleven validity measures, and three MCDM methods to validate the evaluation approach (see Fig. 1). This section provides details of the proposed evaluation approach, clustering algorithms, performance measures, and MCDM methods.

2.1. MCDM-based approach for clustering algorithms evaluation

Assessing the quality of a clustering algorithm, also called cluster validation, is one of the fundamental questions that need to be addressed in clustering analysis. However, this task is intrinsically difficult because of the lack of objective measures.

There are three major types of cluster validation methods [36]: external assessment, internal examination, and relative test. An external assessment compares the predicting labels to the actual class labels. Though this type of assessment is objective, it requires a priori structure of data, which is often unavailable in cluster analysis. An internal criterion judges clustering algorithms according to the structures of resulting clusters. An algorithm is regarded as good if the resulting clusters have high intra-class similarities and low inter-class similarities (e.g., [24]). A relative test takes user needs into consideration [18,35]. Subjective criteria, such as interpretability [7], computation complexity, and visualization (e.g., [8,61]), can be incorporated into the evaluation process. Besides these three types of methods, assessing clustering algorithms of a fuzzy partitioning of data or using fuzzy criteria have also been investigated (e.g., [5,34,53,54]).

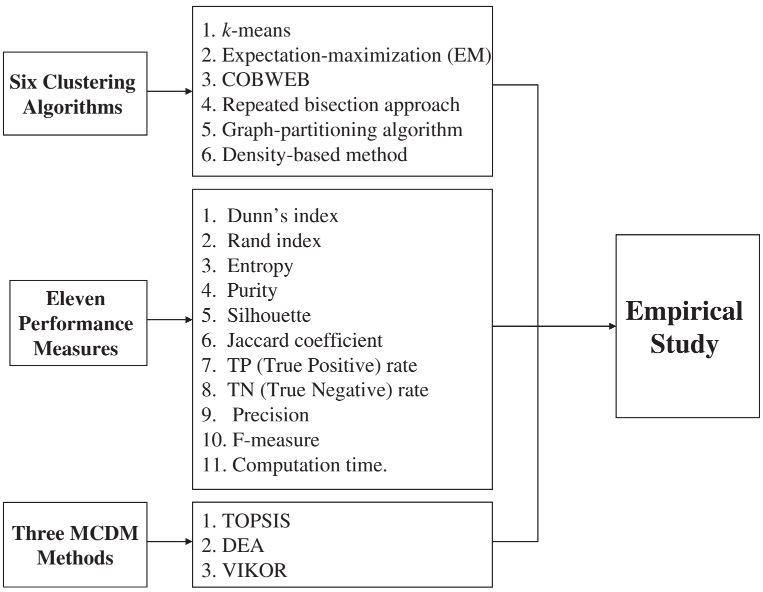

Fig. 1. Clustering algorithms, validity measures, and MCDM methods used in this study.