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Measuring firm performance using financial ratios: A decision tree approach

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ABSTRACT

Determining the firm performance using a set of financial measures/ratios has been an interesting and challenging problem for many researchers and practitioners. Identification of factors (i.e., financial measures/ratios) that can accurately predict the firm performance is of great interest to any decision maker. In this study, we employed a two-step analysis methodology: first, using exploratory factor analysis (EFA) we identified (and validated) underlying dimensions of the financial ratios, followed by using predictive modeling methods to discover the potential relationships between the firm performance and financial ratios. Four popular decision tree algorithms (CHAID, C5.0, QUEST and C&RT) were used to investigate the impact of financial ratios on firm performance. After developing prediction models, information fusion-based sensitivity analyses were performed to measure the relative importance of independent variables. The results showed the CHAID and C5.0 decision tree algorithms produced the best prediction accuracy. Sensitivity analysis results indicated that *Earnings Before Tax-to-Equity Ratio* and *Net Profit Margin* are the two most important variables.

1. Introduction

Evaluating firm performance using financial ratios has been a traditional yet powerful tool for decision-makers, including business analysts, creditors, investors, and financial managers. Rather than employing the total amounts observed on financial statements, these analyses were conducted using a number of financial ratios to obtain meaningful results. Ratio analysis can help stakeholders analyze the financial health of a company. Using these financial ratios, comparisons can be made across companies within an industry, between industries, or within a firm itself. Such a tool can also be used to compare the relative performance of different size companies.

Accounting and finance text books generally organize financial ratios into classes including liquidity, profitability, long-term solvency, and asset utilization or turnover ratios. Liquidity ratios evaluate the ability of a company to pay a short-term debt, whereas long-term solvency ratios investigate how risky an investment in the firm could be for creditors. Profitability ratios examine the profit-generating ability of a firm based on sales, equity, and assets. Asset utilization or turnover ratios measure how successfully the company generates revenues through utilizing assets, collecting receivables, and selling its inventories.

As part of an empirical research, Matsumoto, Shivaswamy, and Hoban (1995) conducted a survey of security analysts to ascertain their perceptions regarding financial ratios. They discovered that growth rates were considered to be the most important, followed by valuation, and then profitability ratios. The analysts ranked earnings per share and leverage ratio slightly lower than the above three. They also found that the ranking orders of ratio groups were quite different for retailers and manufacturers.

Previously, various methodologies had been implemented in order to evaluate the financial performance of companies in association with financial ratios. While the earlier studies primarily used traditional statistical techniques (e.g., Factor analysis, ANOVA, linear regression, etc.) more recent studies employed advanced decision-making approaches. One of the most popular approaches has been the decision tree analysis, which is often preferred because of its simplicity, transparency, descriptive and predictive power. In this study, using decision tree analyses along with several financial ratios, we evaluated the financial performance of Turkish companies listed on the Istanbul Stock Exchange.

The remainder of this paper is organized as follows: the next section (Section 2) provides a literature review; Section 3 presents the methodology developed and followed in this study, and documenting its findings. The Section 4 summarizes and concludes the paper.

2. Literature review

Use of financial ratios to assess the firm performance is not new. A simple literature search can find literally thousands of publica-

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tions on this topic. The underlying studies often differentiate themselves from the rest by developing and using different independent variables (financial ratios) and/or employing different statistical or machine learning based analysis techniques. For instance, Horrigan (1965) claimed that the development of financial ratios ought to be a unique product of the evolution of accounting procedures and practices in the U.S.; further stating that the origin of financial ratios and their initial use goes back to the late 19th century. Financial ratios, which are calculated by using variables commonly found on financial statements, can provide the following benefits (Ross, Westerfield, & Jordan, 2003):

- Measuring the performance of managers for the purpose of rewards;
- Measuring the performance of departments within multi-level companies;
- Projecting the future by supplying historical information to existing or potential investors;
- Providing information to creditors and suppliers;
- Evaluating competitive positions of rivals;
- Evaluating the financial performance of acquisitions.

Other than the benefits provided above, financial ratios are also used for the purpose of predicting future performance. For example, they are used as inputs for empirical studies or are used to develop models to predict financial distress or failures (Altman, 1968; Beaver, 1966). In fact, a vast majority of the recent studies focused on analyzing and potentially predicting bankruptcy as a means to identify characteristics (in term of financial ratios) of good or bad-performing firms and their potential values (Kumar & Ravi, 2007). Thousands of studies conducted in bankruptcy prediction distinguished themselves from those of the others by using a somewhat unique set of financial characteristics or employing a different set of prediction models (statistical or machine learning based) (Alfaro, García, Gámez, & Elizondo, 2008; Holsapple & Wu, 2011; Lee, Han, & Kwon, 1996; Martín-Oliver & Salas-Fumás, 2012; Olson, Delen, & Meng, 2012; Wilson & Sharda, 1994). Though many of these studies are successful in predicting bankruptcy outcomes, they often fall short on identifying and explaining the characteristics that can be used as determinants of the firm performance.

There is no universally agreed-upon list regarding the type, calculation methods and number of financial ratios used in earlier studies. For instance, Gombola and Ketz (1983) used 58 ratios to detect financial ratio patterns of within retail and manufacturing organizations, while Ho and Wu (2006) used 59 ratios, Cinca, Molinero, and Larraz (2005) used 16 ratios, Uyar and Okumuş (2010) used 15 ratios, and Karaca and Çiğdem (2012) used 24 ratios. However, most text books and research studies published in reputable journals provided somewhere in between 20 to 30 of the more commonly used ratios, which are often found to be sufficient to evaluate the performance of a firm.

Earlier studies have provided empirical evidence that the structure of financial ratio patterns differs between retail and manufacturing firms (Gombola & Ketz, 1983). Cinca et al. (2005) proved that the size of the company and the country where the company is located impact the financial ratio structure. Uyar and Okumuş (2010) investigated the impact of the recent global financial crisis on publicly traded Turkish industrial enterprises using financial ratios, finding that firms had been weakened financially during the crisis period.

In earlier studies, researchers utilized statistical methods which are prone to unrealistic normality and linearity assumptions. For example, Altman (1968) applied multiple discriminant analysis, which requires data to meet normality, equal covariance and independency of variables conditions. The superiority of decision tree methods (arguably the most popular data mining techniques) is that they are free from these limiting assumptions. Furthermore, decision trees can be represented as easily understandable graphical displays, making them transparent and easily understandable to managers. Therefore, in this study we chose to use the most popular decision tree methods as our analysis tools.

Previous studies have also focused primarily on financial performance, stock return, and bankruptcy or financial distress prediction by using various statistical and data mining techniques such as decision trees and neural network (Chen & Du, 2009; Lam, 2004; Sun & Hui, 2006; Wang, Jiang, & Wang, 2009; Yu & Wenjuan, 2010). For instance, Zibanezhad, Foroghi, and Monadjemi (2011) employed classification and regression trees (C&RT) to predict financial bankruptcy using financial ratios as well as to determine the most important variables. Wang et al. (2009) implemented the bagging-decision tree model to predict stock returns by using fifty financial ratios. Sun and Hui (2006) focused on financial distress prediction of Chinese listed firms applying decision tree and genetic algorithms. Yu and Wenjuan (2010) used the decision tree to examine which financial ratios have strong influence on the profit growth of listed logistics companies; they have employed C5.0, which is one of the decision tree techniques. In this study, we used four popular the decision tree algorithms to develop prediction models and by the way of conducting information fusion based sensitivity analysis on these prediction models, we discovered which financial ratios have the strongest impact on financial performance. In our analysis, we used a large and feature rich financial database of Turkish public companies listed on Istanbul Stock Exchange.

3. Methodology

3.1. Data and sample

Our goal was to identify and use a large and feature rich dataset. After an exhaustive search we identified FINNET, which is a company providing variety of financial data, software, and Web-based analysis tools to their members. FINNET has the largest financial database on Turkish firms. Even though the FINNET data is large and feature-rich in content, it had variety of data problems; demanding a through process of data cleaning and pre-processing.

The initial sample of the study consisted of all Turkish listed public companies from 2005 to 2011. In total, 2722 data records/cases were available for analysis. Out of this, 371 cases had significant missing-date problems on financial ratio values; therefore they were eliminated. Also, 6 cases were identified as extreme outliers, and therefore they were also eliminated from the dataset. At the end of the cleaning and pre-processing procedures, there were 2345 usable cases for model building and testing purposes. The final dataset of financial ratios covered the time period of 2005 to 2011. For this study, 31 financial ratios were calculated and used. Table 1 lists and briefly defines these financial ratios. The main tasks/steps employed in this study are presented in a graphical form in Fig. 1.

3.2. Exploratory factor analysis (EFA)

The Exploratory factor analysis (EFA) was adopted in order to identify and validate the underlying dimensions of the financial ratios. To locate the underlying dimensions, the principal component factor analysis was used. Principal component analysis (PCA) decomposes given data into a set of linear components within the data. It indicates how a variable contributes to that component, while factor analysis establishes a mathematical model from which factors are estimated (Dunteman, 1989). PCA is a mathematical