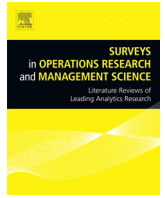




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Review

Classification methods applied to credit scoring: Systematic review and overall comparison

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ABSTRACT

The need for controlling and effectively managing credit risk has led financial institutions to excel in improving techniques designed for this purpose, resulting in the development of various quantitative models by financial institutions and consulting companies. Hence, the growing number of academic studies about credit scoring shows a variety of classification methods applied to discriminate good and bad borrowers. This paper, therefore, aims to present a systematic literature review relating theory and application of binary classification techniques for credit scoring financial analysis. The general results show the use and importance of the main techniques for credit rating, as well as some of the scientific paradigm changes throughout the years.

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1. Introduction

The need for credit analysis was born in the beginning of commerce in conjunction with the borrowing and lending of money, and the purchasing authorization to pay any debt in future. However, the modern concepts and ideas of credit scoring analysis emerged about 70 years ago with Durand [1]. Since then, traders have begun to gather information on the applicants for credit and

catalog them to decide between to lend or not certain amount of money [2–4].

According to Thomas et al. [5] credit scoring is “a set of decision models and their underlying techniques that aid credit lenders in the granting of credit”. A broader definition is considered in the present work: credit scoring is a numerical expression based on a level analysis of customer credit worthiness, a helpful tool for assessment and prevention of default risk, an important method in credit risk evaluation, and an active research area in financial risk management.

At the same time, the modern statistical and data mining techniques have given a significant contribution to the field of

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information science and are capable of building models to measure the risk level of a single customer conditioned to his characteristics, and then classify him as a good or a bad payer according to his risk level. Thus, the main idea of credit scoring models is to identify the features that influence the payment or the non-payment behavior of the customer as well as his default risk, occurring as the classification into two distinct groups characterized by the decision on the acceptance or rejection of the credit application [6].

Since the Basel Committee on Banking Supervision released the Basel Accords, specially the second accord from 2004, the use of credit scoring has grown considerably, not only for credit granting decisions but also for risk management purposes. The internal rating based approaches allow the institutions to use internal ratings to determine the risk parameters and therefore, to calculate the economic capital of a portfolio Basel III, released in 2013, render more accurate calculations of default risk, especially in the consideration of external rating agencies, which should have periodic, rigorous and formal comments that are independent of the business lines under review and that reevaluates its methodologies and models and any significant changes made to them [7,8].

Hence, the need for an effective risk management has meant that financial institutions began to seek a continuous improvement of the techniques used for credit analysis, a fact that resulted in the development and application of numerous quantitative models in this scenario. However, the chosen technique is often related to the subjectivity of the analyst or state of the art methods. There are also other properties that usually differ, such as the number of datasets applied to verify the quality of performance capability or even other validation and misclassification cost procedures. These are natural events, since credit scoring has been widely used in different fields, including propositions of new methods or comparisons between different techniques used for prediction purposes and classification.

A remarkable, large and essential literature review was presented in the paper by Hand and Henley [9], which discusses important issues of classification methods applied to credit scoring. Other literature reviews were also conducted but only focused on some types of classification methods and discussion of the methodologies, namely Xu et al. [10], Shi [11], Lahsasna et al. [12] and Nurlybayeva and Balakayeva [13]. Also, Garcia et al. [14] performed a systematic literature review, but limiting the study to papers published between 2000 and 2013, these authors provided a short experimental framework comparing only four credit scoring methods. Lessmann et al. [15] in their review considered 50 papers published between 2000 and 2014 and provided a comparison of several classification methods in credit scoring. However, it is known that there are several different methods that may be applied for binary classification and they may be encompassed by their general methodological nature and can be seen as modifications of others usual existing methods. For instance, linear discriminant analysis has the same general methodological nature of quadratic discriminant analysis. In this sense, even though Lessmann et al. [15] considered several classification methods they did not consider general methodologies as genetic and fuzzy methods.

In the most general point of view of operational research (OR) and management science (MS), regardless of the close relationship of both terms, as the use as synonyms or frequently used together OR/MS. The MS can be defined as the application of a scientific approach to solving management problems in order to help managers make better decisions [16]. On the other hand, OR can be interpreted as a mathematical and computer modeling emphasized in the approaches at the expense of systems thinking [17]. In this paper, a MS focus is considered broader, addressing the more general question of the application of the scientific method and knowledge

to problems of management, while an OR focus is considered addressing mathematical decision solutions, as the studies whose objective is only to build a powerful model.

In this paper, therefore, we aim to present a more general systematic literature review over the application of binary classification techniques for credit scoring, which features a better understanding of the practical applications of credit rating and its changes over time. In the present literature review, we aim to cover more than 20 years of research (1992–2015) including 187 papers, more than any literature review already carried out so far, completely covering this partially documented period in different papers. Furthermore, we present a primary experimental simulation study under nine general methodologies, namely, neural networks, support vector machine, linear regression, decision trees, logistic regression, fuzzy logic, genetic programming, discriminant analysis and Bayesian networks, considering balanced and unbalanced databases based on three retail credit scoring datasets. We intend to summarize researching findings and obtain useful guidance for researchers interested in applying binary classification techniques for credit scoring.

The remainder of this paper is structured as follows. In Section 2 we present the conceptual classification scheme for the systematic literature review, displaying some important practical aspects of the credit scoring techniques. The main credit scoring techniques are briefly presented in Section 3. In Section 4 we present the results of the systematic review under the eligible reviewed papers, as well as the systematic review over four different time periods based on a historical economic context. In Section 5 we compare all presented methods on a replication based study. Final comments in Section 6 end the paper.

2. Survey methodology

A systematic review is an adequate alternative for identifying and classifying key scientific contributions to a field on a systematic, qualitative and quantitative description of the content in the literature. Interested readers can refer to Hachicha and Ghorbel [18] for more details on systematic literature review. It consists of an observational research method used to systematically evaluate the content of a recorded communication [19].

Overall, the procedure for conducting a systematic review is based on the definition of sources and procedures for the search of papers to be analyzed, as well as on the definition of instrumental categories for the classification of the selected papers, here based on four categories to understand the historical application of the credit scoring techniques: year of publication, title of the journal where the paper was published, name of the co-authors, and conceptual scheme based on 13 questions to be answered under each published paper. For this purpose, there is a need for defining the criteria to select credit scoring papers in the research scope. Thus, two selection criteria are used in this paper to select papers related to the credit scoring area to be included in the study:

- The study is limited to the published literature available on the following databases: ScienceDirect, Engineering Information, Reaxys and Scopus, covering 20,500 titles from 5000 publishers worldwide.
- The systematic review restricts the study eligibility to journal papers in English, especially considering 'credit scoring' as a keyword related to 'machine learning', 'data mining', 'classification' or 'statistic' topics. Other publication forms such as unpublished working papers, master and doctoral dissertations, books, conference proceedings, white papers and others are not included in the review. The survey horizon covers a period of almost two decades: from January 1992 to December 2015.

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