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# Are hazard models superior to traditional bankruptcy prediction approaches? A comprehensive test

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ABSTRACT

In recent years hazard models, using both market and accounting information, have become state of the art in predicting firm bankruptcies. However, a comprehensive test comparing their performance against the traditional accounting-based approach or the contingent claims approach is missing in the literature. Using a complete database of UK Main listed firms between 1979 and 2009, our Receiver Operating Characteristics (ROC) curve analysis shows that the hazard models are superior to the alternatives. Further, our information content tests demonstrate that the hazard models subsume all bankruptcy related information in the Taffler (1983) *z*-score model as well as in Bharath and Shumway (2008) contingent claims-based model. Finally, using a mixed regime competitive loan market with different costs of misclassification, the economic benefit of using the Shumway (2001) hazard model is clear, particularly when the performance is judged with return on risk weighted assets computed under Basel III.



## 1. Introduction

The risk of going bankrupt is of major interest to shareholders, creditors, and employees of a firm and a vast body of literature is devoted to assessing the risk that individual firms will go bankrupt.[1] There is an extensive literature on predicting corporate failure starting with Beaver (1966) and the three dominant approaches are: (i) traditional models predominantly based on accounting information (e.g. Altman, 1968), (ii) contingent claims-based models that view equity as a call option on assets (e.g. Vassalou and Xing, 2004), and (iii) more recent hazard models that assess bankruptcy risk using both accounting and market data (e.g. Shumway, 2001).

While some of the models are argued to be superior due to their theoretical grounding (e.g. Vassalou and Xing, 2004), eventually, the empirical performance of the approaches is what really matters. The discriminatory power of the models can be assessed along three dimensions: the ability to discriminate between failures and non-failures, the incremental information about bankruptcy captured by different models, and the performance of the models when costs of misclassifying a failed company is different to the cost of misclassifying a company that does not fail. The relative importance of these dimensions depends upon the context. The model with the highest accuracy ratio is the most appropriate if the primary interest is to identify the most accurate model while if the objective is to assess whether different models carry information incremental to each other then the tests of information content are more relevant. Finally, if one takes the lender's perspective, the differential misclassification costs cannot be ignored and the model with the best risk return profile should be preferred.

The existing literature typically compares the models along one of the three dimensions and provides conflicting evidence on the usefulness of competing approaches for predicting corporate failure. Hillegeist et al. (2004) use information content tests to conclude that the contingent claims approach dominates the traditional accounting-based approach while Reisz and Perlich (2007) reach the opposite conclusion using Receiver Operating Characteristics (ROC) analysis. Similarly, Keenan and Sobehart (1999) show that the contingent claims approach dominates the hazard models using ROC analysis and information entropy tests while Campbell et al. (2008) use the information content test to conclude the opposite. In addition, with the exception of Agarwal and Taffler (2008a), the literature that compares the predictive

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[1] Throughout the paper we use the terms bankruptcy, failure and financial distress interchangeably.

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ability of different models typically makes the unrealistic assumption that the cost of lending to a firm that fails is the same as the opportunity cost of not lending to a firm that does not.

We extend the framework of existing studies by comparing all three dominant bankruptcy prediction approaches across the three dimensions of model performance. Specifically, using all non-financial firms listed on the Main market segment of the London Stock Exchange at any time between 1979 and 2009, a total of 28,804 firm-year observations,[2] we test two hazard models (Shumway, 2001; Campbell et al., 2008), the Taffler (1983) *z*-score model, and a contingent claims model (Bharath and Shumway, 2008). We employ the Receiver Operating Characteristics (ROC) curve to assess model accuracy and information content tests for incremental information. In addition, we use the framework of Stein (2005) and Agarwal and Taffler (2008a) to test the economic impact of using different bankruptcy prediction models in a competitive environment when costs of misclassification differ.

To our knowledge, this is the first study to provide comprehensive evidence on the relative merits of the three most popular approaches to bankruptcy prediction using a full array of tests of their discriminating power including the performance when the assumption of equal misclassification costs is relaxed. The comprehensive analysis in this paper also raises the bar for new bankruptcy models, they should outperform the existing models on not just accuracy and information content, but also perform better through improved risk weighted return for the lender when differential misclassification costs are explicitly used in the analysis.

We find that while all three approaches possess bankruptcy prediction ability, the hazard models dominate the other two, both in our ROC curve analysis and information content tests. We also show that the most-parsimonious hazard model of Shumway (2001) has best risk-return characteristics in a competitive loan market with differential misclassification costs.

The paper proceeds as follows. The next section provides a review of existing literature and Section 3 introduces the basic form of the hazard models as well as the accounting and contingent claims-based models used in this study. Section 4 describes our sample, data sources and the variables used. Section 5 presents the approaches used to compare the bankruptcy prediction models. Section 6 discusses the results, and Section 7 concludes.

## 2. Existing literature

Accounting data-based bankruptcy prediction models filter the relevant information from publicly available accounts to assess bankruptcy risk. In a way, traditional accounting models are a structured fundamental analysis using published financial statements and are typically developed by searching for the linear combination of ratios that best differentiates between (matched) samples of non-failed and failed firms through discriminant or logit models.

Despite the widespread use of the accounting-based bankruptcy prediction models in the literature,[3] they are often criticised for their lack of theoretical grounding. Hillegeist et al. (2004) argue that accounting data is by nature historical and prepared on a going concern assumption, hence their use in predicting future, especially one that involves violating the going concern assumption itself is fundamentally flawed. Similarly, Agarwal and Taffler (2008a) acknowledge that (i) accounting numbers are subject to reporting standards (such as conservatism and historical cost accounting) that might hinder a true representation of the economic value of assets, and (ii) accounting numbers can, at least to some extent, be manipulated by the management. In addition, there are methodological issues associated with the development of accounting-based bankruptcy prediction models. For instance, Zmijewski (1984) argues that such models are biased as they typically oversample failed firms during model development. Mensah (1984) argues that as ratios change over time, a regular re-estimation of the models is necessary to maintain their utility. However, Begley et al. (1996) and Hillegeist et al. (2004) find that simply updating the model coefficients does not improve the performance, hence such models have to be re-developed periodically.

Contingent claims-based bankruptcy prediction models overcome many of the fundamental shortcomings of accounting-based models. First, in efficient markets, prices reflect both historical financial information (i.e. accounting data) as well as the individual and market-wide outlook of a business. Second, market prices are less likely to be influenced by accounting policies. Third, while accounting-based models typically lack theoretical underpinnings, contingent claims-based models have impeccable theoretical grounding as they draw on the Black and Scholes (1973) and Merton (1974) option pricing framework. In these models, equity is viewed as a call option on the firm's assets, and the probability of going bankrupt is simply the probability that the call option is worthless at maturity (i.e. market value of total assets is less than the face value of total liabilities).

However, implementation of the contingent claims framework for bankruptcy prediction is far from straight forward. First, Saunders and Allen (2002) argue that such models are unable to differentiate between the different durations of debt since they assume a zero-coupon bond for all liabilities. Second, Avramov et al. (2010) argue that distressed firms are prone to suffer from market microstructure problems such as thin trading or limitations to short-selling which might result in prices deviating from fair values for extended period. Perhaps more importantly though, some key variables required for these models (e.g., asset volatility, expected asset returns, and market value of assets) are unobservable and need to be approximated introducing potentially large errors.

The competing arguments in accounting and contingent claims-based bankruptcy prediction frameworks enforce a trend in literature that argues for combining the two information sources. Sloan (1996) finds that market prices do not accurately reflect the information from company accounts, hence, accounting data can be used to complement market data. Pope (2010) argues for combining the accounting and finance disciplines. In line with these arguments, latest hazard models dismantle the strict separation of accounting and market data while incorporating the informational benefit of both.

The majority of recent hazard models combine accounting and market data in simple discrete time logit models following Shumway (2001). Chava and Jarrow (2004) use a mixture of accounting and market-based ratios consisting of profitability, liquidity as well as market volatility or market price. Campbell et al. (2008) integrate accounting and market information even further by using ratios that contain accounting variables (e.g. profit) in the numerator and the market value of total assets in the denominator. However, given the critical importance of the ability to identify potential failures early, the true worth of different approaches should be measured by how good they are empirically rather than how sound they are theoretically.

The evidence in the existing literature that compares the performance of contingent claims and accounting-based approaches shows that the theoretical superiority of the former does not necessarily imply a higher explanatory power. Hillegeist et al. (2004) compare the Ohlson (1980) *o*-score and Altman (1968) *z*-score with the contingent claims-based measure using information content tests. While they claim their contingent claims based model carries more information about future bankruptcy, they also find

[2] Our out of sample tests use data from 1985 to 2009, a total of 22,217 firm-years.
[3] See Agarwal and Taffler (2007) for examples.