Predicting failure risk using financial ratios: Quantile hazard model approach

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A B S T R A C T

This study examines the role of financial ratios in predicting companies' default risk using the quantile hazard model (QHM) approach and compares its results to the discrete hazard model (DHM). We adopt the LASSO method to select essential predictors among the variables mentioned in the literature. We show the preeminence of our proposed QHM through the fact that it presents a different degree of financial ratios' effect over various quantile levels. While DHM only confirms the aftermaths of "stock return volatilities" and "total liabilities" and the positive effects of "stock price", "stock excess return", and "profitability" on businesses, under high quantile levels QHM is able to supplement "cash and short-term investment to total assets", "market capitalization", and "current liabilities ratio" into the list of factors that influence a default. More interestingly, "cash and short-term investment to total assets" and "market capitalization" switch signs in high quantile levels, showing their different influence on companies with different risk levels. We also discover evidence for the distinction of default probability among different industrial sectors. Lastly, our proposed QHM empirically demonstrates improved out-of-sample forecasting performance.

1. Introduction

The literature has long studied the modeling and forecasting of default risk at all levels. The occurrences of bankruptcy filing events bring strong negative effects to an economy and society, not to mention massive financial losses. Developing a bankruptcy prediction model that can help gain insights into understanding the relationship between a company's financial performance and its default risk has thus become critical to creditors, shareholders, and regulators especially under the current framework of BASEL II, which sets a higher standard on the calculation of cash reserves. Given the broad interests in various areas, the literature has extensively studied financial distress prediction models. For example, Schwaab, Koopman, and Lucas (2016) conduct a study using data on 41 countries to find the dynamic properties of systematic default risk; Switzer, Wang, and Tu (2016) examine the relationship between corporate governance and default risk in financial firms in 28 countries outside of North America over the post-financial crisis period; and Memmel, Gunduz, and Raupach (2015) attempt to find the common drivers of default risk across different industries in Germany and many other countries.

In spite of its importance, most research studies prior to the 2000s adopt a static single-period classification model to estimate default risk using cross-sectional financial ratios – for example, Beaver (1966, 1968), Altman (1968), Ohlson (1980), Zmijewski...
While a vast amount of literature focuses on developing a bankruptcy prediction model using time-varying firm-specific predictor variables, it only provides an “overview” or a “snapshot” with a summary of the relationship between the predictor variables and default risk in the condition mean value. Just as the mean provides incomplete information about any distribution, a full description of a regression curve at all points would be helpful in revealing more useful information with a grand summary. In a similar vein, the current bankruptcy literature encompasses the relationship between default risk and its firm-specific predictor variables using a single regression model, but such a parametric relationship in a firm’s behaviors may be heterogeneous across quantiles in bankruptcy prediction. In this work we introduce a quantile hazard regression model to discover how a company’s behavior at different quantiles affects default risk and present a grand summary of the relationship between the predictor variables and a firm’s default status over time. More specifically, we divide companies into quantiles based on their probability of default and find that the relationships between the default status and the predictor variables using accounting and market data are quite different at the upper tail quantile levels versus the estimates at lower tail or middle quantile levels.

The statistics literature has extensively studied the quantile regression model, demonstrating success at discovering extreme behaviors by examining distributions, especially at tail quantiles, and by presenting a more thorough view in the distribution description (Koenker, 2005). This approach is strongly suitable for looking at companies’ default risk, because of its asymmetric distribution (the number of failure companies is usually much less than the number of survival ones). In a similar vein, Xiao, Hwang, and Chu (2016) use logistic quantile regression to study companies’ recovery rates (after bankruptcy filing). While applying the quantile approach, their work repeats the shortcomings of static models in ignoring the time-varying characteristics of firms and uses only one outcome observation value per company. Motivated by the developments in Koenker and Bassett (1978), Bassett and Koenker (1982), Yu, Lu, and Stander (2003), and Chen, Gerlach, and Wei (2009), in this work we propose to adopt quantile analysis into a hazard model and use the quantile hazard model (QHM hereafter) to investigate how default risk correlates with the determinants at different quantile levels using time-varying accounting and market data. We aim to complement the current gap in the literature by thoroughly exploring the relationship between a company’s financial performance and its default risk across different quantile levels in order to discover some potential “tail properties”.

This work adopts the proposed QHM on the bankruptcy database using a set of predictor variables selected by the least absolute shrinkage and selection operator (LASSO) technique. The LASSO method is a popular statistical variable selection approach that provides a parsimonious predictor variable-set solution through penalizing the regression coefficient via a shrinkage method (for details, see Tibshirani, 1996; Efron, Hastie, Johnstone, & Tibshirani, 2004; Meier, Van de Geer, & Bühlmann, 2008; Pereira, Basto, & Ferreira da Silva, 2016). Tian, Yu, and Guo (2015) show that the LASSO method demonstrates strong success in improving the bankruptcy prediction model’s forecasting accuracy using a comprehensive U.S. database. For this work, we use LASSO method to choose the predictor variables so as to study the prediction performance using our proposed QHM model.1

Our empirical study reveals that the loadings of the predictor variables at high quantile levels are quite different versus the estimates from fitting the discrete hazard model. In particular, for five predictor variables – stock volatility (SIGMA), stock excess return (EXRETURN), the profitability ratio of net income over the market value of total assets (NIMTA), the liability ratio of total liability over the market value of total assets (LTMTA), and the log of stock price (PRICE) – the scale of the coefficient estimates in predicting a default increases with the expected signs over high quantile levels. Such findings show that these variables have become increasingly important measures in predicting bankruptcy. Conversely, the liquidity ratio of cash and short-term investment to the market value of total assets (CASHMTA), the current liabilities to total asset (LCTAT) ratio, and the market capitalization variable (RSIZE) that are insignificant in DHM are found to be important indicators in high quantile levels of QHM. More interestingly, CASHMTA and RSIZE switch signs over the high quantile levels, indicating their different effects toward low and high risk companies. Our empirical results also denote that the coefficient estimates at middle quantile levels are similar to the estimates from the discrete hazard model fitting, but the estimates from low quantile levels are instead not statistically significant in predicting corporate default. We use QHM to evaluate the in-sample fitting over the training data from 2000 to 2009 and its out-of-sample performance on the testing data from 2010 to 2014. The forecasting results illustrate that QHM improves the out-of-sample performance compared to the popular discrete hazard model. In addition, we investigate the differences in default risk that may exist between various industrial sector firms by introducing three industrial dummy variables used in Chava and Jarrow (2004). Our empirical study displays that the significance and the magnitude of the industrial dummy variables are different across quantile levels of QHM and also different from DHM’s results. Such a finding is rather interesting especially for risk management purposes as more and more global investors are striving to formulate diverse portfolios.

The rest of the paper runs as follows. Section 2 presents DHM, the LASSO method, and our proposed QHM model in greater detail. Section 3 provides a description about our bankruptcy database, the detailed LASSO procedure, and the construction of industrial dummy variables. Section 4 summarizes the empirical results of the predictive ability of the financial ratios on corporate default

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1 We also try other sets of predictor variables, like the variable set in Campbell et al. (2008). The results are qualitatively similar.
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