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Introducing the Northfield Global Fixed Income Model

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Northfield Webinar
March, 2019

Northfield's Fixed Income Legacy

- In 2001, Northfield Information Services introduced the Everything Everywhere (EE) model which evolved to cover about 4 million instruments globally. The vast majority of them are fixed income instruments.

- Along the way, we introduced a number of "first of a kind" modelling approaches and capabilities in the fixed income space that were published in peer review journals and recognized with industry awards. Among them:
  - DiBartolomeo – Corporate viability, Expected life of firms, Journal of Investing, 2010
  - Sovereign Credit Risk – PRMIA New Frontiers in Risk Management Award for 2013
  - ARES 2015 Best Practitioner Research - Approach to Illiquid Asset Optimization inclusive of collateralized and private debt
- The EE framework features a robust and concise factor set geared towards a multi-asset class portfolio. It also incorporates a very efficient and granular pricing algorithm for fixed income instruments that deals with embedded options and path dependency.

Enter the Pure Fixed Income Factor Set

- Term Structure Factors
  - Instead of one Global Curve factor set that is part of EE the Pure Fixed Income Features 6 major currency denomination risk –free yield curves – USD, GBP, CHF, EUR, JPY, and AUD. These denominations cover approximately 90% of the outstanding debt around the world.
  - The rest of the 69 currency denomination yield curves covered by the model are a weighted representation of the major curves based on explicit economic relationships. Consequently, the bonds denominated in the rest of the currencies have terms structure exposures that are first exposed to their own curve which is then remapped to exposures to the major curves.
- Descriptors of the yield curve shape
  - The explicit factors describing changes in the shape of the yield curve are the familiar parallel, slope, and curvature moves – "shift", "twist", and "butterfly"
  - By their nature, the S/T/B factor exposures easily convert to key rate durations

The Fixed Income Factor Set (cont'd)

- Credit Risk Factors
  - The EE approach is similar to the structural credit risk approach suggested by Robert Merton. It provides a cohesive construct for portfolios consisting of both bonds and equities.
  - The Pure Fixed Income replaces the use of a structural credit risk approach with explicit capture of credit spreads. It defines 300 credit buckets defined by geography, rating, and sector that feature a time series of associated Option Adjusted Spreads
  - The factors are formed selectively either in Absolute Spread Difference (ASD) fashion or Duration-Times-Spread (DTS) fashion. More on how the ASD vs DTS selection per bucket is made in a bit.
  - The exposure of the bond to its bucket's factor is respectively the (a) spread duration, or the (b) spread duration times the most recent OAS, depending on whether ASD or DTS were selected for the bucket.

The Fixed Income Factor Set (cont'd)

The factor invariant formulation under DTS is:

$$\frac{(Spread_t - Spread_{t-1})}{Spread_{t-1}}$$

The factor invariant formulation under ASD is:

$$Spread_t - Spread_{t-1}$$

Accordingly the factor exposure under DTS at time t is:

$$Spread_t * Spread\ Duration_t$$

The factor exposure of a bond under ASD is:

$$Spread\ Duration_t$$

DTS: The Good, the Bad, and the Untold

- DTS has gained prominence since the mid-2000s due to empirical evidence of good historical volatility fits for investment grade bonds.
  - DTS makes the assumption that OAS is proportional to the bond volatility. This makes the spread factor invariant similar to equity returns.
  - Assumptions typically used for equity returns (normal, symmetric) are not applicable to bonds due to the asymmetry of their distribution. For individual bonds the returns are bound from above and have a long fat tail. For a bond portfolio, the Central Limit Theorem applies only weakly due to the non-independent nature of individual bond returns.
  - The issue is not so severe for high grade bonds because the probability mass is concentrated away from the lower fat tail.
  - The issue is pronounced for lower grade bonds where the second moment is a much of a lesser consideration to the investor risk premium, so the DTS theory will fit spuriously, at best.
  - These concerns predicated our choice to use DTS for investment grade bonds and ASD for sub-investment grade bonds.

Rates Volatility Factor

Interest Rate Volatility Factor

- A factor that affects the volatility of global interest rates was added to the Fixed Income model. It is expressed as the proportional change in average interest rate volatility along the global yield curve.
- Fixed Income instruments would be exposed to this factor for two reasons. The first and dominant one is that bonds with embedded options will be affected by a change of interest rate volatility as it will affect the value of the embedded options. Hence the interest rate volatility factor can be thought of a "prepayment" factor.
- The second effect, which is relatively minor, relates to changes in the risk free rate and the projected constant credit spread used in discounting. A change in the volatility will precipitate a different distribution of the risk free rate in combination with an unchanged spread level. Due to multiperiod discounting this change of the distribution of the "one period" rate will translate into some trace rate vol factor sensitivity.

Currencies

Currency Factors

- The currency factors are incorporated in the Fixed Income Model similarly to the way they are in the Everything Everywhere model. Each security is exposed to a currency factor in relation to its denomination to that currency. For example, a US Treasury bond will have a unit exposure to the USD factor and zero to all other currency factors.

Currency Positions

- Apart from currency factors to which bonds are exposed the model also covers cash currencies. Forwards and other currency derivatives will be covered in the very near future.

Idiosyncratic Risk

Bond Specific Risk

- Only a very small percentage of bonds trade consistently and continually on a daily basis. That makes tracking bond by bond idiosyncratic spread behavior over time simply implausible for a universe of 4 million securities.

- That is why, the *idiosyncratic* risk portion of the bond risk in the Northfield Fixed Income model comes from the existing EE Merton process. This has several benefits. First it, assures that even non-regularly traded bond instruments have the requisite data to establish idiosyncratic risk estimates, as long as their associated equity instruments have transparent and continual pricing, which is almost universally true.

- Secondly, this approach opens the way to include textual news feed adjustment of issuer specific risk estimates on a daily basis, linking the Northfield Fixed Income model to our Risk Systems That Read ™ process.

Factor structure considerations

Covariance matrix.

- The number of non-currency factors in the Fixed Income (300+) is larger than those in the EE model (less than 30) while the number of historical observation has remained approximately the same (60 months for the monthly FI model and likewise for EE).

- To avoid the large number of factors making the model rank deficient, we do not use directly the correlations derived by the time series of the spread factors. Instead, we use Merton model derived default correlations among the bond buckets associated with the spread factors, as would be computed through the EE model.

- This ensures that correlations across securities themselves are effectively based on a much smaller number of factors. Unlike correlations, we observe the spread factor volatilities directly in the Fixed Income Model.

Factor structure considerations (cont'd)

Yield curve factor alternatives.

- An alternative to the shift, twist, and butterfly curve factor representation is the "key rate" approach, which samples specific maturity points on the yield curve. The exposures to each of those factors are known as "key rate durations".

- While intuitive, the liquid points on the different key rate curves across the world are not the same, due to different market segmentation, investor preferences, and government borrowing practices. This makes a small set of key rate horizons across countries impossible, essentially requiring a pre-formulated fit approach, similar to the shift, twist, and butterfly view we have adopted.

- In recognition that some users prefer risk decompositions from yield curve movements in kay rate units, we have adapted a transformation of the shift, twist, and butterfly representation of yield curve risk from shift, twist, and butterfly into key-rate factor representation. The tools to perform this transformation are available on demand.

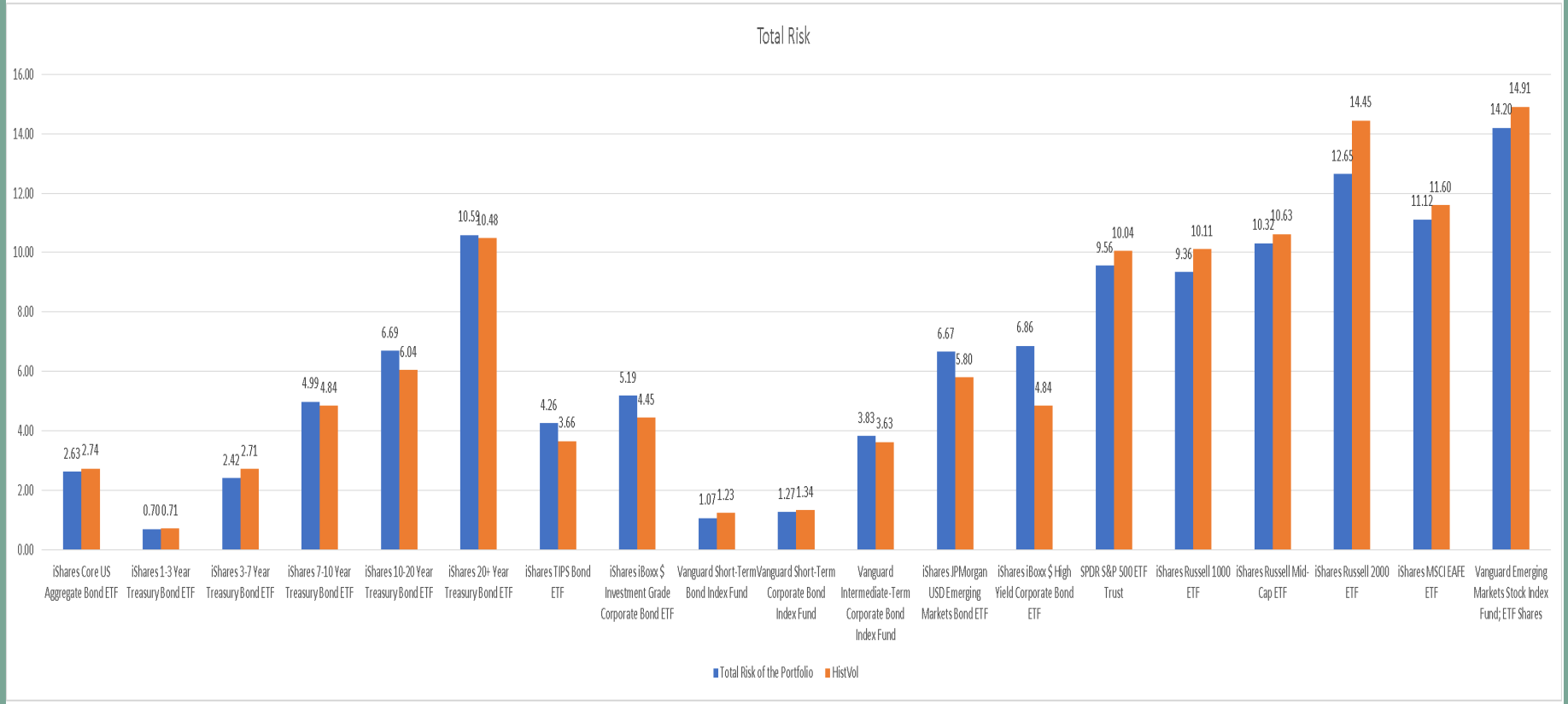
Frequency of Model Updates

There are two varieties of the model in terms of frequency of operation – monthly and daily. This mirrors the approach to updating all other Northfield models.

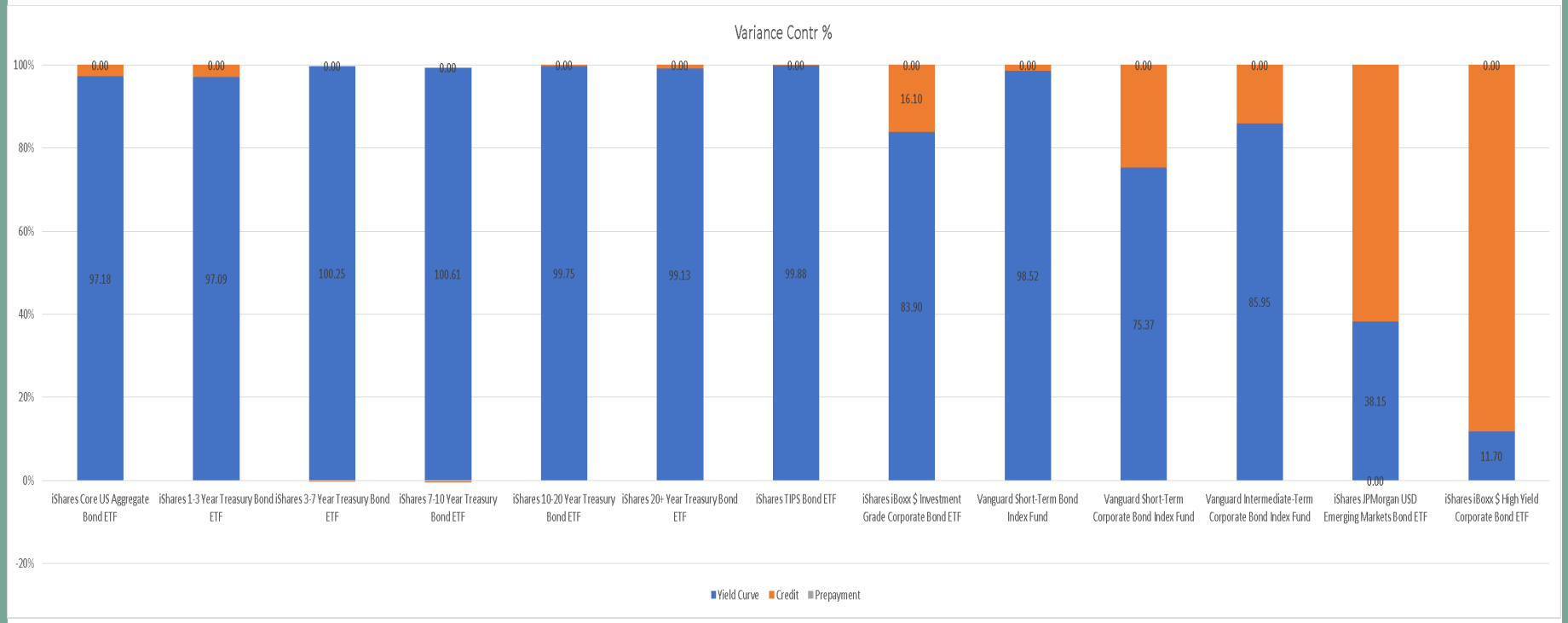
Monthly update. Operates similarly to the Everything Everywhere model, fully re-estimating the entire bond universe at the end of each month. Factor returns used have monthly frequency, and the historical observation window is 60 months.

Daily updates Full repricing done for government and corporate bonds, agency debentures, and MBS. This process is identical to the monthly update, with the only two differences that the daily update use daily changes in yield curves and spread as factors, etc. and the historical observation window is 500 trading days. CMO, ABS and other structured products are matrix priced on a daily basis.

Model Performance



Model Performance (cont'd)



Soon-to-be Added Features

- Emerging Markets tend to have their own unique detrimental potential – a massive ***economic and political collapse*** (e.g. Venezuela); we are adding an adjustment to idiosyncratic risk that will reflect the binary probability of such extreme adverse scenarios

- As noted, ***higher moments*** have a significant impact on the risk attractiveness of fixed income instruments. A lower volatility in a distressed debt instrument does not make it preferable in optimization unless accompanied by a pronounced positive skew. Likewise, a relatively high negative skew of one investment grade bond might make it less attractive than another one with lesser negative skew, while both might have the same volatility and expected return.

- While ratings are qualitatively assigned, the issuer viability implied by the Merton-style model may suggest an instrument be placed ***"in between" credit*** buckets, which incorporates downgrade risk.

Conclusion

- The new Northfield Fixed Income model builds upon proven bond data and pricing infrastructure that embeds numerous advantages in accuracy, efficiency, and economic integrity over competitive products. In that sense, while new, the model is based on 20 years of "in-the-trenches" fixed income industry experience.

- Meanwhile it provides a new way for the Fixed Income investment managers to analyze risk that translates and transcends the 'best of breed" features of the existing EE model into the factor set, metrics, and reporting framework that is the natural way of thinking for Fixed Income investors and firms.

- It provides an escape route from the dependency on expensive fixed income models and systems by "take it all" vendors. The Northfield model has all the same and many more attractive features, while mitigating many of the drawbacks, including providing a categorically higher level of vendor independence and objectivity.

Question and Answer Session

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