

Kamakura
Corporation

KAMAKURA

RISK INFORMATION SERVICES

Implied Credit Spreads Kamakura Public Firm Models

Version 4.1

— JUNE 2013 —

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I. Introduction

Kamakura Risk Information Services (KRIS) public firm default probabilities were launched in November 2002, followed by the KRIS Sovereign Default Service in 2008. The KRIS service provides estimates of the full term structure of default probabilities of an individual public firm based upon current public information about the firm, its economic environment, firm-specific financial ratios and equity market inputs. Maturities are available at 1 month, 3 months, 6 months, 1 year, 2 years, 3 years, and 5 years.

The KRIS default probabilities are used by major corporations and financial institutions in Europe, Asia and the Americas for two major purposes:

1. Monitoring the risk of single counterparties
2. Monitoring the risk of large portfolios of counterparties whose default risk is highly likely to be correlated.

The KRIS default probability service also contains the estimated credit default swap (“CDS”) quotations for each of the 22,000 companies in KRIS, i.e. “Implied Spreads.” These implied spreads rely on the joint assumptions that (a) CDS contracts were actually traded for that particular company and that (b) CDS quotes are consistent with the average relationship between spreads and company attributes that prevailed over the period in which the implied spreads were fitted to a very large CDS data set. A complete description of the calculation of implied spreads is contained in Appendix D to the KRIS Version 4.1 Technical Guide. Appendix D was authored by Professor Robert A. Jarrow, Li Li, Mark Mesler and Dr. Donald R. van Deventer in 2006 and available to KRIS subscribers only. A companion paper was published in RISK Magazine in September 2007.

II. KRIS Implied Spreads

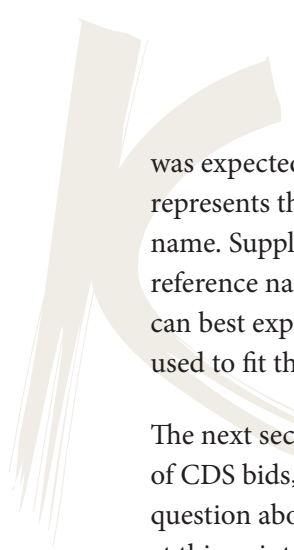
The KRIS implied spread calculation was design to address a simple and frequently asked question:

The CDS market has ABC company with a 50 basis, point 5 year spread, and Kamakura’s version 4.1 KDP-jc Jarrow Chava default probabilities are 10 basis points; why are the numbers different?

In 2003 and 2004, the early days of the credit default swap market, many traders believed that the credit default swap quotes were linked to default probabilities in a very simple way:

$$CDS = (1 - \text{recovery rate})(\text{Default Probability})$$

Although believers that this relationship was true were very passionate, a look at the data made it obvious that it is definitely not true. A fixed income trader for a major pension fund explained the reason very simply: “If all I got providing credit insurance in the CDS market



was expected loss, why would I want to do that?” Put another way, the credit default swap represents the intersection of supply and demand for credit for that particular corporate name. Supply and demand for credit are impacted by many attributes of the underlying reference name. The five year default probability is just one of many potential variables that can best explain the level of CDS spreads for all issuers at all points in time in the database used to fit the implied spread function.

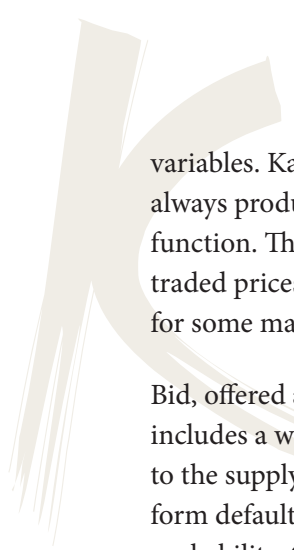
The next section explains how implied spreads were estimated from a very large database of CDS bids, offers and traded prices provided by the broker GFI. Going back to the question above, what does it tell us if the implied spread for ABC company is 42 basis points at this point in time, when the default probability for ABC is 10 basis points and the “mid market” CDS quote is 50 basis points? The implied spread calculation tells us this: if CDS market participants were behaving “on average” as they did during the historical period from which the data were taken, ABC Company would have a CDS spread of 42 basis points when its default probability is 10 basis points. The difference between the actual spread of 50 basis points and the “average” implied spread of 42 basis points is either (a) an arbitrage opportunity or (b) a rational increment to the historic “average” because of some special factor not yet reflected in the KRIS models.

For example, ABC may have just announced that it has lost \$500 million in the 2009 Bernie Madoff hedge fund fraud. As KRIS is updated once a day, the previous day’s inputs would not have reflected this bad news, and it is indeed rational for the current CDS to be at a different level than the level consistent with historic average market behavior. What the implied spread does tell us, however, is that 32 basis points of the difference between CDS spreads and default probabilities (42 basis point implied spread – 10 basis point default probability) is “normal,” and the remaining 8 basis points (50 basis point market CDS spread – 42 basis point implied spread) is unexplained by the KRIS models. We turn now to the estimation of implied spreads on KRIS.

III. KRIS Implied Spread Calculations

The KRIS default probability service includes four default models described below, each of which has 7 different maturities of default probabilities available (note only 1 year maturities are available for the Merton model because of the single period nature of that model). The KRIS service currently covers 22,000 public companies in 30 countries, and for most companies default probabilities are available back to January 1990. The CDS quotes that are used for the implied CDS spreads modeling were supplied by the broker GFI. The GFI CDS database includes daily data from January 2, 2004 to November 3, 2005 with about 500,000 total credit default swap bid, offered, and traded price observations. Statistical relationships for bid prices, offered prices and traded prices were all estimated separately.

Many analysts fit linear equations between credit spreads and the relevant explanatory



variables. Kamakura has instead chosen the logistic function to model spreads because it always produces credit spreads that are greater than or equal to zero, unlike a linear spread function. Three separate logistic functions were fitted to CDS bid prices, offered prices, and traded prices. All maturities are fitted in one function, since the data available was too scarce for some maturities to produce a reasonable spread curve otherwise.

Bid, offered and traded implied CDS prices were calculated using a hybrid model that includes a wide variety of variables that sophisticated market participants believe are relevant to the supply and demand for credit. The hybrid model incorporates the KRIS 3.0 reduced form default term structure and its inputs, KRIS 3.0 Merton structural model default probability, CDS maturities, ratings, and all of the individual macro-economic factors and other inputs to the Jarrow-Chava version 3.0 reduced form models. Contrary to the trader's view summarized above, 45 other variables in addition to the five year default probability are statistically significant in predicting the credit default swap levels.

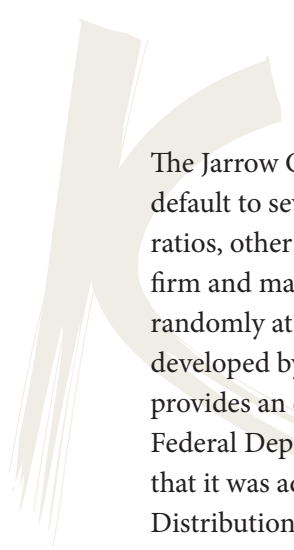
The most statistically significant variables are the full term structure of the Jarrow Chava version 3.0 default models, the KRIS Merton default probability, dummy variables for ratings levels, the nature of the credit event definition, whether or not the borrower was Japanese (because of the unique main bank system behind Japanese public firms), and various financial ratios and stock-price related returns and volatilities. The three implied spread functions for bid prices, offered prices, and traded prices explain 80-83% of the variation in CDS quotes over the 500,000 observations in the data base. The implied spread functions are updated with each new version of KRIS.

The remainder of this brochure summarizes the main types of default models available under the KRIS default probability service.

IV. KRIS Public Firm Models: A Summary

Kamakura's Public Firm Models currently offer four different quantitative approaches to modeling default probabilities: two versions of the Jarrow Chava Model (KDP-jc), the Merton Structural Model (KDP-ms), and the Jarrow Merton Hybrid Model (KDP-jm). Both the third generation (version 3.0, released in October 2004) and the fourth generation (version 4.1, released January 9, 2006) of the Jarrow-Chava models are available on our Web site at the request of the KRIS client base. All of these approaches incorporate information on market prices of firm equity and interest rates so that current market expectations are fully reflected in the default probability estimates. The availability of multiple Public Firm Models provides subscribers with theoretically sound alternative views on the likelihood a particular firm will default. Version 5.0 of the KRIS models will be released in 2009.

V. The Jarrow Chava Model



The Jarrow Chava Model is a statistical hazard model that relates the probability of firm default to several explanatory variables. The explanatory variables include firm financial ratios, other firm attributes, industry classification, interest rates and information about firm and market equity price levels and behavior. In this model, firm default can occur randomly at any time with an intensity determined by the explanatory variables. Originally developed by Kamakura's Director of Research, Robert Jarrow, the Jarrow Chava Model provides an objective, statistically reliable method of predicting potential firm defaults. The Federal Deposit Insurance Corporation of the United States announced in December 2003 that it was adopting the methodology incorporated in the Jarrow Chava Model for its Loss Distribution Model for the bank and savings and loan insurance funds. Both the third and fourth generation Jarrow-Chava models incorporate multiple equations for forecasting default at different forward time intervals, conditional on survival to that point in time. These equations share the same inputs but they have different weightings depending on the time horizon. The current and forward conditional default probabilities are combined to derive the full default term structure out to five years.

VI. Merton Structural Model

The Merton Structural Model uses option pricing methods to relate the probability of firm default to its financial structure and information about the firm's market price of equity. The explanatory variables include a measure of the firm's outstanding debt, its market valuation, and information about firm and market equity price behavior. In this model, firm default occurs when the market value of the firm's assets decline below a threshold related to the firm's outstanding debt. Robert Merton, winner of the Nobel Prize in Economic Sciences in 1997, originally developed this model.

VII. Jarrow Merton Hybrid Model

The Jarrow Merton Hybrid Model is a statistical hazard model that relates the probability of firm default to the same explanatory variables as the Jarrow Chava Model, but it also incorporates the default probability of the Merton Structural Model as an additional explanatory variable. In this model, firm default can occur randomly at any time with an intensity determined by the explanatory variables. Kamakura offers this Model to combine the default prediction capabilities of the associated models. Forward default probabilities and the full term structure of default are derived in the same fashion as for the Jarrow-Chava models.

About Kamakura Corporation

Founded in 1990, Honolulu-based Kamakura Corporation is a leading provider of risk management information, processing and software. Kamakura has provided daily default probabilities and default correlations for listed companies since November, 2002. Kamakura announced the KRIS Sovereign Default Probability Service on May 19, 2008. Kamakura launched its collateralized debt obligation (CDO) pricing service KRIS-CDO in April 2007. Kamakura is also the first company in the world to develop and install a fully integrated enterprise risk management system that analyzes credit risk, market risk, asset and liability management, transfer pricing, and capital allocation. The Kamakura Risk Manager system, now in version 7.0, was first offered commercially in 1993 and has been continually enhanced since then. Kamakura has served more than 185 clients ranging in size from \$3 billion in assets to \$1.6 trillion in assets. Kamakura's risk management products are currently used in 27 countries.

Kamakura has world-wide distribution alliances with Fiserv (www.fiserv.com), Unisys (www.unisys.com), and Zylog Systems (www.zylog.co.in) making Kamakura products available in almost every major city around the globe.



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