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Can Structural Models of Default Explain the Credit Spread Puzzle?

BY ROBERT GOLDSTEIN

Structural models of default are widely used to analyze corporate bond spreads, but have generally been unable to explain why risk premiums are as high as they are. This credit spread puzzle can be addressed by taking into account such factors as the variability of the level of risk premiums and the likelihood of default over the course of the economic cycle. Models that incorporate such variations over time are more successful at generating spreads consistent with historical observations.

So-called structural models of default provide a framework for estimating credit spreads and default rates of corporate debt. While such models have been shown to be useful theoretical constructs, in practice some key empirical observations are difficult to explain using the standard structural model of default, especially the magnitude of credit spreads on corporate bonds.

This *Economic Letter* discusses why standard versions of structural models of default tend to underpredict the level of risk premiums and variations in those premiums over time. Drawing on recent research, the *Letter* suggests modifications to these standard models in order to better explain historical levels and time variations of corporate bond spreads.

Foundation for structural models of bond defaults

The foundation for structural models of default stems from the work of Black and Scholes (1973) and Merton (1974), who showed that the equity and debt of a firm can be viewed as contingent claims on some underlying firm value. In particular, an equity position can be viewed as if it were a portfolio of three securities: a long position in the firm's assets, a short position in a risk-free bond, and a long position on a put option that gives stockholders the right to "put" the firm's assets onto debt holders in lieu of paying the promised interest and principal. Exercise of this option is synonymous with a default and captures the notion of limited liability.

Analogously, owning a corporate bond can be interpreted as having a long position in a risk-free bond and a short position in a put option with a strike price equal to the face value of the bond. If the firm does well, the equity holder retains control and the debt holder receives the promised cash flows from the bond. In contrast, if the firm does poorly, the equity holder exercises the option, leaving the debt holder with the assets of the firm, the value of which is typically below the initial value of the risky debt, representing the "recovery rate" on the risky bond.

From this options-based perspective, structural models of default relate the value of a risky bond to the variability of the firm's return on assets, its capitalization, the structure of its debt, as well as other factors such as risk-free interest rates. The basic Merton model of default also incorporates other simplifying assumptions about recovery rates and the absence of frictions affecting liquidity in financial markets.

The puzzle

With all the simplifying assumptions, it is difficult for a basic structural model to explain why credit spreads are as high as they have historically been, given relatively low historical default rates and significant recovery rates. For example, according to the 2005 annual report of Moody's Investors Service, the four-year cumulative default rate for Baa bonds was only 1.55% from 1970 to 2001. Furthermore, the recovery rate for unsecured senior debt was approximately 45%. If investors merely required compensation for expected losses, these historical values would imply a credit spread of only 0.22 percentage point, or 22 basis points. However, four-year Baa-Treasury spreads have historically been closer to 1.60 percentage points, or 160 basis points. The high observed credit spread compared with the model-implied spread is referred to as the "credit spread puzzle." It suggests that assumptions underlying the Merton model may be overly restrictive or that factors other than credit risk affect Treasury and corporate bond prices.

Several researchers have argued that rates on U.S. government debt are well below the true risk-free rate because of the benchmark status and extreme liquidity of Treasury securities. Still, even if we were to estimate the risk-free rate using AAA corporate bond yields instead of Treasuries, we would still need to explain approximately 1 percentage point of spread. This apparent excessive compensation for default risk is reminiscent of the so-called equity premium puzzle of Mehra and Prescott (1985). They noted that the standard economic model suggests that historical excess returns on equity seem to be too large given the relative smoothness of aggregate consumption. Corporate bonds and equities share many of the same systematic risk sources. Hence, we argue that the credit spread puzzle and this equity premium puzzle are related. If we incorporate an equity premium model into the standard structural model and make a few other modifications, we can produce credit spreads much closer to those actually observed.

Another puzzle for standard structural models of default is the high degree of clustering of defaults during recessions. To understand this, we look at asset returns as comprised of a market component and an idiosyncratic component. The market component captures the degree to which a firm's asset value moves in line with an overall market index. The idiosyncratic component captures asset returns that are firm-specific and unrelated to the market. It is natural that defaults occur more often during recessions than during nonrecessionary periods since such downturns are when overall market returns are poor. Market movements generate a positive correlation between individual asset returns. Empirically, though, most of an asset's volatility stems from the idiosyncratic component. Therefore, when a standard model is calibrated to match the level of market and idiosyncratic volatility, it doesn't fully capture the degree of default clustering that occurs during recessions. The standard model does generate some level of clustering, but not nearly as much as we observe empirically.

Alternative structural default models

In one of the earliest studies to apply the Merton framework to empirical data, Jones, Mason, and Rosenfeld (1984) calibrated a model that generated spreads of only a few basis points. This puzzle of excessively small risk spreads long remained unresolved. As Huang and Huang (2003) showed, subsequent models that tried to incorporate historical default and recovery rates all generated risk spreads that were also well below historical levels.

Going a step further, Chen, Collin-Dufresne, and Goldstein (2009) showed that credit spreads are a function of only three combinations of the seven free parameters specified by Merton: the default rate, the recovery rate, and the Sharpe ratio, which is a measure of a risk premium relative to an actual degree of risk. The authors showed that, given historical values for these factors, Merton-type models are only able to generate spreads of approximately 0.57 percentage point, including 0.22 in compensation for expected losses and 0.35 for taking on default risk. Unfortunately, this compensation for default risk is less than half its historical value.

Modifications to Merton

The Merton model makes some important simplifying assumptions, such as constant recovery rates and constant Sharpe ratios, which measure an asset's excess return over the risk-free rate relative to risk. A unit of risk is defined as the standard deviation of the asset's return. However, evidence suggests that both of these factors vary over time. For example, Altman, Resti and Sironi (2004) found that recovery rates are countercyclical. Moreover, many researchers (e.g., Cochrane 2006) have noted that excess returns in financial markets are countercyclical in that they tend to be low when price-dividend ratios are high, and vice versa. These facts are important since standard economic theory states that bond prices should be low, and, thus, credit spreads should be high, if their associated cash flows are low when marginal utility of consumption is high. If we model recessions as times of high marginal utility since consumption is low, then it might be possible to explain historical credit spreads.

Chen, Collin-Dufresne, and Goldstein investigate whether a structural model of default embedded within a habit-formation economy of Campbell and Cochrane (1999) can capture historical credit spreads. Habit formation in this context refers to the idea that a person's utility from consumption depends not only on the current level of consumption but also on an individual's past consumption levels. This characterization allows for more variation in marginal utility of consumption and thus time variation in risk premiums. The authors reverse engineer the Campbell-Cochrane model to capture not only high average excess returns on equities but also Sharpe ratios that vary strongly with time. This model generates extremely high prices for those securities that pay off only in recessionary states. Note that a well-diversified portfolio of corporate bonds pays its promised cash flows during good times but only a fraction of those flows during recessions when default rates are high. A portfolio of corporate bonds has cash flows that are very similar to a portfolio that is long a risk-free bond and short those securities that pay off only during recessions. Thus, we would expect a structural model embedded in a habit-formation framework to generate higher spread predictions than the Merton model. Indeed, if they are calibrated to match the historical countercyclical default rate, then structural models of default can capture both the historical level and time variation in spreads between bonds rated Baa and those rated Aaa.

The variation in credit spreads over time also has implications for default clustering. One way to generate time-varying spreads is by creating a countercyclical default boundary—having the value of the firm at which it would default be higher in recessions than in expansions. For example, if it is difficult to issue new debt to retire old debt during recessions, then the probability of default rises for all firms during recessions, implying higher default correlation than the standard model predicts.

The habit-formation model matches the overall default pattern extremely well from 1928 to 2005, for example, predicting huge defaults during the Great Depression. Moreover, the time-series results seem to provide strong support for the notion that credit spreads are good indicators of variations in expected returns over time, consistent with the literature.

Conclusion

Structural models of default price debt and equity as contingent claims on a firm's value. Standard structural models of default assume that expected recovery rates and Sharpe ratios measuring risk premiums to units of risk are constant. Those standard models, when calibrated to historical default rates, recovery rates, and Sharpe ratios, predict spreads and default clustering that fall well below historical levels. However, if structural models of default incorporate strongly time varying Sharpe ratios and take into account the greater likelihood of default during recessions, then they can capture both the level and time variation of historical spreads, resolving the credit spread puzzle.

Robert Goldstein is an associate professor at the University of Minnesota and a visiting scholar at the Federal Reserve Bank of San Francisco.

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