FIRST QUADRANT

FQ INSIGHT:

Bond "Risk" and Multi-Asset Portfolios: Volatility is Just the Beginning

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> "DYING IS TOUGH, BUT NOT AS TOUGH AS COMEDY."
>
> - EDMUND KEAN

These purported last words of the 19th century Shakespearean actor Edmund Kean well describe a similar challenge multi-asset managers face today.

As we see it, "Defining equity risk is tough, but not as tough as defining bond risk." Many people see bonds as straightforward defensive assets used for income and diversification – but, like comedy, defining bond risk is not as easy as you might think.

Modern Portfolio Theory (MPT) ties risk to statistics – that is, standard deviation, correlation and tail risk. That may be fine for equities and most other "risk assets," but it does not work for bonds.[1] Instead, these statistical risks are, at best, an incomplete view of bond risk.

Unlike stocks and other risk assets whose downside risk increases dramatically when their volatility rises[2], bonds tend to experience higher average returns and less downside risk with an increase in bond standard deviation (volatility). In fact, bond managers rarely discuss statistical risks when describing portfolio risk. Instead, discussions turn to fundamental risks, which are better tied to inflation and monetary policy. Yet in a multi-asset portfolio (MAP), fundamental terms are absent, particularly in multi-asset styles like risk parity, where balancing statistical risk is the primary focus. In this paper, we address this disconnect and proffer a better way of looking at the role of bonds in a multi-asset context.

To understand this, we discuss:

- Statistical risks for stocks vs. bonds in a MPT framework
- Interest rate risk factors as defined in the bond risk literature, leading to the concept of "utility" or "usefulness" as a measure of the risk/return tradeoff for bonds
- The implications for MAPs, especially those that rely on volatility as a measure of downside risk

Two Kinds of Risk: Statistical vs. Fundamental

Statistical Risks: The Multi-Asset Manager's View

Statistical measures of risk are now widely used in portfolio management, with even managers who do not view themselves as "quants" using quantitative techniques. Their use has been legislated, as in the European Union's use of value at risk (VAR). Our earlier research about risky assets (see text box on the next page) has shown that statistics are useful for suggesting the downside risk of stocks and other traditional growth assets such as commodities and high yield bonds.

However, we have also shown that statistical measures of risk for bonds, unlike for "risky" assets, tend to vary little over time.[3] That's a

The behavior of risky assets in different market states

Our earlier research has shown that markets for risky assets have two states —high uncertainty and low uncertainty. The VIX, and whether it's above or below its long-term median, is the best-known indicator of which state applies. However, other indicators, such as widening and narrowing credit spreads, can also capture states of high or low uncertainty.

History suggests the following lessons about risky assets:

- Increased volatility is accompanied by lower returns on average, while lower volatility typically means higher returns on average.
- Risk changes over the market cycle, and periods of high and low uncertainty typically last for years.
- "Tail risk," the chance of extreme events, happens much more frequently than a random process suggests.
- "Tail events" tend to happen in the high-uncertainty state when markets are fragile.
- Diversification can fail just when you need it the most. When tail events happen, correlations within asset classes like equities rise to high levels, basically eliminating diversification benefits.

problem if you're constructing multi-asset portfolios using a covariance matrix that combines standard deviation and correlations to measure diversification. Current methodology defines risk for all assets in a multi-asset portfolio in the same manner as equity risk. Our previous studies have shown that bond risk and return, however, are only marginally affected by these same measures. Since we can be fairly certain that bonds do indeed have bull and bear markets, we need to look elsewhere for an explanation.

Fundamental Risks: The Bond Manager's View

In the last few years, there has been much digital ink spilled over risk factors. Interest rate risk is one of the more prominent risk factors and is loosely described as an asset's downside sensitivity to rising interest rates. But what causes interest rates to rise?

Interest rate risk for bonds can be examined by looking at short-term yields, the slope of the yield curve, curvature and the term premium. These factors have been identified by Litterman and Scheinkman's classic 1991 bond risk paper[4] and Adrian et al.'s 2014 paper[5].

Let's look at these four factors.

- **Short-term interest rates** are a measure of current central bank policy.
- **Slope** is the yield spread between short- and long-term bonds, typically between maturities of two and 10 years.
- **Curvature** is typically defined as the difference between the 10-year yield and the average of the two- and 30-year maturities.
- **Term premium** is the extra yield demanded by investors to hold longer-maturity bonds instead of rolling over nearer-term debt. It is more difficult to measure than the other three factors discussed here.

These four factors share key characteristics which we can examine for insights into changes in the yield curve since they reflect inflation expectations and central bank policy.

Each measure reflects a different piece of the yield curve. We have already investigated the impact of changes in short-term interest rate targets set by the central banks in previous First Quadrant work such as "Risk Cascades", (2015)[6]. That research had already confirmed the effect of short rates in a MAP framework, so we will focus on the remaining factors.

By looking at the change in each factor, we can see whether long-term inflation expectations are actually changing or whether it is instead near-term uncertainty tied to central bank activity or political issues. When all factors point in one direction, risk is a long-term rather than near-term phenomenon. And it is long-term risks that cause bear markets.

This view contrasts with the statistical view of risk used by most MAP managers (see Table 01 for a comparison). We believe that it would be useful to combine the two perspectives. But first, we must understand the role that bonds play in MAPs.

TABLE 01: BOND RISK: TRADITIONAL MAP MANAGER VS. BOND MANAGER

Bond Risk	MAP	Bond Manager
Source	Volatility	Inflation
		Monetary Policy
Measures	Variance	Interest Rate Levels
	Correlation	Slope
	Tail Risk	Curvature
		Term Premium

The Role of Bonds in MAPs

Do Your Job: Usefulness and Utility

MAPs use multiple asset classes for a reason: each asset has a job or function, such as growth, diversification or inflation/deflation protection. In fact, most assets have **multiple** functions. Inflation-linked bonds, for instance, are tied to both interest rate risk and hedging nominal bonds against inflation risk, as well as diversifying the growth assets. Looking at the different jobs bonds have in the portfolio may help determine how we should measure risk.

Sovereign bonds serve three basic functions in a MAP: (1) diversifying risk assets, (2) indirect tail-risk hedging of risk assets, and (3) deflation hedging. Many would also list income, but while investors may buy bonds individually for income, this is not true for buyers of multi-asset portfolios. Saying that a MAP manager buys high-yielding assets for income is disingenuous though current yields are an important component of bond risk.

Given the three functions that bonds perform, when are bonds useful? Or in quant-speak, when do bonds have the highest utility?

As shown in previous work, risky assets go through periods of high and low uncertainty as measured using the VIX or credit spreads. Because risky assets have growth as their primary function, we saw empirically that risky assets like stocks have high returns and low volatility during periods of low uncertainty – and low returns and high volatility in periods of high uncertainty. It would follow that for a strategic asset allocation, stocks have more usefulness, or higher utility, in periods of lower rather than higher uncertainty. That does not mean that you cannot have positive returns from equities in high uncertainty periods; however, those positive returns are more tactical, or short term, in nature than strategic or longer term. Thus, defining utility for stocks is fairly straightforward: low uncertainty means high utility and vice versa for high uncertainty.

For bonds, however, defining utility is "tough." "Risk Cascades", (2015)[7] showed that bond risk and return do not appear to be tied to these statistical measures of uncertainty. Since a MAP does not invest in bonds for growth, but rather for diversification, tail-risk hedging and deflation hedging, it might be more useful to examine how bonds do their job in these periods of high and low uncertainty than simplistically looking at their volatility.

Bond Utility in Two Market States

First, we will examine the diversification and tail-risk hedging effectiveness in the two states. In Table 02, we used daily returns of the MSCI US equity price index and the return of the US 10-year T-Note from 1/1/88 to 12/31/16, and disaggregated the returns of bonds into price and yield components. A large part of bond total

TABLE 02: RETURNS IN PERIODS OF HIGH VS. LOW UNCERTAINTY: ANNUALIZED DAILY RETURN VS. RISK

(JANUARY 1988 - DECEMBER 2016)

		10-Year US T-Note			
Macro Uncertainty		Yield	Price Return	Total Return	MSCI US Equity Index
High	Return	4.70	2.42	7.23	5.65
	Risk	0.12	7.99	7.99	22.22
	IR		0.30	0.90	0.25
Low	Return	5.26	0.27	5.55	10.32
	Risk	0.13	6.31	6.31	11.33
	IR		0.04	0.88	0.91

Source: Datastream

returns historically has been the yield. In periods of high and low uncertainty, the information ratio (IR) for bonds looks similar, implying that bonds are unaffected by the regimes. However, if we decompose the returns, we see that in high uncertainty periods capital gains play a large part, while in low uncertainty periods, bonds essentially return just their yield. So to examine the tail-risk hedging aspects, it is important to disentangle these two components. Looking forward, this could also be significant since the yield on the T-Note has averaged about 5% over this period where currently the yield is about half that. The implication for the future is that in high uncertainty periods, capital gains will become a larger part of bond total return and returns overall will be lower. Uncertainty regimes here are defined simply as when the VIX is above or below its long-term (1988-2016) median.

Table 02 reinforces our earlier finding (See "Stable vs. Unstable Markets: A Tale of Two States", 2014)[8] that high equity volatility leads to lower average returns for stocks, while low volatility leads to higher average returns, in contradiction of traditional capital market theory. In contrast, higher bond volatility leads to higher bond returns and the boost in risk and return derive primarily from the price variability. This table shows that the "constant risk" methodology of adjusting capital allocations for volatility (often used by risk parity managers) may be beneficial for equities but not for bonds.

In Table 03 (Bond Tail-Risk Hedging and Diversification), we focus on tail-risk hedging by dividing the uncertainty regimes into sub-periods of positive and negative equity returns. This allows us to see when bonds most effectively hedge tail risk.

Table 03 shows that bonds provide downside protection for equities primarily in the high uncertainty state, where bond and stock returns have a strong negative correlation

TABLE 03: BOND TAIL-RISK HEDGING AND DIVERSIFICATION

(JANUARY 1988 - DECEMBER 2016) (AVERAGE DAILY RETURN)

			10-Year US T-Note		
Macro Uncertainty	Stock Return	MSCI US	Price Return	Correlation	Days
High	Down	-1.00	0.09	-29.17%	1742
	Up	0.91	-0.06	-19.27%	2047
Low	Down	-0.53	-0.05	1.90%	1660
	Up	0.49	0.04	10.89%	2117

Source: Datastream

TABLE 04: BOND TAIL-RISK HEDGING AND THE INFLUENCE OF YIELDS: BOND AVERAGE DAILY RETURNS
(JANUARY 1988 - DECEMBER 2016)

		10-Year US T-Note			
Macro Uncertainty		Yield	Price Return	Total Return	MSCI US Equity Index
High	Down	0.02	0.09	0.11	-1.00
	Up	0.02	-0.06	-0.04	0.91
Low	Down	0.02	-0.05	-0.03	-0.53
	Up	0.02	0.04	0.06	0.49

Source: Datastream

(–29.17%) and the returns have opposite signs. In periods of low uncertainty, however, downside protection from bonds is much weaker. On average in such periods, bonds are down when stocks are down. As a result, downside correlation is slightly positive.

Table 04 (Bond Tail-Risk Hedging and the Influence of Yields) breaks bond returns into yield and price returns for another perspective on tail-risk hedging. We again see the stabilizing effect of high yields on the total return of bonds.

While bonds are useful for diversification in both states, they primarily provide tail-risk protection when uncertainty is high. So, we can say that bonds are more useful, or have higher "utility," in the high uncertainty state despite the fact that they have higher volatility as well. We can also see that reducing capital allocations to bonds to compensate for this increased volatility is counterproductive because bonds give higher risk-adjusted returns in addition to hedging against tail risk when volatility is high.

But VIX regimes alone are not enough to describe bond risk. After all, the total bond return in the low VIX state is still good, and its IR is virtually identical during both high and low uncertainty. This shows that risk and return go up and down together when using the VIX to define uncertainty states. For this reason, we look next at the fundamentals underlying bond risk, rather than examining bonds exclusively from the perspective of statistical risks.

Relating Interest-Rate Risk to Bonds' Utility

We examined trends in three of the key indicators of interest-rate risk to see if they could help to identify when bonds will experience high uncertainty, along with the higher volatility and higher returns that have historically accompanied it. We found that these indicators were more effective than standard deviation in indicating when the downside risk of bonds is higher than their upside risk.

We identified the trends in these three indicators that are associated with high vs. low uncertainty in Table 05, but keep in mind that high macro uncertainty is good for bond returns vs. risk while low uncertainty is not as favorable.

TABLE 05: HIGH VS. LOW UNCERTAINTY AND BOND RISK FACTORS

Macro Uncertainty	Slope	Curvature	Term Premium
High	Steepening	Expanding	Rising
Low	Flattening	Contracting	Falling

Our rationale for these associations follows:

- Steepening yield curves have historically happened in the US when the Fed was lowering interest rates in reaction to an economic contraction. In this environment, short rates fall faster than long rates. In contrast, when the yield curve is flattening, economic conditions

TABLE 06: INTEREST RATE FACTORS AND BOND UTILITY: ANNUALIZED DAILY RETURNS (JANUARY 1988 - DECEMBER 2016)

		10-Year US T-Note		
Macro Uncertainty		Slope	Curvature	Term Premium
High	Price Return	3.75	3.67	4.13
	Price Risk	8.03	8.03	8.09
	IR	0.47	0.46	0.51
	Total Return IR	1.15	1.07	1.09
	Skew (Std Error)	0.03(+0.6)	-0.02(-0.5)	0.11(+2.4)
Low	Price Return	0.02	0.01	0.03
	Price Risk	6.51	6.47	6.57
	IR	0.00	0.00	0.00
	Total Return IR	0.77	0.80	0.79
	Skew (Std Error)	-0.16(-4.3)	-0.13(-3.3)	-0.20(-5.6)

Source: Datastream, NY Federal Reserve

are strong and the Fed raises rates to slow economic growth and relieve inflationary pressures. This preemptive activity by the Fed did not start until Alan Greenspan chaired the Fed, 1987–2006. Before then, the Fed was more reactionary.

- Curvature also expands with falling rates because the two-year note yield drops faster than the spread between the 10-year and the 30-year. Curvature confirms that the steepening yield curve is due to a contracting economic environment and building disinflationary or deflationary pressures.
- The term premium rises if investors feel that disinflationary pressures are rising. In that case, investors require a high risk premium to go to longer maturities. But if inflation is rising, investors will prefer to roll short-term instruments rather than hold longer-term debt. This is tied to the yield curve slope, but the term premium, as defined in Adrian, Crump, Mills and Moench (2013)[9] goes across the entire term structure.

To evaluate trends in these factors, we measured their deviation from four-year medians. The four-year period is the average length of the market cycle, as shown in "Fractal Market Analysis", (1994)[10]. When the value exceeds the four-year median, macro uncertainty is considered high. When it is below the median, macro uncertainty is considered low. We look at deviations from the four-year medians to try to capture turning points in the interest rate cycle. This isn't a perfect measure because, although the average cycle length is four years, each cycle is different.

Table 06 (Interest Rate Factors and Bond Utility) shows the results of our analysis. We used the price return series for the 10-year US T-note so we could evaluate the dynamics without the cushion of the bond yield, which was much higher over the full period than it is as we write this.

The results confirm what we learned using the VIX, but they also reveal more. As with our analysis using the VIX, we see that bond volatility and returns are higher during periods of high uncertainty. However, the interest rate factors appear to capture this difference in a more significant way because compared with findings using the VIX, the IR is higher in high uncertainty (1.07 vs. 0.90) and lower in low uncertainty (0.80 vs. 0.88).

Also, the shape of the distribution differs in the two environments, as shown by the conditional skew statistic introduced in an earlier paper (See "How 'Tail Risk' Changes Over the Market Cycle", 2014)[11]. Using the full population mean and standard deviation to calculate skew for a subsample allows a skew attribution to be calculated. In Table 06, we see the conditional skew for the sub-periods of high and low macro uncertainty. In high uncertainty, the skew is close to zero and insignificant for slope and curvature. But for the term premium, it is positive and significant as seen by the standard error (+/-2.0 means significance at the 95% level). However, in low uncertainty, the skew is negative and significant for all three factors.

What do these statistics tell us? They say that risk is symmetrically distributed around the mean in high uncertainty, but in low uncertainty, there is a longer negative tail. **So, counterintuitively, downside risk is higher when volatility is lower.** Thus, unlike volatility, these factors capture times when the downside risk of bonds is higher than the upside risk.

These factors preserve the diversifying properties of bonds to equities, as the correlations are within a few percentage points of the correlations using the VIX as an indicator.

Table 06 reinforces our earlier point that the utility, or usefulness, of bonds is much higher in periods of high uncertainty, even though bond volatility is higher. So, high volatility is not a good measure of bond "risk," particularly downside risk. Nor is volatility the best indicator of the utility of bonds. The fundamental risk factors better capture the utility of bonds.

Implications for MAPs

Statistical measures, such as volatility, are not the best way to drive a MAP's allocation to bonds. As we have shown, cutting a MAP's allocation to bonds on the basis of rising volatility, as many

"FOR BONDS, HIGH VOLATILITY MEANS HIGHER POTENTIAL RETURNS, MORE HEDGING AND DIVERSIFICATION IMPACT ON THE PORTFOLIO AND HIGHER UTILITY."

constant-risk and risk parity managers do, can be a mistake. However, combining statistical and fundamental risk factors when looking at bonds' utility in two regimes—high uncertainty and low uncertainty—may prove useful. We will address how to do that in a future paper.

Volatility's significance for bonds contrasts with that for equities and other risk assets when constructing a MAP. High volatility for equities means less growth, greater downside tail risk and lower utility. For bonds, high volatility means higher potential returns, more hedging and diversification impact on the portfolio and higher utility. As a result, reducing a MAP's capital allocation to bonds because of a rise in volatility (as done by many constant-risk and risk parity managers) can be counterproductive.

Our research also suggests that we should be careful when using bond returns for back-testing because historical bond returns will probably overstate future returns while understating their downside risks. A large part of bond total return comes from the yield, which has averaged 5% since 1988. Current yields are about half of that. This means that price return, which is where bond volatility lies, will make up a much larger part of total return in today's environment.

This study also confirms that bonds have regimes, but they are quite different from equity regimes. Volatility is not a good risk regime indicator for bonds, unlike equities. Instead, as MAP managers, we should be concerned with the utility of bonds as regime indicators rather than bond volatility.

Measures of high and low utility should use a combination of statistical and fundamental risk factors to create a more complete view of bond utility. How these factors are combined depends upon the specific application, a topic we will cover in future papers. As a preview, for multi-asset strategies such as risk parity, equal volatility allocation is not always optimal when bond utility is taken into account.

We should note some caveats. The research period was characterized by declining inflation and interest rates. High inflation is a separate regime, as we discussed in "Essential Beta and Inflation Regimes", (2015)[12]. In periods of high inflation (6% and higher), rising bond volatility can be a precursor to lower returns and increased correlation with equities. The increased correlation with equities means that bonds offer neither diversification nor tail-risk hedging for equities or other risk assets. As a result, they become less useful.

A second caveat relates to implied bond volatility. In a forthcoming paper, we will show that—unlike in the case of implied vs. realized volatility for equities—there appears to be little relationship between implied and realized bond volatility. Instead, bonds' implied volatility is tied to equity volatility and the changing covariance between stocks and bonds. Bonds' implied volatility does not necessarily function as a "fear index," as implied volatility does for equities. But that's a story for another day.

This paper has focused on US government bonds, but similar results can be found using other developed market government bonds. However, as in the US, the relationship between interest rate risk factors and bond risk depends upon central bank transparency. Compared to the US, central bank transparency for other developed countries is a relatively recent development. Since the period of central bank transparency is shorter and varies by country, a viable study using other countries is less conclusive than the US as used in this study.

Finally, there are implications for pension plans, as well. The liabilities of corporate plans in particular (and public plans less directly) are tied to changes in long-term interest rates. As a result, understanding bond downside risk helps in anticipating liability risk. When bond downside risks are decreasing (and yields/discount rates are falling), liabilities start rising. As Table 01 showed, asset downside risk is also increasing so that there is a risk of liabilities rising simultaneously with asset values falling, as we saw after the global financial crisis of 2007–2008. These measures may help plan sponsors prepare for those risks and prepare liability hedges accordingly using liability-driven investing (LDI). Conversely, when liabilities are falling and assets are growing, plan sponsors can benefit from shifting their focus to growth and reducing dependence on LDI.

Conclusion

Like comedy, defining bond risk is tough. Bond risk (meaning downside risk) is not well defined by the standard MPT statistical risks used for most MAP construction. In particular, standard deviation, or volatility, does not describe whether downside bond risk is increasing or decreasing. So, rather than use the terms "volatility" and "risk" synonymously, we should consider the concept of usefulness, or "utility" as a measure of risk. When are assets like bonds useful in a portfolio? When do they and other assets do the jobs we have assigned them? When would they fail? We found that incorporating fundamental interest rate factors into the picture broadened our view of bonds and when they are useful in a portfolio. By shifting perspectives and definitions in this manner, constructing a MAP may be easier.

Endnotes

[1]When we say "bonds," we refer to the sovereign debt of developed countries. Credit, both investment grade and high yield, as well as emerging market bonds, have a risk premium attached to them which is more equity and risk-asset oriented. Also, we restrict our review to a period of low to moderate inflation. We address inflation of 6% or greater in Peters and Miranda (2015).

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