Multi-Level Risk-Controlled Sector Optimization of Domestic and International Fixed-income Portfolios Including Conditional VaR

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Recent experience in capital markets has highlighted the need for risk-sensitive portfolio strategies in both domestic investment grade as well as opportunistic high-yield and emerging market portfolios. We have previously developed a fixed-income sector[4] optimization methodology to facilitate tradeoffs between various sectors based on their contribution to the total portfolio return and risk[5]. We maximize portfolio return subject to constraints including Value-at-Risk (VaR) and other downside risk measures, both absolute and relative to a benchmark (market and liability-based). Our method optimizes interest rate, curve, credit, and volatility exposures to achieve the highest expected return (view-oriented, historically based, or quantitatively forecast) within the allowed risk space defined by various specified risk constraints.

This work advances the state-of-the-art in the risk-controlled optimization process for cases where there are a large number of subsector decision variables. These advances include: 1) introduction of a multi-level optimization process to avoid ill-conditioned joint risk characterization of a large number of subsectors, and to reduce required length of time histories, 2) refinement of our previous VaR and CVaR methodologies to add opportunistic nondollar bonds as well as high yield and emerging markets, and 3) ability to control risk at subsector levels as well as the total portfolio.

Full single-stage optimization of portfolios with varied sectors each composed of multiple subsectors would be highly dependent on cross correlations among all the subsectors (cells). Dependency of returns among the cells within each sector and among different sectors as aggregate tend to be more stable over time and less noisy than the ones among cells of different sectors. For example correlation between mortgage and emerging market sectors tend may be variable than 30-year conventional premium mortgages and long Brazilian Brady bonds. Furthermore, many portfolio mandates require risk controls both at opportunistic sector levels as well as the overall portfolio. These issues favor a multi-level risk controlled sector optimization strategy over a one-stage process.

Another potential limitation of full single-stage optimization is that the inclusion of a large number of distinct sectors implicitly requires long series of historical data for an accurate estimation of the correlation between the subsectors. This requirement might yield stale correlation estimates, as reliable fixed income data are typically available at a low frequency (weekly or monthly). Therefore the resulting portfolio allocations may be inconsistent with recent market conditions. This may be particularly problematic when portfolios that allow for investment in non-dollar or emerging markets are considered. In such context, the need to model local yield curves and exchange rates will result, literally, in dozens of additional

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[4] In this study term "sector" generically refers to securities that fall within fine criteria of type, sector, credit, and effective duration range.

[5] Sector Optimization of Fixed Income Portfolios subject to Value at Risk and Traditional Risk Measures, Working Paper, State Street Research, Boston, MA. Presented at 8th Annual IAFE Conference, New York, NY, October 1999.

variables whose joint risk characteristics must be estimated.

To address this issue we propose a multi-level portfolio optimization approach where rather than including all variables simultaneously, we perform our portfolio optimization in two stages. First, we find detailed optimal allocations for each opportunistic subsector such as nondollar. This is achieved by including all relevant variables for that subsector, e.g. all currencies and country yield curves or factors for non-dollar assets, plus representative indices for the remaining categories, e.g. a Lehman Brothers index for investment grade assets or Salomon Brothers' EMBI+ index for emerging markets. This local optimization is tailored to the specific risk preferences of the portfolio manager for that category. Second, a global optimization is performed using the locally optimal indices obtained from the first stage, to represent each category. As in the local case, the global optimization will be tailored to the portfolio manager's risk preferences, including duration and sector allocation constraints.

The multi-level approach may result in a global portfolio allocation that is ex-ante inferior to that obtained from a full single optimization that makes use of all variables simultaneously. However, given the unfeasibility and lack of reliability of such a full optimization over short time periods, our multi-level approach constitutes an attractive alternative to consider. We explicitly compare the risk-return tradeoff of portfolios obtained from single- and multi-stage optimization procedures to assess merits of each approach.

Our VaR methodology is a combination of a Variance/Covariance approach for domestic high grade corporates, and a GARCH with random jumps approach for emerging markets[6] and high-yield. Performance of the VaR technique is tested in terms of out-of-sample hit rates as well as formal test statistics for emerging markets. A practical method to integrate domestic and emerging market risk estimation techniques has been developed and tested. A model for G-13 non-dollar government bonds is currently being developed and will be integrated in this process.

Another important downside risk measure incorporated in the model is portfolio return under historical or user-defined stress scenarios (defined by curve, volatility, and spreads). This method accounts for the differences between current market and past or potential future extreme conditions. Other downside risk measures included are overall portfolio duration, curve exposure (defined by different duration cells), and effective spread duration by sector.

The objective function can be specified in terms of single scenario return or a probability weighted return under multiple scenarios. The optimization technique could be used for both tactical as well as strategic asset allocation. The implementation allows for using VaR/CVaR estimates based on current or historically referenced dates. Optimized portfolios can be sensitive to forecast scenarios, risk limits as well as VaR assumptions. Our methodology highlights the sensitivity of the optimized portfolio to such input variables.

Furthermore, we use a risk measure we refer to as "Conditional Value-at-Risk" (CVaR). CVaR represents the mean level of losses beyond a specified confidence level. Since VaR is calculated using a Structured Monte Carlo approach with some finite number of paths, it tends to be a nonconvex function of the subsector weights that are being optimized. On the

[6] A New Method for Estimating Value-at-Risk of Brady Bond Portfolios, Working Paper, State Street Research, Boston, MA. Presented at CIFEr, New York, March 30th, 1999

other hand, CVaR tends to be a much smoother function and hence its use significantly enhances the efficiency of the optimization process. Also some may argue that CVaR is a more appropriate measure for risk than VaR.

Our plan also includes the development of more refined models of risk and return for sectors with embedded options such as callable agencies, corporates, and mortgages. While the term structure models for analyzing individual bonds with embedded options are quite developed, it has been much more difficult to forecast performance of these sectors due to multiplicity of factors driving them. A reasonably accurate parametric model for sectors dominated by embedded optionality will be an essential element of our study.

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