PORTFOLIO CONSTRUCTION AND FACTOR INVESTING IN CORE FIXED INCOME

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GALLIARD CORE FIXED INCOME

In our 25 years of managing core fixed income products, we believe portfolio construction has been the most critical element in the tradeoff between realized returns (herein defined as excess return over treasuries) and risk (herein defined as standard deviation of excess return). Additionally, we believe the practicalities of investing in bonds must be weighed against the efficacy of the factors used to build portfolios. A natural consequence of this belief is that traditional equity attributes of factor investing (size, momentum, value, etc.) may not be applicable in broader fixed income portfolio management. In this study, we delve into historical excess returns and show that short corporate and structured credit risk, long non-corporate credit risk, mortgage risk, and the interaction between these factors deliver superior investment results. We apply our factors in a mean-variance framework to determine the efficient portfolio frontier across the duration spectrum. The analysis shows that a 50bps active return target versus benchmarks is the sweet spot where we add substantial active return without taking outsized risk. This finding aligns with our investors' objectives and preferences. Further, we find that the multi-factor portfolio derived from our mean variance analysis closely matches our portfolio construction and return distribution across our primary managed composites.

The study used excess return data from the Bloomberg Barclays Aggregate Index from 1990 onward. A drawback of our mean-variance analysis is that we do not match the partial durations over time, but instead target the durations over time. Moreover, we take average durations of the sectors over the time period to come up with an efficient portfolio frontier. We know these sector durations are stable in credit and treasuries but can change significantly in MBS. Nevertheless, our approach illuminates a general methodology which guides our portfolio construction process across investment styles.

FACTORS IN FIXED INCOME

There is established research in equities where factors such as size, value, and momentum are the determinants of excess returns. These attributes have served as the catalyst for new equity market products, each striving to capture the excess return promised by the investment factor. More recently, there have been attempts to employ the same factors used in equity markets to core bonds. In our opinion this leap of faith ignores the inherent differences between the two markets; most notably, transaction costs in bonds make these factors much less relevant. Fixed income factors should be practical and sufficiently broad so that portfolios are not forced into a costly turnover strategy. Furthermore, factors leading to better risk-adjusted return should be readily available and liquid. In our view, the sector, structure, quality, and liquidity are the most visible security-level characteristics that determine excess return. Therefore they serve as a proxy for issuer attributes and as a starting point in our search for fixed income factors.

We first evaluate long-term historical excess returns by sector. Table 1 displays the annualized excess return, standard deviation of excess return, and the information ratio, which is defined as the ratio of the former to the latter. Also shown is the average OAS and OAS capture ratio, defined as the ex-post excess return over average OAS. This metric helps to give a sense of how much ex- ante spread was actually earned. Data is since index inception through Q2 2019. Most indices go back to the early 1990s with the exception of CMBS. Commercial mortgages first came to the market in the late 1990s.

TABLE 1

Sector Excess Returns	Corporates	NonCorporates	CMBS	ABS	MBS
Average OAS	135	84	180	82	38
Excess Return	0.72%	0.69%	1.25%	0.69%	0.28%
StdDev Excess Return	4.51%	2.41%	7.08%	2.39%	1.39%
IR	0.16	0.29	0.18	0.29	0.20
OAS Capture Ratio	53%	82%	69%	84%	74%

Source: Bloomberg Barclays Aggregate Index

Non-corporates[1] and ABS, assets with marginal credit risk, have the highest information ratios and highest ex-ante OAS capture of the group while credit sensitive corporates and CMBS have the lowest. MBS straddles the middle ground with an information ratio of 20bps and a capture ratio of 74%. Notably, corporate bonds gave up over half of their ex-ante spread over the period. This fact highlights the significant default and downgrade risk embedded in the sector.

[1] US Non-Corporates include the taxable municipal, supranational, government owned, and sovereign component of the US Credit index.

At this point, it might be plausible to construct portfolios with a high quality credit risk factor, but this strategy disregards the notion that credit risk varies by maturity which is obscured in broad index data. Table 2 breaks the previously examined sectors into maturity buckets:

TABLE 2

Excess Returns

Sector	1-3	3-5	5-7	7-10	10+
Corporates	0.92	0.85	1.06	0.58	0.55
NonCorporates	0.42	0.63	0.79	0.79	1.10
CMBS	1.65	1.76	1.89	0.80	
ABS	0.69				
MBS	0.28				

Excess Return Volatility

Sector	1-3	3-5	5-7	7-10	10+
Corporates	2.12	3.20	4.58	4.95	7.11
NonCorporates	0.82	1.44	2.30	3.04	5.13
CMBS	3.33	5.41	8.27	10.92	
ABS	2.39				
MBS	1.39				

Risk-Adjusted Excess Returns

Sector	1-3	3-5	5-7	7-10	10+
Corporates	0.43	0.27	0.23	0.12	0.08
NonCorporates	0.51	0.44	0.34	0.26	0.21
CMBS	0.50	0.33	0.23	0.07	
ABS	0.29				
MBS	0.20				

OAS Capture Ratio

Sector	1-3	3-5	5-7	7-10	10+
Corporates	0.78	0.62	0.67	0.35	0.31
NonCorporates	0.88	0.98	0.86	0.72	0.74
CMBS	1.06	1.09	1.01	0.42	
ABS	0.84				
MBS	0.74				

Source: Bloomberg Barclays Aggregate Index and ICE Merrill Lynch Broad Index

The results show that corporate risk adjusted returns skew to lower and intermediate maturities. Corporates and structured credit have delivered excellent ex-post risk-adjusted returns on the front end with an information ratio of 43bps for corporates, 50bps for CMBS, and 29bps for ABS versus 8bps for long corporates. Short non-corporates have also performed well, earning 50bps risk-adjusted returns over the length of the study. Long non-corporates are a source of superior excess returns on the long end, outperforming long corporates by 2.6x on a risk-adjusted basis. Additionally, mortgages offer remarkably stable excess returns, likely earning the asset class a place in a diversified portfolio.

Perhaps the most conspicuous result in Table 2 is the OAS capture ratio. Front end spread, including mortgages, earn more than three quarters of ex-ante return, affirming their high excess returns and information ratios. This result holds for non-corporates across the curve, but long corporates and 7-10 year CMBS fail to follow. Long corporates, which have higher spread levels but longer spread durations, lose 70% of ex-ante spread.

The dominant theme is the direction and magnitude of ex-post excess returns from credit risk. The ex-ante yield premium over treasuries is widely assumed to be sufficiently wide to deliver an attractive ex-post return given expected downgrades and defaults. Naturally, as credit risk goes longer in maturity, the probability of a negative credit event grows. Investors rightly demand more spread to compensate for heightened credit risk as they extend in maturity. The average OAS on long corporates is 180bps versus 118bps on the front end, but has the extra premium been enough? The results in Table 2 support the conclusion that long corporate credit buyers are not fairly compensated.

The single factor from the broad index data now evolves into three: short term credit risk, long non-corporate credit risk, and, through its stable excess return profile, mortgage risk. It is tempting to believe that the high risk-adjusted excess returns delivered by long non-corporates signal the same for long highly rated corporates. Table 3 presents excess return data for corporates partitioned by maturity and rating. It shows that this hypothesis is emphatically false.

TABLE 3 CORPORATE BONDS BY QUALITY AND MATURITY

Corporate Bonds by Quality and Maturity

ExcessReturns	1-3	3-5	5-7	7-10	10+
AA	0.64	0.63	0.69	0.23	0.53
A	0.74	0.94	1.00	0.38	0.17
BBB	1.19	1.16	1.17	0.80	0.96

StdDev	1-3	3-5	5-7	7-10	10+
AA	1.32	3.49	3.51	4.03	5.63
A	2.54	4.67	4.70	4.78	6.68
BBB	2.79	5.74	5.80	6.33	8.40

IR	1-3	3-5	5-7	7-10	10+
AA	0.48	0.18	0.20	0.06	0.09
A	0.29	0.20	0.21	0.08	0.03
BBB	0.43	0.20	0.20	0.13	0.11

OAS Capture Ratio	1-3	3-5	5-7	7-10	10+
AA	0.85	0.69	0.68	0.21	0.43
A	0.70	0.78	0.75	0.27	0.11
BBB	0.71	0.62	0.58	0.39	0.43

Source: Bloomberg Barclays Aggregate Index and ICE Merrill Lynch Broad Index

Long corporates have a low information ratio regardless of rating which suggests that maturity, not credit rating, dominates as a driver of risk-adjusted return. Although credit quality is fundamental to security selection and credit underwriting, maturity, not ratings, should drive the portfolio construction process. Notably, lower rated corporates perform no worse on a risk-adjusted basis than highly rated AA paper. In fact, BBB corporates earn higher excess returns than higher rated substitutes. The market offers spread commensurate with heightened credit risk for down in credit issues, but affords an inadequate premium for long maturity issues.

Next, we consider whether bonds are available to implement a strategy grounded in our three factors. Although this analysis is undeniably more qualitative in nature and hinges on our 25 years of experience in the market, it is nevertheless constructive to look at the market value of each index. This data is shown in Table 4.

TABLE 4

Sector	Inception Date	Inception Market Value (Bn)	Median Market Value	6/30/19 Market Value
US Corporates	12/31/1989	500	1,600	5,000
US ABS	9/30/1991	70	85	100
US CMBS	6/30/1999	60	240	260
US Non Corporates	12/31/1989	65	340	650
US MBS	12/31/1992	1,000	2,800	5,800

Source: Bloomberg Barclays Aggregate Index

Corporates and mortgages are the largest non-treasury asset classes in the fixed income market with a current market value of $5 trillion and $5.8 trillion, respectively. Overshadowed by these two sectors are ABS, CMBS and non-corporates which number in the hundreds of billions. Given that the relationship between the sizes of the sectors has held true since inception, it is evident a strategy that incorporates short corporates and mortgages is a viable one, and investors should have no issues sourcing these bonds for portfolios. In our experience, structured credit on the front end is also liquid and available, although perhaps less so CMBS than ABS. On the other hand, front-end non-corporates are somewhat difficult to source, as the entities that comprise the index tend to issue longer maturities. Therefore, we do not deem the non-corporate sector capable of adding much value to a large portfolio, and remove short non-corporate credit risk as a viable factor

We now have three well-defined factors: (1) short corporate and structured credit risk, (2) long non-corporate credit risk, and (3) mortgage risk. Before moving on, let's recall that the definition of a factor is an attribute that delivers consistent risk-adjusted return. These three factors generate higher risk-adjusted returns over the time studied, but are these results consistent over a smaller investment horizon? To test this, we take rolling 3-year returns, annualize them, and study the distribution of outcomes. This data is shown in Table 5 and Table 6.

TABLE 5 ROLLING 3Y ANNUALIZED EXCESS RETURNS

Sector	# of Obs	Median ExRet	Median StdDev	Median IR	P(x)>0
Corp 1-3 Yrs	107	0.86	0.77	1.33	91
Corp 3-5 Yrs	107	0.98	1.29	0.88	77
Corp 5-7 Yrs	107	1.18	2.08	0.68	74
Corp 7-10 Yrs	107	1.02	2.46	0.44	70
Corp 10+ Yrs	107	0.53	4.37	0.22	66
Non-Corporates 10+ Yrs	107	1.21	3.27	0.41	76
Short ABS	100	0.59	0.42	1.74	92
Short CMBS	69	1.20	0.87	1.33	87
MBS	107	0.30	1.19	0.30	78

Source: Bloomberg Barclays Aggregate Index

TABLE 6 PROBABILITY DENSITY OF ROLLING 3Y ANNUALIZED EXCESS RETURNS

Sector	(,-7.5]	(-7.5,-5.0]	(-5.0,-3.0]	(-3.0,-1.5]	(-1.5,0.0]	(0.0,1.5]	(1.5,3.0]	(3.0,5.0]	(5.0,7.5]	(7.5,)
Corp 1-3 Yrs	-	-	1	2	7	71	17	1	2	-
Corp 3-5 Yrs	-	2	1	3	18	51	19	5	2	-
Corp 5-7 Yrs	2	1	1	3	20	37	21	12	1	2
Corp 7-10 Yrs	2	2	3	7	17	38	23	7	-	2
Corp 10+ Yrs	3	-	6	8	18	33	20	10	1	2
Non-Corp 10+ Yrs	-	2	1	11	10	33	25	17	1	-
Short ABS	-	-	1	3	4	83	4	4	1	-
Short CMBS	1	1	3	3	4	46	14	12	7	7
MBS	-	-	-	-	22	73	5	-	-	-

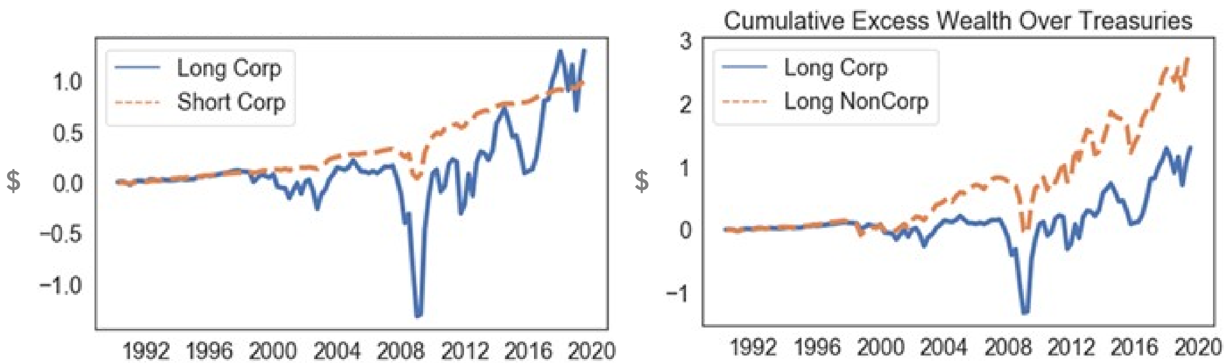
Source: Bloomberg Barclays Aggregate Index

The data lets us examine our factors in a probabilistic framework. Table 5 shows that the probability of earning positive excess returns with 1-3 year corporate and short structured credit risk is 90%, which is almost a sure bet, but declines to 66% with long corporate credit risk. Investing in long corporate bonds and hoping for positive excess returns is practically like flipping a coin! Sure enough, distribution medians reflect these odds with long corporates earning 22bps of risk adjusted return, severely underperforming short corporates. Perhaps the most germane result from Table 5 concerns the direction of returns. As corporates extend in maturity, they perform ever more poorly versus treasuries, validating our short corporate and structured credit risk factor obtained from the full data set.

Earning more than double the excess return of long corporate credit risk is long non-corporate credit risk—the extra 10% chance of earning a positive return doubles the information ratio. Indeed, Table 6 shows that returns from longer corporate credit risk tend to exhibit fatter tails and are tagged with wider return distributions than short credit risk mortgage risk, and long non-corporate credit risk. Mortgages have an extremely tight distribution which corroborates mortgage risk as a practical factor.

Finally, we consider how excess returns impacts total excess wealth over time. Chart 1 shows the growth of $1 versus duration-matched treasuries for two of our factors. Short corporate credit risk offers a smooth, stable increase in excess wealth whereas long corporate credit risk is volatile and has only surpassed short credit in the last couple of years. Long non-corporate credit risk earned a hefty $1.30 over long credit in our sample.

CHART 1 CUMULATIVE EXCESS WEALTH OVER TREASURIES



Charts created by Galliard utilizing the Bloomberg Barclays Aggregate Index

The skeptical investor may be quite surprised at the low ex-post excess returns earned by long corporates. After all, a basic tenet of investing is that one must be paid for taking higher levels of risk. Ng and Phelps[2] (2011) show that investment grade corporate returns suffer not only from general spread volatility and downgrade bias, but also from index constraints that force the index to sell bonds at the most inopportune time. Specifically, once a bond ceases to be investment grade, the index sells the bond, usually at depressed market prices. The authors show that by adopting a downgrade-tolerant portfolio the investor may recoup some of the lost ex-ante spread premium. However, this approach fundamentally alters the asset allocation of the portfolio and assumes the investor has a higher risk tolerance than he or she might actually have. Allowing the portfolio to hold high yield bonds exposes the investor to an asset class with a unique risk and return profile, which will change the performance of the portfolio. For investors whose risk-tolerance precludes high yield or junk bonds from the portfolio, this buy-and-hold to maturity strategy does not align with their preferences and is therefore not a viable solution.

[2] Source: Kwok-Yuen Ng & Bruce D. Phelps (2011) Capturing Credit Spread Premium, Financial Analysts Journal, vol. 67, no. 3, 63-75

For investors with investment-grade preferences, the index returns will be fairly accurate. Why don't these investors demand a higher ex-ante premium? Ilmanen[3] (2011) posits that the visible level of yield outweighs the less visible negatives such as downgrading bias, agency problems, lower liquidity, and bad timing of losses, all of which are magnified on the long end of the curve. We think these opaque negatives combine to make long corporates an expensive asset class, especially for core bond portfolios.

PORTFOLIO CONSTRUCTION PHILOSOPHY

We believe portfolios should be constructed to take advantage of the excess returns offered by factors and to minimize exposure to interest rate changes. Being agnostic to interest rates requires the portfolio to match benchmark durations, though to achieve a desired exposure to a particular factor, key rates may not match. To map our findings of factors to portfolio construction, we turn to an old tool, slightly modified: mean-variance optimization with a twist. That twist is a duration constraint meant to force the optimizer to pick the best portfolios at any given duration. The theoretical underpinnings of such an analysis rest upon investor utility maximization. In this case, investor utility is defined by the return and variance of the portfolio as well as the risk tolerance of the investor. By changing the risk tolerance of the investor and then maximizing risk-adjusted return, we can calculate the efficient frontier from a group of assets. Maximizing utility conditioned on risk tolerance is equivalent to selecting a portfolio on the efficient frontier. A full description is available in the Data and Methodology section of this paper on page 12.

Before diving into the results, we look at our factor correlations. Table 7 shows that our factors' excess returns are only somewhat related with all measures of correlation less than 0.90. Basic portfolio theory dictates that portfolios comprised of uncorrelated assets perform better on a risk adjusted basis, therefore it should not be surprising if all three factors find a place in the portfolio. Mortgages, with plodding yet stable positive excess returns, have a low correlation with short corporates and long non-corporates which should ensure the asset class a place in the portfolio regardless of duration. Short corporates are somewhat correlated with ABS and CMBS and likely dominate the allocation from structured credit given the high ex- cess returns generated from the sector. Lastly, long non-corporates have a low correlation to all other asset classes which may offer a glimpse of the composition of a long duration portfolio. These factor correlations and factor returns are the drivers of the efficient portfolio construction.

[3] Source: Antti Ilmanen (2011) Expected Returns, John Wiley & Sons Inc. Pg. 187

Chart 2 on the following page shows the results of the 2-year, 4-year, and 6-year mean-variance optimization. The 2-year portfolio is able to achieve the highest excess returns per unit of risk, embodied by the steep slope of its curve. The slope of the frontier flattens out as the duration constraint gets longer which is consistent with our historical excess return analysis—long duration bonds simply earn lower risk-adjusted returns. The 2-year portfolios reach a high of 50bps excess return per unit of risk on the front end of the frontier and fall to 42bps as investors become less risk-averse. The 4-year and 6-year portfolios reach a high of 43bps and fall to 29bps and 27bps, respectively, farther out on the frontier. Now, consider that the excess return on Bloomberg Barclays benchmarks over the sample period is 25-30bps, regardless of duration. Given that the whole point of active management is to beat the assigned benchmark, only the portfolios that lie above that point on the frontier are relevant. This fact precludes maximum information ratio portfolios from being considered by portfolio managers—they simply do not earn enough absolute excess return.

We believe the sweet spot on these frontiers lies at 70-80bps of excess returns which corresponds to an active return of 50bps versus benchmarks. This point corresponds to risk-adjusted returns of 44bps for the 2-year portfolio, 33bps for the 4-year portfolio, and 29bps for the 6-year portfolio. These returns are achieved with a reasonable 1.80, 2.49, and 2.71 excess return volatility, respectively. Portfolios that lie past this point of the frontier begin to take on unnecessary volatility. This is observed in Chart 2, primarily in the longer duration frontiers, as the part of the curve that lies beyond 80bps of excess return. The slope of the curve noticeably flattens at this point which indicates a lower risk adjusted return.

TABLE 7 CUMULATIVE EXCESS WEALTH OVER TREASURIES

Multi-Factor Correlation Matrix

Sector	Short Corp	Long NonCorp	Short ABS	Short CMBS	MBS
Short Corp	1.00				
Long NonCorp	0.70	1.00			
Short ABS	0.80	0.49	1.00		
Short CMBS	0.89	0.58	0.87	1.00	
MBS	0.57	0.30	0.76	0.80	1.00

Source: Bloomberg Barclays Aggregate Index

CHART 2 EFFICIENT FRONTIER BY DURATION

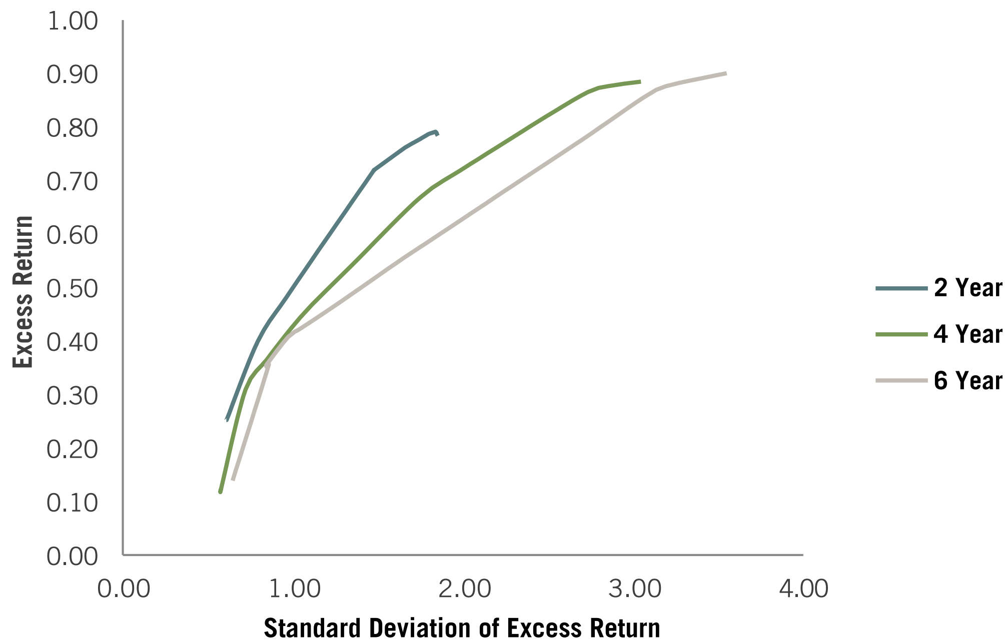


Chart produced by Galliard utilizing the Bloomberg Barclays Aggregate Index

CHART 3 +40-50BP ACTIVE RETURN PORTFOLIOS

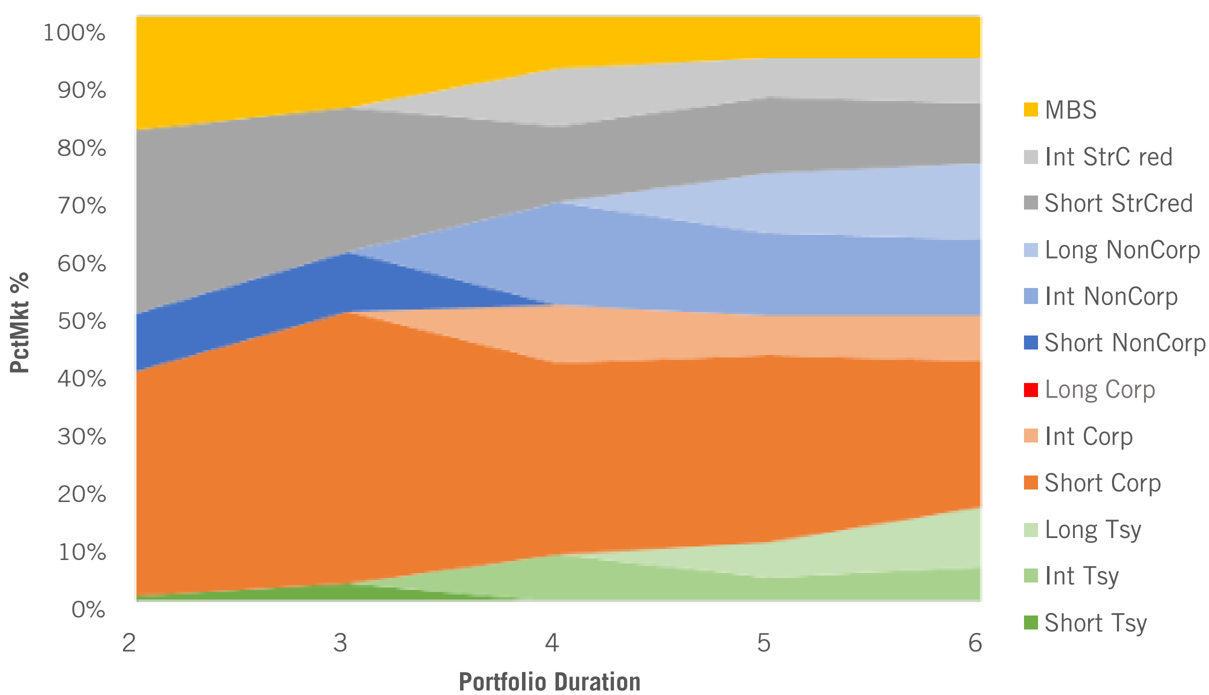


Chart produced by Galliard utilizing the Bloomberg Barclays Aggregate Index

Chart 3 and Table 8 show the asset mix of our preferred multi-factor portfolios across the duration spectrum. Short credit has a place in the portfolio regardless of portfolio duration. Just as the historical excess return data suggest, long corporates do not play a strategic role in a fixed income portfolio optimized for excess return. On the structured side, mortgages have a consistent 10-20% allocation in every portfolio which shows the power of uncorrelated returns. Intermediate and long non-corporates and treasuries creep into the asset mix starting at 4-years and dominate the allocation to longer corporate credit. Remarkably, the results show that long treasuries, an asset class with zero excess returns by definition, beat out long corporates in a portfolio context.

TABLE 8 40-50 BP ACTIVE RETURN PORTFOLIOS

Duration	Tsy	Corp	NonCorp	StrCred	MBS	Excess Return	Vol	IR
2	1	39	10	32	18	0.79	1.80	0.44
3	3	45	10	25	17	0.79	1.98	0.40
4	9	43	18	22	8	0.82	2.49	0.33
5	10	40	24	19	7	0.82	2.71	0.30
6	17	33	26	17	7	0.78	2.71	0.29

Hypothetical portfolios. Returns based off of historical Bloomberg Barclays Aggregate returns.

MULTI-FACTOR PORTFOLIOS

Table 9 shows our multi-factor model portfolio and actual composite results versus the Bloomberg Barclays Aggregate and the Bloomberg Barclays Intermediate Government/Credit benchmarks during the sample period. The model portfolios performed right on top of our actual portfolios, and both beat the benchmark by approximately 50bps. These returns are achieved with a reasonable 100bps tracking error and 300bps standard deviation of absolute returns.

TABLE 9 MODEL MULTI-FACTOR PORTFOLIO VS. GALLIARD COMPOSITES[4]

Returns from Q4 1995	Aggregate*	Int. Gov Cred**
Benchmark Return	5.19	4.71
Model Return	5.72 (+53)	5.32 (+61)
Galliard Composite Return	5.75 (+56)	5.18 (+47)
Model Tracking Error	1.20	1.07
Portfolio Tracking Error	0.92	0.95
Model StdDev	3.75	3.15
Portfolio StdDev	3.43	2.87

Model returns are obtained from hypothetical portfolios.
*Galliard Broad Market Core Composite.
**Galliard Intermediate Gov't/Credit Composite.

Fundamentally, our factors render the portfolio production process analogous across styles which enables us to deliver low-cost and effective risk-adjusted returns regardless of the managed product.

[4] These composites represent Galliard's investment strategies as compared against typical industry benchmarks. Based on the investment strategy selected and specific guidelines, performance may vary. Galliard Capital Management claims compliance with the Global Investment Performance Standards (GIPS ®). GIPS disclosures relating to this table can be located on pages 14-16 of this document. To receive a complete list and description of Galliard composites and/or a presentation that adheres to the GIPS standards, please contact Galliard Client Service at 612.667.3220 or galliardclientservice@galliard.com.

CONCLUSIONS

The study shows that passive factors, restricted to sectors available in the Broad Index, deliver considerable excess return across the duration space without excessive tracking error. These factors should be the building blocks for any core fixed income portfolio. The study also highlights that credit risk is perhaps mispriced, particularly as maturity increases, suggesting that investors are not adequately compensated for longer credit risk. As previously mentioned, one drawback of this study is that we do not match the partial duration of our factor portfolios to the benchmark. Rather, we mitigate this basis risk by restricting duration/maturity of assets in our optimizer to that of the benchmark. We also recognize that past results are no guarantee of future results; however, we don't anticipate a structural shift in these factors.

Importantly, the factors identified in this study can be enhanced by using securities and sectors that are not part of the Broad Index. In our experience, we have utilized active factors consistently since the inception of the firm and have found ample ways to deploy them in our portfolios in spite of having realized considerable AUM growth. High quality sectors with minimal credit migration risk such as non-corporates, ABS, and short/intermediate credit form the core of our portfolio manufacturing process. The agency MBS sector, with a lower correlation to other sectors and a desirable excess return distribution, naturally comprises a portion of our client portfolios. In addition, we utilize asset securitizations like SBA participations, agency multifamily, and agency specified pool stories that offer less negative convexity and higher OAS capture than generic agency MBS passthroughs. In corporate credit, we favor securities with covenants such as REITS, first mortgage utility bonds, and senior bank notes. Within the non corporate sector, our portfolios have been invested in longer maturity taxable municipals (high quality general obligation bonds), premier universities, and high quality health care entities as a substitute for longer corporate credit. Notably, this approach to using non corporates has generally kept pace even during periods when long credit has delivered outsized excess returns. Finally, taxable municipal deals that are big enough to be part of the Broad Index present a good opportunity for portfolios in core fixed income.

DATA & METHODOLOGY

EXCESS RETURNS:

Data is procured from the Bloomberg Barclays Aggregate Bond Index and every bond contained therein is eligible for inclusion to the US Aggregate index.

$$Total\ Return = \prod_{i}^{n}\left(1 + r_{Index_i}\right)^{\frac{4}{n}} - 1$$

$$Treasury\ Return = \prod_{i}^{n}\left(1 + r_{Tsy_i}\right)^{\frac{4}{n}} - 1$$

$$Excess\ Return = Total\ Return - Treasury\ Return$$

$$Cov(x,y) = \frac{1}{n-1}\sum_{i}^{n}(x_i - \bar{x})(y_i - \bar{y})$$

Excess returns are calculated by taking the difference of the annualized compounded return of the index and the duration-neutral treasury. The returns are compounded quarterly. Contingent on historical availability, average OAS values are taken from either the ICE Merrill Lynch basket of indices or Bloomberg Barclays indices.

Average OAS by Maturity

Sector	1-3	3-5	5-7	7-10	10+
Corporates	118	137	159	165	180
NonCorporates	48	64	92	110	148
CMBS	156	161	187	189	
ABS	82				
MBS	38				

Average OAS by Quality

Corps	1-3	3-5	5-7	7-10	10+
AA	75	91	101	110	122
A	105	121	134	140	152
BBB	168	186	202	205	221

DURATION CONSTRAINED MEAN-VARIANCE OPTIMIZATION:

We consider a mean-variance utility framework to find optimal duration-constrained portfolios. In this context, utility, defined by the return and variance of the portfolio, is maximized at each level of risk tolerance over all possible combinations of asset weights. Maximizing mean-variance utility on our sample space is equivalent to choosing the highest possible indifference curve that is tangent to the efficient frontier at a particular point. This problem is represented in matrix notation in Equation 1, shown without constraints:

EQUATION 1

$$\max_{w} \; U(w) = w'R - Tw'\Sigma w$$

Where

* U(w) is the Utility Function which defines the set of indifference curves in mean-standard deviation space

* w is an Nx1 vector of portfolio weights

* w'R is portfolio return and r is an Nx1 vector of sector returns

* T is a risk aversion parameter

* w'Σw is portfolio variance and Σ is an NxN covariance matrix

We use the gradient descent algorithm in Tensorflow, an open-source statistical and machine learning package developed by Google, to solve Equation 1 numerically. Gradient descent is an iterative algorithm that finds the minimum of a function. To use this algorithm, we multiply Equation 1 by -1 and minimize the result, a well-known function, shown by Equation 2, with constraints:

EQUATION 2

$$\begin{gathered}\min_{w} w'\Sigma w - Tw'R \\ s.t \\ w'I = 100\% \\ 0\% \le w_i \le 100\% \\ w'd = b\end{gathered}$$

We constrain the program by restricting short selling and by adding a duration constraint w' d=b where d is a vector of median sector durations and b is the target duration. Equation 2 moves along the efficient frontier by increasing the risk tolerance parameter T. At T=0, a point where the investor is completely risk averse, the optimization finds the minimum variance portfolio. As risk tolerance increases, it finds portfolios with higher return and more risk, portfolios which lie on a flatter indifference curve.

We use a penalty-approximated solution to Equation 2 by introducing the duration constraint w' d=b to the objective function, shown in Equation 3:

EQUATION 3

$$\begin{gathered}\min_{w} w'\Sigma w - Tw'R + \alpha(w'd - b)^2 \\ s.t \\ w'I = 100\% \\ 0\% \le w_i \le 100\%\end{gathered}$$

The last term a(w' d-b)^2 penalizes the optimization as it moves away from the desired duration, b. Here, a is a scaling parameter which we set to be 1. Finally, before solving Equation 3, we constrain CMBS and short non-corporates to be at most, 10% of a portfolio allocation, reflecting the inception date of the former and the market scarcity of the latter.

Global Investment Performance Standards (GIPS)

Galliard Capital Management, Inc.

Broad Market Core Total Composite

As of December 31

Year	Gross Return (%)	Net Return (%)	Benchmark Total Return (%)	Internal Dispersion (%)	Number of Accounts	Composite Assets ($ millions)	Percentage of Firm Assets (%)	Total Firm Assets ($ millions)
2018	0.46	0.16	0.01	0.08	19	2,073.1	2.3	91,904.9
2017	4.06	3.75	3.54	0.15	19	2,014.6	2.2	90,975.8
2016	2.99	2.68	2.65	0.25	19	1,382.1	1.5	91,601.1
2015	1.61	1.30	0.55	0.14	15	1,040.9	1.2	85,418.3
2014	6.92	6.61	5.97	0.12	17	704.5	0.8	84,790.8
2013	-2.26	-2.55	-2.02	0.31	18	628.0	0.7	84,585.2
2012	6.21	5.90	4.21	0.48	23	1,031.3	1.2	85,347.3
2011	8.45	8.13	7.84	0.23	28	1,296.5	1.7	77,569.7
2010	7.79	7.47	6.54	0.34	29	1,016.9	1.6	64,280.4
2009	13.00	12.67	5.93	1.30	39	6,159.8	12.4	49,600.1

Galliard Capital Management, Inc. claims compliance with the Global Investment Performance Standards (GIPS®) and has prepared and presented this report in compliance with the GIPS standards. Galliard Capital Management, Inc. has been independently verified for the period from October 1, 1995 through December 31, 2018.

Verification assesses whether (1) the firm has complied with all the composite construction requirements of the GIPS standards on a firm-wide basis and (2) the firm's policies and procedures are designed to calculate and present performance in compliance with the GIPS standards. The Broad Market Core Total Composite has been examined for the period from October 1, 1995 through December 31, 2018. The verification and performance examination reports are available upon request.

1. Galliard Capital Management, Inc. ("Galliard") is a registered investment adviser and wholly owned by Wells Fargo Asset Management Holdings, LLC, a subsidiary of Wells Fargo & Company. Registration with the U.S. Securities and Exchange Commission does not imply a certain level of skill or training. The oral and written communications of an adviser provide you with information for you to determine whether to hire or retain an adviser. Since it began operations on July 1, 1995, Galliard has provided fixed income and stable value investment portfolio management for institutional clients. Prior to January 1, 2011 certain stable value assets were excluded from firm assets because they were valued at book value and were not compliant with the marked-to-market valuation criteria of the GIPS standards. A list of composite descriptions and policies for valuing portfolios, calculating performance and preparing compliant presentations are available upon request.

2. The Broad Market Core Total Composite consists of all discretionary separate accounts invested in fixed income securities managed against the Bloomberg Barclays U.S. Aggregate Bond Index or similar indices. These accounts allow the purchase of BBB and/or A rated securities, but do not allow the purchase of high yield bonds. Some accounts in the composite may use derivatives such as futures, swaps and options or certain more complex securities and/or strategies to manage duration on a fully covered basis. No leverage is employed. Accounts are included in the composite at the beginning of the quarter following the first full quarter of management to assure the composite strategy is fully implemented in each account. The composite is an asset-weighted average of each account's monthly time-weighted total return calculated on an accrual basis, and includes reinvestment of income and capital gains. Trade date valuation is used to calculate composite returns. The composite was created on October 1, 1995.

3. Gross composite returns include all income, realized and unrealized gains and losses, and all brokerage and other transactional costs. Model net composite returns are calculated by subtracting the highest applicable fee on a monthly basis from the gross composite returns. The standard fee schedule in effect is as follows: 0.30% on the first $50 million, 0.25% on the next $50 million, 0.20% on the next $100 million, with a negotiable fee on the balance. Actual client fees may vary depending on the size of the assets, competitive discounts, etc. The composite may contain accounts with performance based fees. Galliard's advisory fees are disclosed in the firm's SEC Form ADV Part 2A, which is available upon request. All returns are expressed in U.S. dollars.

4. From January 1, 2003 to December 31, 2007, an account would be temporarily removed from the composite if it experienced a cash inflow or outflow greater than or equal to 10% of the account's beginning market value.

5. The internal dispersion of annual returns is calculated from the equal-weighted variance of annual account returns from the equal-weighted mean annual return of all accounts included in the composite for the full year. For periods with 5 or less accounts included for the entire year, internal dispersion is not presented as it is not considered meaningful (n/m).

6. The three-year annualized ex-post standard deviation measures the variability of the composite (using gross returns) and the benchmark for the 36-month period ended at the following dates:

	3-Yr Annualized Standard Deviation (%)	
December 31	Composite	Benchmark
2011	2.94	2.78
2012	2.35	2.38
2013	2.79	2.71
2014	2.81	2.63
2015	3.11	2.88
2016	3.12	2.98
2017	2.91	2.78
2018	2.91	2.84

7. The Bloomberg Barclays U.S. Aggregate Bond Index returns are provided to represent the investment environment existing during the time periods shown. For comparison purposes, the index is fully invested and includes the reinvestment of income. The returns for the index do not include any transaction costs, management fees, or other costs, and are not covered by the report of the independent verifiers. Source: Bloomberg Barclays.

8. Individual account performance results may differ from composite returns depending on the size of the account, investment guidelines and/or restrictions, inception date, and other factors. Past performance is not indicative of future results. As with any other investment vehicle, there is always the potential for gains as well as the possibility of losses.

Galliard Capital Management, Inc.

Intermediate Government/Credit Total Composite

					As of December 31			
Year	**Gross Return (%)**	**Net Return (%)**	**Benchmark Total Return (%)**	**Internal Dispersion (%)**	**Number of Accounts**	**Composite Assets ($ millions)**	**Percentage of Firm Assets (%)**	**Total Firm Assets ($ millions)**
2018	1.04	0.74	0.88	0.05	19	5,359.0	5.8	91,904.9
2017	2.71	2.41	2.14	0.07	19	6,531.4	7.2	90,975.8
2016	2.52	2.22	2.08	0.20	20	6,049.3	6.6	91,601.1
2015	1.56	1.26	1.07	0.10	17	4,038.3	4.7	85,418.3
2014	4.24	3.93	3.13	0.14	18	3,830.2	4.5	84,790.8
2013	-1.28	-1.58	-0.86	0.19	17	2,937.9	3.5	84,585.2
2012	5.21	4.89	3.89	0.24	19	3,758.3	4.4	85,347.3
2011	6.50	6.18	5.80	0.32	23	4,016.6	5.2	77,569.7
2010	7.41	7.09	5.89	0.52	25	5,480.7	8.5	64,280.4
2009	12.51	12.18	5.24	1.75	23	4,730.7	9.5	49,600.1

Galliard Capital Management, Inc. claims compliance with the Global Investment Performance Standards (GIPS®) and has prepared and presented this report in compliance with the GIPS standards. Galliard Capital Management, Inc. has been independently verified for the period from October 1, 1995 through December 31, 2018.

Verification assesses whether (1) the firm has complied with all the composite construction requirements of the GIPS standards on a firm-wide basis and (2) the firm's policies and procedures are designed to calculate and present performance in compliance with the GIPS standards. The Intermediate Government/Credit Total Composite has been examined for the period from October 1, 1995 through December 31, 2018. The verification and performance examination reports are available upon request.

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2. The Intermediate Government/Credit Total Composite consists of all discretionary separate accounts invested in fixed income securities managed against the Bloomberg Barclays U.S. Intermediate Government/Credit Bond Index or similar indices. These accounts allow the purchase of BBB and/or A rated securities, but do not allow the purchase of high yield bonds. Some accounts in the composite may use derivatives such as futures, swaps and options or certain more complex securities and/or strategies to manage duration on a fully covered basis. No leverage is employed. Prior to July 1, 2018, the Intermediate Government/Credit Composite was named the Intermediate Core Total Composite. Accounts are included in the

composite at the beginning of the quarter following the first full quarter of management to assure the composite strategy is fully implemented in each account. The composite is an asset-weighted average of each account's monthly time-weighted total return calculated on an accrual basis, and includes reinvestment of income and capital gains. Trade date valuation is used to calculate composite returns. The composite was created on October 1, 1995.

3. Gross composite returns include all income, realized and unrealized gains and losses, and all brokerage and other transactional costs. Model net composite returns are calculated by subtracting the highest applicable fee on a monthly basis from the gross composite returns. The standard fee schedule in effect is as follows: 0.30% on the first $50 million, 0.25% on the next $50 million, 0.20% on the next $100 million, with a negotiable fee on the balance. Actual client fees may vary depending on the size of the assets, competitive discounts, etc. The composite may contain accounts with performance based fees. Galliard's advisory fees are disclosed in the firm's SEC Form ADV Part 2A, which is available upon request. All returns are expressed in U.S. dollars.

4. From January 1, 2003 to December 31, 2007, an account would be temporarily removed from the composite if it experienced a cash inflow or outflow greater than or equal to 10% of the account's beginning market value.

5. The internal dispersion of annual returns is calculated from the equal-weighted variance of annual account returns from the equal-weighted mean annual return of all accounts included in the composite for the full year. For periods with 5 or less accounts included for the entire year, internal dispersion is not presented as it is not considered meaningful (n/m).

6. The three-year annualized ex-post standard deviation measures the variability of the composite (using gross returns) and the benchmark for the 36-month period ended at the following dates:

	3-Yr Annualized Standard Deviation (%)	
December 31	Composite	Benchmark
2011	2.67	2.55
2012	1.98	2.16
2013	2.10	2.11
2014	2.10	1.94
2015	2.25	2.10
2016	2.25	2.23
2017	2.11	2.11
2018	2.06	2.09

7. The Bloomberg Barclays U.S. Intermediate Government/Credit Bond Index returns are provided to represent the investment environment existing during the time periods shown. For comparison purposes, the index is fully invested and includes the reinvestment of income. The returns for the index do not include any transaction costs, management fees, or other costs, and are not covered by the report of the independent verifiers. Source: Bloomberg Barclays.

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You can also visit the Galliard website at www.galliard.com

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