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Structural models of credit risk are useful: Evidence from hedge ratios on corporate bonds ☆

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ABSTRACT

Structural models of credit risk provide poor predictions of bond prices. We show that, despite this, they provide quite accurate predictions of the sensitivity of corporate bond returns to changes in the value of equity (hedge ratios). This is important since it suggests that the poor performance of structural models may have more to do with the influence of non-credit factors rather than their failure to capture the credit exposure of corporate debt. The main result of this paper is that even the simplest of the structural models [Merton, R., 1974. On the pricing of corporate debt: the risk structure of interest rates. Journal of Finance 29, 449–470] produces hedge ratios that are not rejected in time-series tests. However, we find that the Merton model (with or without stochastic interest rates) does not capture the interest rate sensitivity of corporate debt, which is substantially lower than would be expected from conventional duration measures. The paper also shows that corporate bond prices are related to a number of market-wide factors such as the Fama-French SMB (small minus big) factor in a way that is not predicted by structural models.

1. Introduction

Structural models of credit risk do a poor job of explaining the prices of corporate bonds. Most studies (e.g., Huang and Huang, 2003) find that structural models overvalue corporate debt; others find both over- and undervaluation but the results are nonetheless generally poor.[1] Structural models employ the contingent claims approach to value the default put option embedded in limited liability equity. Used extensively in practice to value contracts related to equity, interest rates, and foreign exchange, contingent claims models are one of the major success stories of financial theory. Thus the failure of such models to explain corporate debt prices is surprising and, while their poor performance has been recognized for many years, this failure continues to surprise.

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[1] For early empirical investigation of the Merton model, see Jones, Mason, and Rosenfeld (1984). For a more recent analysis, see Eom, Helwege, and Huang (2004), who study the empirical performance of a number of structural models and find a significant estimation error with some models overvaluing and other models undervaluing corporate bonds.

This paper makes two simple but important and related points. First, while structural models provide a poor prediction of prices and returns, they perform much better as a predictor of the *sensitivity*, or hedge ratio, of debt to equity, and we find that even the simplest structural model (Merton, 1974) predicts hedge ratios that are in line with those observed empirically. We use an approximation to infer equity sensitivities from the spreads computed in the study by Huang and Huang (2003) of more complex structural models and show that these, too, are remarkably consistent with our empirical estimates. Thus the ability of structural models to produce good estimates of equity hedge ratios does not appear to be limited to the Merton model.

Second, while returns on corporate bonds are significantly related to the Standard and Poor's (S&P) index and the Fama-French SMB (small minus big) and HML (high minus low) factors, this does not arise as a result of the bond's exposure to the issuing firm's equity or interest rates. Moreover, these sensitivities do not appear to be related to any standard measure of credit exposure such as rating, leverage, or asset volatility.

These findings are important since, in the contingent claims framework, the sensitivity of debt to equity determines the composition of the replicating portfolio which, according to the theory, determines the price. Thus, if we find that a model provides a good prediction of hedge ratios but a poor prediction of the price, we are better able to identify the reasons for its failure.

Consider the two most likely explanations for the poor performance of structural models. The first is that they might fail to predict accurately the probability of default.[2] This would hardly be surprising since most current models treat the firm's long-run financial policy in a highly simplified manner. Much recent work has focused on improved ways to model credit events and an arsenal of models now includes stochastic default boundaries, dynamic capital structure (e.g., Leland and Toft, 1996) and opportunistic behavior on the part of claimholders (e.g., Anderson and Sundaresan, 1996; Collin-Dufresne and Goldstein, 2001). Important as these developments have been, however, such empirical tests, as have so far been conducted, fail to improve substantially the ability of structural models to explain the level of corporate bond prices (Eom, Helwege, and Huang, 2004; Huang and Huang, 2003).

A second possibility is that corporate bond prices are influenced by factors that are unrelated to credit risk and therefore absent from structural models altogether. Huang and Huang (2003) conclude that credit risk accounts for only a small fraction of the observed level of yield spreads and Collin-Dufresne, Goldstein, and Martin (2001) find that the variables present in structural models explain only a small fraction of the variability in spreads. However, these analyses do not extend to studying sensitivities and, as with the simpler Merton model, the failure to explain spreads does not reveal whether these same models would succeed in explaining hedge ratios.

If much of the variation in corporate bond prices is unrelated to structural model variables, it could also be unrelated to credit risk. For example, some of this variation may be linked to fluctuations in market liquidity. In this case, structural models might account well for the credit risk component of bond prices and returns, while, at the same time, being responsible for only a part, perhaps not even a large part, of the total spread and the variability of returns.

It is this view that motivates our paper. Suppose that the actual price of a corporate bond, D, consists of two components. The first, D_C, represents the bond's "fundamental value", i.e., the present value of its future cash flows taking into account its credit exposure and valued using a discount rate that is consistent with the risk of the firm's equity. Suppose further that this component of the bond's value is well captured by a structural model. The second component, D_{NC}, reflects the influence of the non-credit variables identified by Collin-Dufresne, Goldstein, and Martin (2001) and Huang and Huang (2003). Together, these two components sum to the actual bond price

$$D = D_C + D_{NC}. \tag{1}$$

(If the structural model overvalues the bond, then the second component, D_{NC}, is negative.) If D_{NC} is indeed unrelated to credit risk and, therefore, to the firm value, V, then the hedge ratio of the debt value, D, with respect to V is equal to the hedge ratio of the credit-related component, D_C. Thus, if structural models provide a reasonable estimate of the credit-related component of the corporate bond price, D_C, they simultaneously succeed in predicting the hedge ratios of actual prices while failing to explain their level. This prediction is the focus of our paper.

Thus we do not focus on the level of prices or the size of the spread but instead on the ability of structural models to predict hedge ratios, i.e., on their *second-moment predictions*. Using data on monthly returns for a large sample of US corporate bonds over a 7-year period, we find that the variables present in structural models explain a large fraction of the returns on investment-grade bonds and a smaller but significant fraction for high-yield bonds. This result is in itself not surprising, since a large fraction of the variation in investment-grade debt is explained by changes in the riskless yield curve. We also find that corporate debt returns are significantly related to returns on the equity of the issuing firm and that the pattern of sensitivities is broadly consistent with the level of credit exposure.

In structural models, any change in the value of a credit-risky bond is the result of a change in either the value of the assets that collateralize the debt or in riskless rates. In our empirical analysis we ask whether *the sensitivities* of corporate bond returns to the issuing firm's equity and riskless bond returns are consistent with the model. Our main results support the view that structural models account well for the credit-related component of corporate bond prices, and we find that even the simple Merton (1974) model produces hedge ratios to equity that

[2] Another is that they fail to predict recovery rates. However, little evidence exists on this point one way or the other.