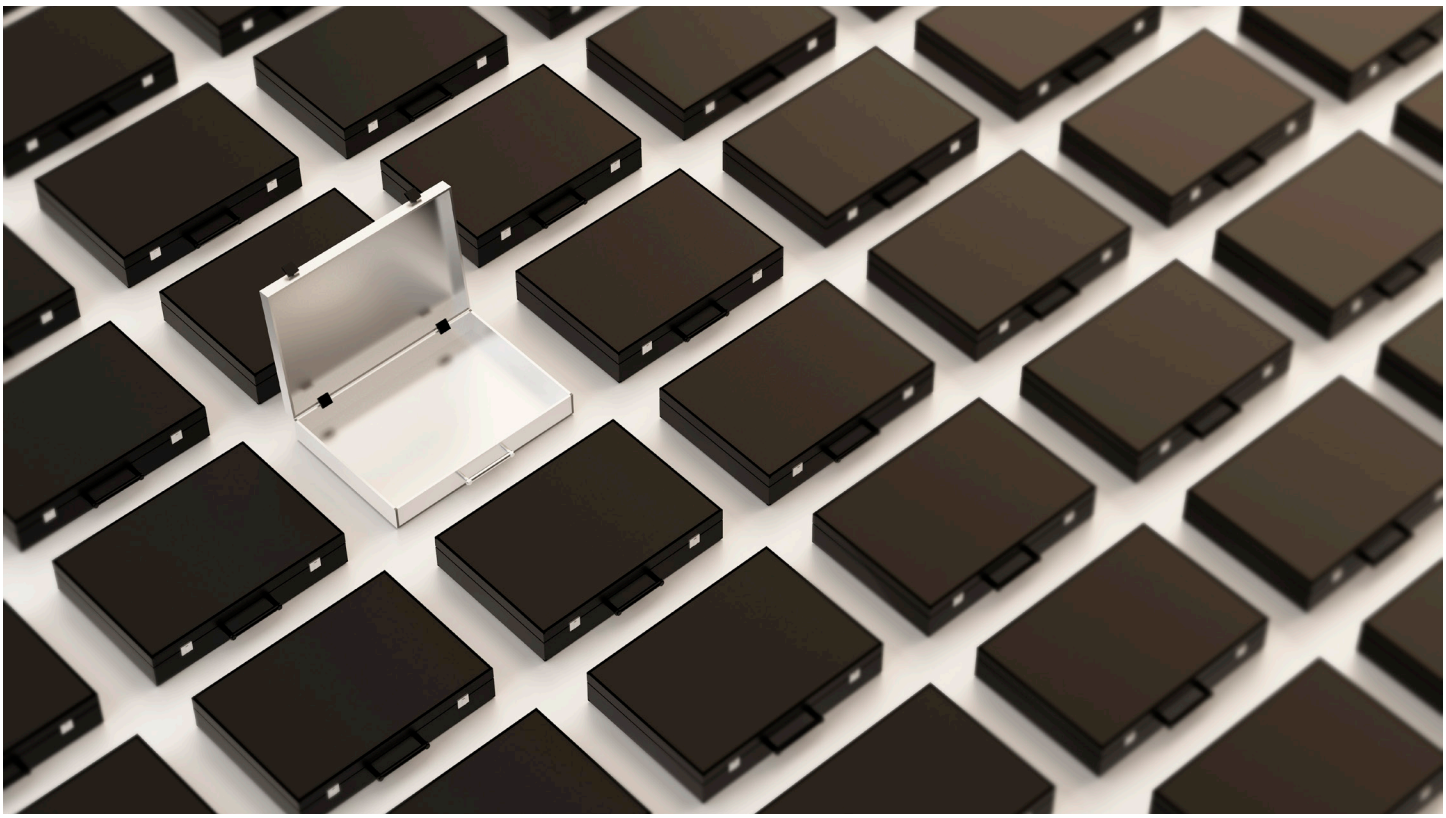

Why Should Investors Consider Credit Factors in Fixed Income?

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A substantial body of academic research and a long track record of use in portfolios has led to a growing acceptance of factor investing within the investment community. Most of the academic research and practical implementation of factors has been done in the equity asset class, where factors have been used to explain equity risk and return. In more than 50 years of research, three general reasons have been given for why factors earn excess returns.

First, factors can earn higher returns given higher risk levels. Second, factors address the collective behavioral biases of investors that result in sub-optimal investing. And third, structural impediments to the efficient use of capital can lead to excess returns. For example, companies downgraded to below investment grade — so-called "fallen angels" — may be off-limits to certain investors but offer opportunities to others. Often, a single factor's return pattern encompasses all three explanations.

Factors Should Exist in All Asset Classes

While factor investing is quite established within equities, there is much less academic research and a much shorter track record when it comes to fixed income portfolios. However, we believe the underlying reasons for factors are not asset class-specific.

Factors simply connect investor behavior to investment returns. As such, there is no reason to believe they cannot be applied to other asset classes, such as fixed income.

However, factors are only recently being harvested in fixed income portfolios. What are the reasons for this lag in adoption? First, fixed income securities are inherently more complex than equities, causing fixed income factor research to be slower to evolve. For example, while equities of one issuer are interchangeable, bonds are typically not. Bonds of the same issuer can have different

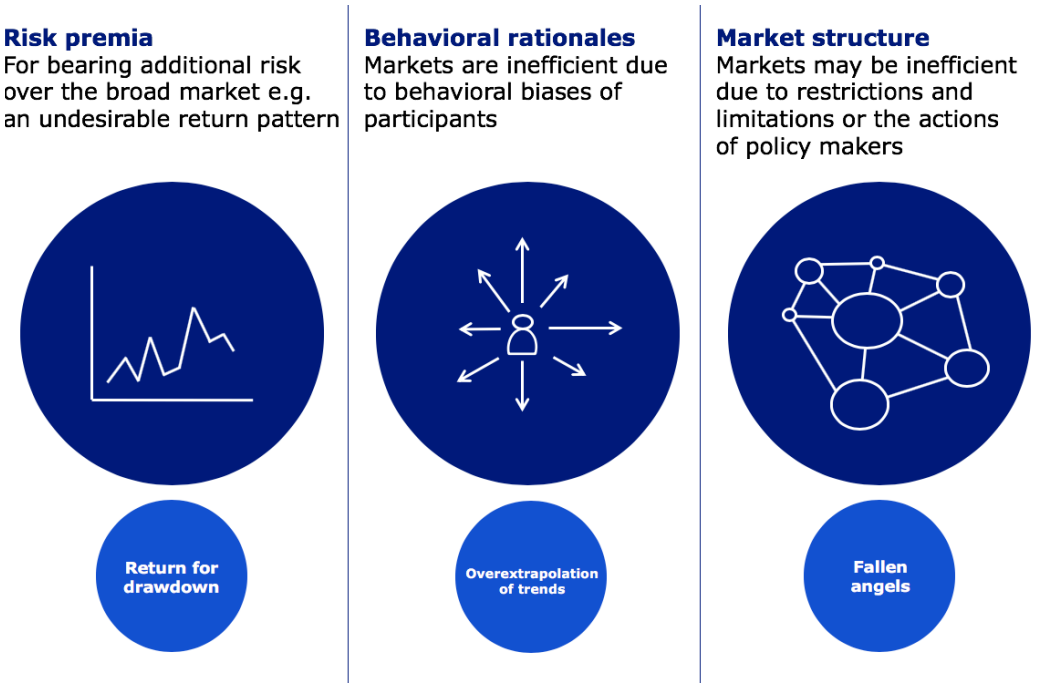

Exhibit 1: Three major reasons for excess returns associated with factors
Source: Invesco.

maturities, levels of liquidity, embedded optionality and can represent different parts of the capital structure.

Second, when interest rates were high, many investors were content to earn returns from coupons, without giving much thought to price appreciation. However, as yields have fallen, factors have become viewed as more valuable in helping to generate returns from prices, and not just from coupons.

Risk Premia Definitions Matter

Many investors have concerns about using factors in fixed income investing. We believe choosing the right factor definitions can improve reliability and comfort around the concept of factors. In our view, risk premia definitions are favorable since they are the most likely to provide attractive long-term outcomes to investors.

Risk premia definitions are based on the rationale that excess returns can be generated by assuming unwanted risks. We believe this fits into an efficient market framework and offers a compelling and consistent approach to understanding asset performance.

A recent review of academic literature confirms this view. Two new studies utilizing robust techniques to guard against data mining confirm that only a few factor definitions have a high likelihood of existence — these definitions are based largely on risk premia.[1] Several authors have also identified a striking relationship between factor strategies with high tail risk and higher Sharpe ratios.[2]

Another advantage of risk premia definitions is gaining more certainty around risk. By pre-identifying the risks inherent in strategies, and not mistaking them for pure alpha, investors can better size these factors in portfolios. For a conservative investor, we believe risk premia-based factors are likely to entail fewer unidentified risks.

Fixed Income Factor Definitions Must Be Carefully Designed to Allow Practical Implementation

There are major differences between equity and fixed income factor investing. The spread of electronic trading, dedicated pools of factor investors and deeper shorting liquidity among equities relative to bonds are among the reasons that equity and fixed income factor implementations differ. Fixed income, generally, has higher transaction costs, lower liquidity and lacks a deep short market, apart from a few types of government bonds.

Higher transaction costs mean that factor returns need to be heavily scrutinized to ensure that their returns are positive and not just trading frictions.

In addition, less liquidity at the bond level means that factor definitions must be robustly designed so that their risk and return characteristics are relatively independent of the number or types of bonds used. Often, only 60% of the bonds desired for a factor portfolio are available for trading. There needs to be some confidence that factor portfolios can be formed given the available liquidity underlying the market. Finally, it is generally difficult to short bonds. Therefore, practically speaking, long-only portfolios are the principal way to gain fixed income factor exposure.

Fixed Income Investors May Wish to Consider Credit Factors First

While we strongly believe that factors can be found in all asset classes, we believe credit offers the best place to start fixed income factor investing. Corporate bonds offer a larger cross-sectional universe from which to build portfolios than government bonds

or currencies, facilitating larger, more diversified portfolios that retain mostly factor exposures. Second, given the long-only constraint, we would expect credit beta exposure to be a large driver of returns — credit beta has one of the most consistent Sharpe ratios among all asset classes and clear risk-return characteristics, which build confidence in the likelihood of future excess returns.

Factors in Action — Liquidity, Quality, Value, Momentum and the Multi-Factor Approach

Our research has focused on creating credit factor definitions consistent with traditional equity factors and applying them to corporate bonds. While corporate bonds have traditionally been classified by maturity, rating and industry, we have created a four-factor model that includes liquidity, quality, value and momentum. We briefly describe these factors below. In keeping with our factor philosophy, we describe the fundamental rationale, regime dependency of each factor and consistency of performance across investment grade, high yield and equities, which we believe indicates robustness. Our definitions build on studies found in academic literature, although some key details differ.[3,4,5] Finally, we provide an example of the potential excess return generated by a multi-factor credit model.[6]

Table 1
a. Investment grade

	Index	Liquidity	Quality	Value	Momentum	Multi-factor
Beta	1.00	0.82	0.48	1.17	0.67	0.63
Alpha (bps)	0.00	4.10	2.47	5.96	-0.09	5.02
Turnover (annual %)	19	39	57	269	295	209
Tracking error bps (ER)	0	129	244	126	246	188
Sharpe ratio (ER)	0.18	0.31	0.29	0.34	0.14	0.38
Drawdown (%) (ER)	24	22	14	24	15	14
b. High yield						
Beta	1.00	0.80	0.64	1.40	0.68	0.71
Alpha (bps)	0.00-	23.28	11.27	3.51	21.27	8.10
Turnover (annual %)	31	85	65	255	276	192
Tracking error bps (ER)	0-	296	386	561	433	324
Sharpe ratio (ER)	0.31	0.54	0.51	0.32	0.61	0.72
Drawdown (%) (ER)	45	38	34	51	33	33

Exhibit 2:
Source: Bloomberg Barclays US Corporate Investment Grade Index (IG Index) and Bloomberg Barclays US Corporate High Yield Index (HY Index), Invesco calculations. Summary statistics are shown for investment grade and high yield factors over the period Jan. 1, 1994 to March 31, 2017. "bps" is basis points. All statistics are in excess returns (ER), or duration-hedged returns. Turnover is calculated as half of the percentage of portfolio buys and sells. The drawdown is calculated from peak to trough over the period. Past performance is not a guarantee of future results. An investment cannot be made directly into an index

Summary of Factor Risks and Returns

Exhibit 2 summarizes the risk and return characteristics of the four factors relative to the Bloomberg Barclays US Corporate Investment Grade and High Yield Indices (IG and HY indices). All the Sharpe ratios, except investment grade momentum, exceed those of the benchmark issue-weighted indices.

Credit Factor Descriptions

Liquidity

We start with liquidity and treat it separately because it is somewhat unique to the fixed income space. The liquidity factor explains the excess risk and return associated with holding illiquid bonds. The liquidity factor is defined by those older bonds that are small in issue size relative to large, newly issued bonds. This factor definition has been well researched.[7]

- In fixed income, illiquid bonds are often not marked to market accurately. As a result, they tend to have higher yields relative to comparable liquid bonds. Historically, they seem to have higher Sharpe ratios (Exhibit 2) without any additional drawdown.
- Exhibit 3 shows the average return of the liquidity factor for both high yield and investment grade bonds in different risk environments, i.e. five different VIX scenarios.[8] Bucket one represents the periods with the largest decreases in the VIX and represents periods when risk sentiment was the best (risk-on). Bucket five represents the periods with the largest increases in the VIX and represents periods when risk sentiment was the worst (risk-off).
- The returns are plotted in terms of duration-hedged excess returns versus the benchmark returns. The benchmarks used were the Bloomberg Barclays US Corporate Investment Grade and High Yield Indices for the investment grade and high yield liquidity factors, respectively.

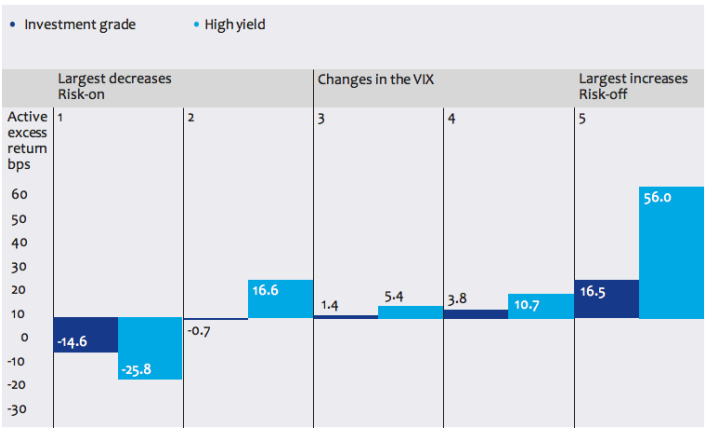

Exhibit 3: Liquidity factor excess returns in different VIX Scenarios:
Source: Bloomberg Barclays US Corporate Investment Grade and High Yield indices, Invesco calculations. The scenarios were during the period January 1, 1994–March 31, 2017. The average return of the liquidity factor in both high yield and investment grade is plotted for five different scenarios of VIX changes. Bucket 1 represents the periods when the VIX decreased the most and, therefore, represents periods of very positive risk sentiment (risk-on). Bucket 5 represents the periods when the VIX increased the most and, therefore, represents periods of very negative risk sentiment (risk-off). The returns are duration-hedged returns (excess returns), relative to the respective benchmark returns (active returns). The benchmarks used were the Bloomberg Barclays US Corporate Investment Grade and Bloomberg Barclays US Corporate High Yield Indices.

Contrary to the idea of a higher "risk premium" driving higher returns, the liquidity factor outperformed during periods of extreme market stress (bucket five). However, in reality the risk is significant, in that it is extremely likely that selling an illiquid bond during times of market stress would result in a significant loss. The scenario analysis returns only accrue to buy-and-hold investors. Therefore, only investors who can hold illiquid bonds through market turmoil would be able to harvest higher Sharpe ratios.

Quality

The quality factor explains the higher risk-adjusted returns associated with holding low volatility, bonds, as is widely observed in the academic literature.[9] These are typically shorter-maturity bonds with low default risk, as measured by their credit ratings. The quality factor is a characteristic of securities that tend to be good stores of value during times of market stress since they demonstrate low volatility. Exhibit 4, (a-c) shows that the quality factor consistently outperformed during periods of market stress across the three asset classes. Conversely, quality underperformed during market rallies. in Exhibit 2 shows that the quality factor earned risk-adjusted alpha and had a higher Sharpe ratio than the market index of each asset class. Since the quality factor typically underperforms during market rallies, it must offer a higher Sharpe ratio to compensate investors for this trade-off.

Value

The value factor explains the excess return obtained by holding assets that are priced at a discount relative to other similar securities. Since a bond's price is a function of its default risk, it makes sense to look for those bonds that are priced at a discount relative to their implied default rates. Exhibit 2 shows that the value factor earned risk-adjusted alpha and had a higher Sharpe ratio than the market index. Exhibit 4 shows that the value factor provided strong Sharpe ratios in compensation for the materially larger tail risk during times of market stress.

Momentum

The momentum factor explains the return of past winners versus past losers. Momentum produced the weakest Sharpe ratios in investment grade (Exhibit 2), especially using definitions most consistent with traditional equity momentum factors. This is partly because bonds can only appreciate by so much, especially investment grade bonds with prices already close to par. As a result, bonds have a different time horizon and structure than equities. More speculative bonds have the strongest Sharpe ratios using the equity-based definition due to the role of price appreciation in their returns.[10] Our analysis indicates that momentum offers diversification benefits,* which can lead to improved Sharpe ratios in the case of multi-factor portfolios.

Comparing Quality, Value and Momentum Factors in Different Risk Environments

Exhibit 4 (a-c) shows the performance of the quality, value and momentum factors across five different VIX scenarios for high yield, investment grade and equities. There is a striking similarity in the conditional correlations, or return patterns, of the factors across the VIX scenarios and the three asset classes. Quality and momentum were positively correlated to each other but negatively correlated to risk sentiment — they had the highest return periods when risk sentiment was the lowest (risk-off).

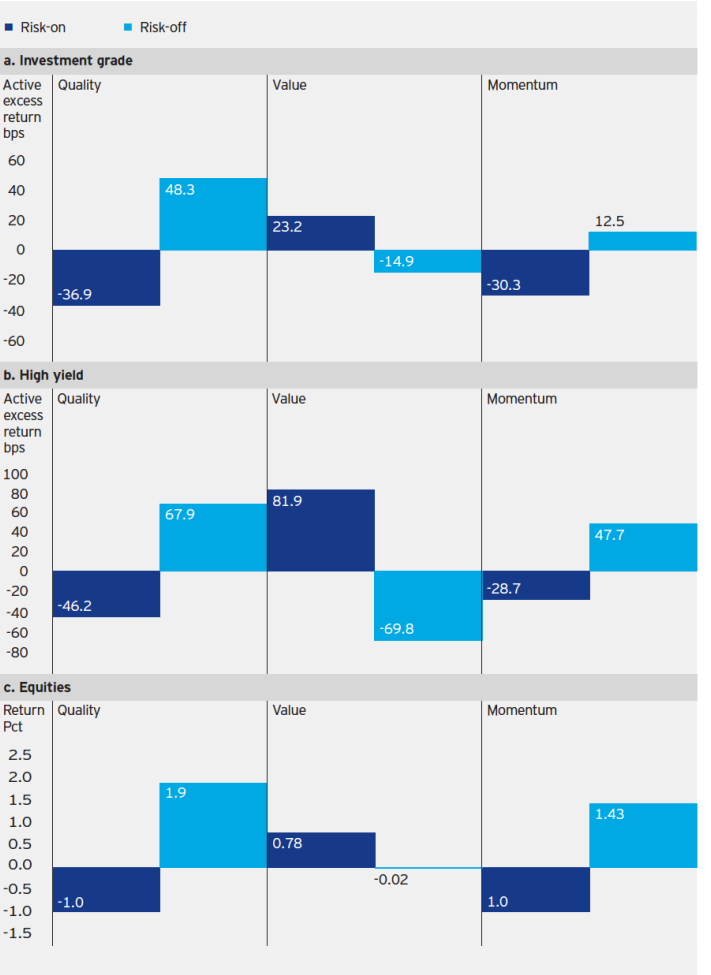

Exhibit 4 (a-c): Average excess returns of quality, value and momentum factors in high yield, investment grade and equities, corresponding to historical changes in the VIX
Source: Bloomberg Barclays US Corporate Investment Grade and High Yield indices, CRSP US Stock Databases, Invesco calculations. Scenario returns were calculated from January 1, 1994–March 31, 2017. "bps" is basis points. For the equity factor returns, "Quality" is taken from Frazzini, Andrea and Lasse H Pedersen, "Betting Against Beta", Journal of Financial Economics, 111, 1–25, 2014. The value factors taken from Asness and Frazzini, "The Devil in HML's Details," Journal of Portfolio Management, 29, 29–68, 2013. The momentum factor is based on Fama and French, "Multifactor Explanations of Asset Pricing Anomalies," Journal of Finance, 51, 55–84, 1996. The returns are duration-hedged returns (excess returns), relative to the respective benchmark returns (active returns). Indices utilized are the Bloomberg Barclays US Corporate High Yield Index and the Bloomberg Barclays US Corporate Investment Grade Index. The dark blue bars represent periods when the VIX decreased the most and represents periods of very positive risk sentiment (risk-on). The light blue bars represent the periods when the VIX increased the most and represents periods of very negative risk sentiment (risk-off).

Value was negatively correlated with quality and momentum and negatively correlated with risk sentiment — value tended to have its highest return periods when the VIX was decreasing the most (risk-on). We believe this consistency suggests that our definitions reflect the generation of a common value risk premium across all three asset classes.

Benefits of a Multi-Factor Portfolio

Exhibit 2 shows that our factors helped generate higher Sharpe ratios over the period shown, underscoring their diversification benefit. However, single factors can experience long periods of underperformance or outperformance. Therefore, we believe it is valuable to take a balanced, multi-factor approach to help ensure consistent outperformance. For simplicity, we show the return profile and attribution of an equally weighted multi-factor portfolio.

Exhibit 2 shows that, in both high yield and investment grade, the multi-factor portfolio produced higher Sharpe ratios without adding a significant amount of downside risk.

Factors are Always Evolving and Require Continuous Research and Active Management

We end our discussion of factors with a word of caution and stress the need for continuous research. It is very likely that factor investing will change the landscape of more fundamentally based investment strategies. As more players adapt to factor-based investing and asset markets evolve, we believe factor definitions and their risks and rewards must be continuously updated to ensure their appropriate use in portfolios. This is particularly true for non-risk premia-based factors, i.e. factors based on behavioral or market structure rationales.

To illustrate, we offer the example of the "fallen angels" factor. A fallen angel is a bond that has been downgraded from investment grade to speculative grade. Because many investors are prohibited from investing in speculative bonds, there can be short-term excess selling pressure around the time of a downgrade, which has historically allowed eligible buyers to realize excess returns. But this pattern may be coming to an end. Exhibit 5 shows the average performance of fallen angel bonds before and after a downgrade, relative to the performance of similar bonds. As shown in Exhibit 5, since 2010, there has been a meaningful reduction in relative returns earned following a downgrade announcement. At the same time, the market value of fallen angel bonds has shrunk from an average of 8% of the speculative market in 1990–2009 to an average of around 2% since 2010.[10] This illustrates one of the challenges of depending on market structure-based factors, which can decrease in effectiveness over time.

Due to such challenges, we believe it is important to constantly re-evaluate risk premia-based factors. Doing so can detect shifts in investor attitudes toward risk and return to determine a factor's likely persistence. We believe such continuous research and active management are necessary to ensure that investors earn the returns they expect from their factor portfolios.

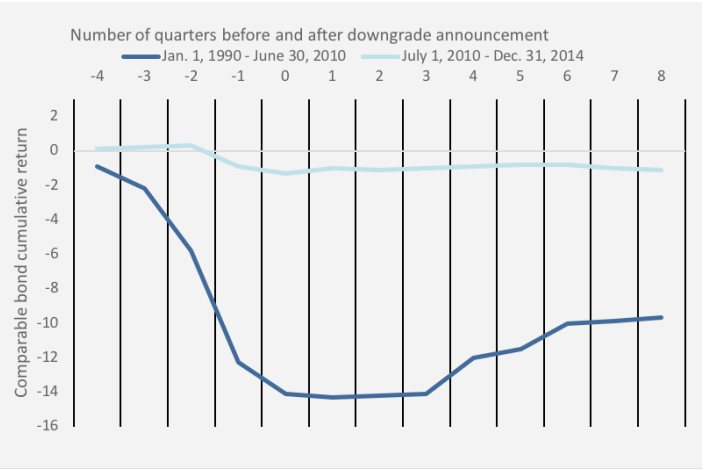

Exhibit 5: Cumulative Returns of Fallen Angel Bonds Compared to Returns of Similar Bonds Before and After Downgrade Announcement
Source: Ben Dor, Arik and Xu, Zhe, "Revisiting the Performance Dynamics of Fallen Angels," Quantitative Portfolio Strategy, Barclays Capital, 2015. The exhibit reports the performance of issuers by quarter relative to the downgrade month (defined as quarter zero). The return of each issuer is compared to the contemporaneous return of a peer group with similar characteristics ("relative returns") based on industry (financials, industrials, and utilities), credit quality (A and higher, Baa, Ba, B, and Caa and lower), and maturity (less than 10 years and greater than 10 years). Cumulative relative returns were calculated by averaging issuers' relative returns by month and then cumulating them from the beginning of the analysis window. Cumulative relative returns are reported as of the end of each quarter

Conclusion

We believe the adoption of fixed income factors allows investors to better decide which risks and returns are appropriate for their portfolios. However, by altering investor behavior, factor-based investing may also alter the risk-return landscape. At IFI, we are constantly adapting our factor framework and investment processes in order to stay ahead of these trends to help clients achieve their financial goals. In future discussions, we will demonstrate practical applications of credit factors in portfolio construction and risk mitigation.

Endnotes

1. Harvey, Liu and Zhu (2015), "… and the Cross-Section of Expected Returns," Working Paper; Harvey and Liu (2016), "Luck Factors," Working Paper.

2. Hamdan, Pavlowsky, Roncalli and Zheng (2012), "A Primer on Alternative Risk Premia," Working Paper; Lemperiere, Deremble, Nguyen, Seager, Potter and Bouchaud (2015), "Risk Premia: Asymmetric Tail Risks and Excess Returns," Working Paper.

3. Israel, Palhares and Richardson (2016), "Common Factors in Corporate Bond and Bond Fund Returns," Working Paper.

4. Houweling and van Zundert (2014), "Factor Investing in the Corporate Bond Market," Working Paper.

5. Bai, Bali and Wen (2016), "Common Risk Factors in the Cross-Section of Corporate Bond Returns," Working Paper.

6. We constructed factor portfolios by market value weighting the top quintile of portfolios ranked by factor score (for example ranked by value score). The constituents of the Bloomberg Barclays US Corporate Investment Grade and High Yield Indices were used in factor construction from the period January 1, 1994 to March 31, 2017. For the construction of factors excluding liquidity, bonds were first screened for liquidity by keeping only the top 60% and 30% in bond size each month for investment grade and high yield, respectively.

7. Bao, Pan and Wang (2011), "Liquidity in Corporate Bonds," *Journal of Finance,* 66, 911–946.

8. The VIX is an index calculated by the Chicago Board Options Exchange, often referred to as the "fear" index. It represents one measure of the market's expectation of future stock market volatility.

9. For example: Frazzini, Andrea and Pedersen (2014), "Betting Against Beta," *Journal of Financial Economics*, 111, 1–25. Low volatility bonds are typically characterized as bonds with short maturities and low default risk.

10. Lin, Wu, and Zhou (2016), "Does Momentum Exist in Bonds of Different Ratings?" Working Paper.

Authors' Bio

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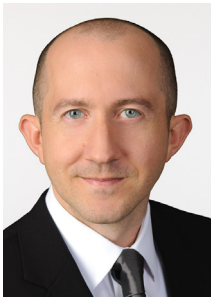
Jay Raol is the Director of Quantitative Research for Invesco Fixed Income (IFI). His team leads the research that underpins IFI's quantitative factor-based strategies across fixed income asset classes. In addition, he also leads the development of the quantitative tools that support the macro research process and factor-based portfolio construction process across the IFI platform. Mr. Raol has been in the industry since 2010. His experience has spanned across functions including quantitative macroeconomic analysis, portfolio construction and risk management. Prior to joining IFI in 2013, Mr. Raol worked within Invesco's risk management group for three years, where he ran the risk analytics function for several large equity funds. Mr. Raol earned a BA degree and a PhD in computational and applied mathematics from Rice University in Houston, Texas. Jay is a CFA Charter holder.



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Shawn Pope is a Quantitative Analyst within Invesco Fixed Income's Multi-Sector Macro Team. Shawn focuses on building quantitative macro models predicting inflation, gross domestic product growth and other economic indicators, researching risk premia factors in credit, and creating systematic strategies and research infrastructure.

Mr. Pope joined Invesco in 2013 as a fixed income risk analyst. He previously served as an analyst at Cambridge Systematics. Mr. Pope earned BS and MS degrees in civil engineering from the Georgia Institute of Technology. In addition, he earned an MS degree in quantitative and computational finance from the Georgia Institute of Technology. Shawn is a CFA charter holder.