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Bankruptcy prediction
Application of the Taylor's expansion in logistic regression

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Abstract

The purpose of the present study is to test whether Taylor's series expansion can be used to solve the problem associated with the functional form of bankruptcy prediction models. To avoid the problems associated with the normality of variables, the logistic model to describe the insolvency risk is applied. Taylor's expansion is then used to approximate the exponent of the logistic function, or the logit. The cash to total assets, cash flow to total assets, and shareholder's equity to total assets ratios operationalize the factors affecting the insolvency risk. The usefulness of Taylor's model in bankruptcy prediction is evaluated applying the logistic regression model to the data from the Compustat database. The classification accuracy in the test data for the first and second years before bankruptcy show that the classification accuracy of a simple financial ratio model can be increased using the second-order and interaction terms of these ratios. However, in the third year, for the test data, Taylor's expansion is not able to increase the classification accuracy when compared with the first-order model.

Keywords: Bankruptcy prediction; Logistic regression analysis; Taylor's expansion; US data

1. Introduction

The main problems in constructing bankruptcy prediction models are the choice of the independent variables and the functional form between these variables. Ideally, we have an economic theory of bankruptcy that gives advice about what financial variables are important and what is the functional relationship between them (for theoretical approaches, see Jones, 1987, pp. 134–136). However, in most bankruptcy prediction studies, the independent

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variables are empirically chosen, for example, by importance in previous studies, statistical univariate significance, factor analysis, or alternative stepwise and searching methods (stepwise discriminant or logit analysis, genetic algorithm, etc.). Theoretical approaches to variable selection are rare. Examples of these kinds of studies are Aziz, Emanuel, and Lawson (1988), which was based on Lawson's cash flow identity, Scott (1981), on the gambler's ruin model, and Keasey and Watson (1987), on Argenti's hypotheses. Generally; however, these theoretical grounds are too simplified or too indefinite to give advice for the selection of the functional form of the model.

The most popular functional forms used by bankruptcy researchers are linear (linear discriminant analysis) and logistic (logistic regression analysis). Linear function assumes full linear compensation between the independent variables, which seldom holds. Quadratic discriminant analysis proposes a more general relationship, which is a quadratic function. However, both linear and quadratic discriminant analyses are sensitive to deviations from multivariate normality (see Karels & Prakash, 1987; Richardson & Davidson, 1983). Furthermore, the quadratic function seems to be more sensitive than the linear one and is therefore only seldom applied in bankruptcy prediction studies. Logistic regression analysis does not assume multivariate normality, but is, however, exposed to a full linear compensation between the variables in the exponent of the logistic function. A solution for the functionality problem is the use of neural networks that are able to describe rather general relationships (see Tam & Kiang, 1992; Wilson & Sharda, 1994). However, there are obvious overfitting dangers and also certain interpretative difficulties in neural network methodology (see Trigueiros & Taffler, 1996).

The purpose of the present study was to test whether Taylor's series expansion can be used to solve the problems associated with the functional form of bankruptcy prediction models. Taylor's expansion can be used to approximate any function that is continuous and has continuous derivatives (see, for example, Kreyszig, 1988, pp. 823–829). However, the application of the expansion is reasonable only when the number of explanatory variables is limited. Therefore, the problem associated with the choice of the independent variables must be solved first. This problem was solved in this study using theoretical analyses of the bankruptcy concept. Empirically, the main problem may be associated with the normality of the explanatory variables when the linear discriminant analysis is applied. To avoid this problem, the logistic regression analysis was applied in this study and Taylor's expansion was used to approximate the exponent of the logistic function. Note that Taylor's expansion includes the interaction terms of the explanatory variables. In addition to the nonlinearity, this may be an important characteristic that allows us to specify bankruptcy, or more generally, insolvency risk more carefully than with pure independent variables: financial bankruptcy (insolvency) determinants no doubt depend on each other.

The content of the paper is organized as follows. In Section 1, the objective and background of the study were briefly presented. Section 2 deals with the analysis of insolvency determinants, the logistic function, and Taylor's expansion. In this section, the variables used in the empirical part are justified on the basis of the insolvency concept. Insolvency is defined here, following Beaver (1966, p. 71), as the inability of a firm to pay its financial obligations as they mature. The determinants of this concept are classified into