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A comparison of neural network and multiple regression analysis in modeling capital structure

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Abstract

Empirical studies of the variation in debt ratios across firms have used statistical models singularly to analyze the important determinants of capital structure. Researchers, however, rarely employ non-linear models to examine the determinants and make little effort to identify a superior prediction model. This study adopts multiple linear regressions and artificial neural networks (ANN) models with seven explanatory variables of corporation's feature and three external macro-economic control variables to analyze the important determinants of capital structures of the high-tech and traditional industries in Taiwan, respectively. Results of this study show that the determinants of capital structure are different in both industries. The major different determinants are business-risk and growth opportunities. Based on the values of RMSE, the ANN models achieve a better fit and forecast than the regression models for debt ratio, and ANNs are cable of catching sophisticated non-linear integrating effects in both industries. It seems that the relationships between debt ratio and independent variables are not linear. Managers can apply these results for their dynamic adjustment of capital structure in achieving optimality and maximizing firm's value.

Keywords: Capital structure; Multiple regression model; Artificial neural network model

1. Introduction

Regarding the qualitative aspects of capital formation within the high-tech industry of the 90s, we find that beginning about 1995 a mob mentality set in within the investment community. Essentially, no rational reason could be quantified for the ability of the high-tech companies to attract large amounts of investment capital. That is, on the surface, there seemed to be an irrational behavior within the investment community. If we mine the information deeper, it would be quite rational for the venture capitalists to fund the high-tech to the extent that they did. Examining the phenomenon of the high-tech, several factors come into play. Firstly, the general economy was doing well and the allure of high-tech business was irresistible to stock purchasers. Secondly, the thought that much of the world business would be internet/computer orientated took root and became the glamorous hot issue of the day. Venture capitalist read the fervor and proceeded to fund startup companies in record numbers. As a result, the capital structure of the high-tech industry seems to be significantly different from that of the traditional industry.

Ever since Myers article (1984) on the determinants of corporate borrowing, literature on the determinants of capital structure has grown steadily. Part of this literature materialized into a series of theoretical and empirical studies whose objective has been to determine the explanatory factors of capital structure. The article of Titman and Wessels (1988) on the determinants of capital structure choice take such attributes of firms as asset structure, non-debt tax shields, growth, uniqueness, industries classification, size, earnings, volatility and profitability, but found only uniqueness was highly significant. But Harris and Raviv (1991) in their similar article on the subject point out that

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the consensus among financial economists is that leverage increases with fixed costs, non-debt tax shields, investment opportunities and firm size. And leverage decreases with volatility, advertising expenditure, the probability of bankruptcy, profitability and uniqueness of the product. Moh'd, Perry, and Rimbey (1998) employ an extensive time-series and cross-sectional analysis to examine the influence of agency costs and ownership concentration on the capital structure of the firm. Results indicate that the distribution of equity ownership is important in explaining overall capital structure and managers do reduce the level of debt as their own wealth is increasingly tied to the firm. Moreover, Mayer (1990) indicated that financial decisions in developing countries are somehow different. Rajan and Zingales (1995) study whether the capital structure in the G-7 countries other than the US is related to factors similar to those appearing to influence the capital structure of US firms. They find that leverage increases with asset structure and size, but decreases with growth opportunities and profitability. Again firm leverage is fairly similar across the G-7 countries. Booth, Aivazian, Demirguc-Kunt, and Maksimovic (2001) take tax rate, business-risk, asset tangibility, firm size, profitability, and market-to-book ratio as determinants of capital structure across 10 developing countries. They find that long-term debt ratios decrease with higher tax rates, size, and profitability, but increase with tangibility of assets. Again the influence of the market-to-book ratio and the business-risk variables tends to be subsumed within the country dummies. Recently, some studies have explored capital structure policies using different models on different countries (Chen, 2004; Dirk, Abe, & Kees, 2006; Fattouh, Scaramozzino, & Harris, 2006; Francisco, 2005). Furthermore, Kisgen (2006) examines credit rating and capital structure, and Jan (2005) develops a model to analyze the interaction of capital structure and ownership structure. Otherwise, in time-series test, Shyam-Sunder and Myers (1999) show that many of the current empirical tests lack sufficient statistical power to distinguish between the models. As a result, recent empirical research has focused on explaining capital structure choice by using time-series cross-sectional tests and panel data.

Though the achievement is rich, but there are few studies that evaluate the model's ability to predict. In addition, comparisons between linear and non-linear models for firm leverage with different industries are rare. Recently, artificial neural network (ANN) non-linear models have been widely used for resolving forecast problems (Altun, Bilgil, & Fidan, 2007; Hill, O'Connor, & Remus, 1996; Tseng, Yu, & Tzenf, 2002). The ANN model attempts to duplicate the processes of the human brain and nervous system using the computer. While this field originated in biology and psychology, it is rapidly advancing into other areas including business and economics (Chiang, Urban, & Baldridge, 1996; Enke & Thawornwong, 2005; etc.). The theoretical advantage of ANNs is that relationships need not be specified in advance since the method itself establishes relationships through a learning process. Also, ANNs do not require any assumptions about underlying population distributions. They are especially valuable where inputs are highly correlated, missing, or the systems are non-linear. A lot of research has been done to compare the performances of ANN and traditional statistical models (Kumar, 2005; Pao, 2006; Wang & Elhag, 2007; Zhang, 2001; etc.). Most researchers find that ANN can outperform linear models under a variety of situations, but their conclusions are not consistent with one another (Zhang & Qi, 2005).

Our focus is on answering three quantitatively oriented questions and proposing a qualitative comments in optimizing capital structure and maximizing firm value: (1) whether if the corporate financial leverage decisions differ significantly between high-tech and traditional industries; (2) whether if the determinants of the capital structure differ significantly in both industries; (3) whether if non-linear models provide better model fitting and forecasting than linear models for capital structure. The rest of the paper is organized as follows. Section 2 presents the data source, the definition of variables, and methodologies. Section 3 presents a comparative study of ANN and linear regression models and an attempt to rationalize the observed regularities. The final section contains the summary and conclusions.

2. Data source and methodology

In this study, corporations are classified into two categories: the high-tech and the traditional corporations. High-tech corporations include electronics, telecommunications, computer hardware, software, networking, information systems, and other related corporations. The rest are traditional corporations such as clothing, textile, trading, agriculture, manufacturing, etc. Leading one hundred corporations with sound financial statements are selected to create a database in each industry. Both data sets include a total of 720 firm-year panel data of public trading high-tech and traditional corporations in Taiwan from 2000 to 2005. The period from 2000 to 2004 is treated as the training period and the subsequent is the out-of-sample period for models. Each corporation contains one dependent variable and 10 independent variables. The Taiwan Economic Journal (TEJ) compiles all variables. Basic statistics are estimated to describe each variable collected and *t*-tests are conducted to determine if variables of high-tech corporations are different from that of traditional corporations.

As for regression models, we used total debt ratio (DEBT) as the response variables, and firm size (SIZE), growth opportunities (GRTH), profitability (ROA), tangibility of assets (TANG), non-debt tax shields (NDT), dividend payments (DIV), and business-risk (RISK) as explanatory variables of corporation's feature. In each model, there are three external macro-economic control variables: capital market factor (MK), money market factor (M2), and inflation level (PPI).