Systematic Credit Investing

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Executive Summary

Credit is not a new asset class — and certainly exposure to the risk of default (credit risk) has existed for as long as people have been making contracts — but only more recently is credit gaining traction as a source of diversifying returns. In particular, the last decade has seen a series of developments in credit markets that is now opening up a new way to gain access to credit: systematic credit investing.

This paper aims to increase familiarity of the credit asset class and provide an overview of our approach to systematic credit investing. We introduce credit instruments and outline a simple framework for understanding sources of credit excess returns. We summarize two avenues for approaching systematic credit investing (and provide many references for readers interested in greater depth): (i) strategic and tactical exposure to the overall credit risk premium and (ii) relative value opportunities across credit instruments. We find that both kinds of systematic credit exposure have the potential to provide meaningful performance and diversification benefits to traditional and alternative portfolios.

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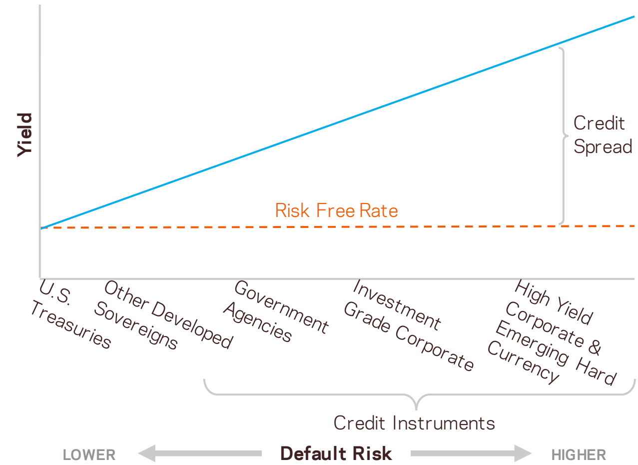
Introduction: What Is Credit?

Credit is a unique asset class within the broader class of fixed income instruments. Fixed income instruments are categorically fixed with respect to contractually specified cash flows over a pre-determined period, but they can be issued by a broad spectrum of entities. These entities may have varying abilities to actually meet their contractual payments and might default on their obligations. Thus, the fixed income instruments they issue are exposed to the risk of default or credit risk. We label fixed income instruments with non-trivial credit risk as "credit instruments." Excess returns for credit instruments, henceforth referred to as "credit excess returns," are defined as the returns over a risk-free fixed income security with the same cash flow and maturity profile. This separates interest rate risk and credit risk, which too often are discussed together.

Part 1: Credit Instruments

Bonds are the canonical fixed income instruments, and many are credit instruments as well. As discussed above, not all fixed income issuers are equally likely to fulfill their payment obligations; thus, they have varying levels of default risk. Exhibit 1 shows fixed income instruments along a spectrum of default risk. U.S. Treasuries fall farthest left, as they are often assumed to be "risk free."[1] Most issuers, however, are not risk free, and as we move to the right we find credit instruments with increasing levels of default risk.[2] Examples of credit issuers include public and private corporations, municipalities, government agencies and sovereign governments (generally of emerging countries when they issue external debt, as that has a clearer risk of default than their local debt or the debt of developed countries).

Exhibit 1: The Link Between Yields and Credit (Default) Risk



Source: AQR. For illustrative purposes only.

Exhibit 1 also depicts how the yields on credit instruments increase with the default risk of their issuers. This yield can be viewed as the risk free rate plus a "credit spread" to compensate for the risk that the contractual payments may not be made. The credit spread is directly related to the default risk,[3] and can be decomposed into two primary components: (i) an expected probability of default (PD) and (ii) an expected loss given default (LGD).[4] Equation (1) shows the approximate relationship between credit spreads and these two components.

$$\textit{Credit Spread} \propto PD \times LGD \qquad (1)$$

The higher the probability of default or the higher the loss given default (i.e., lower recovery rates), the higher the credit spread will be. In practice, other factors such as taxes, liquidity and general market risk premia are also determinants of credit spreads, but this simple framework focuses our attention on the major drivers of expected returns.[5] We will discuss these major drivers further in Part 2 of this paper.

[1] The emergence of default protection against U.S. Treasuries has challenged this popular assumption, but we will assume it to be true for the purpose of this paper.

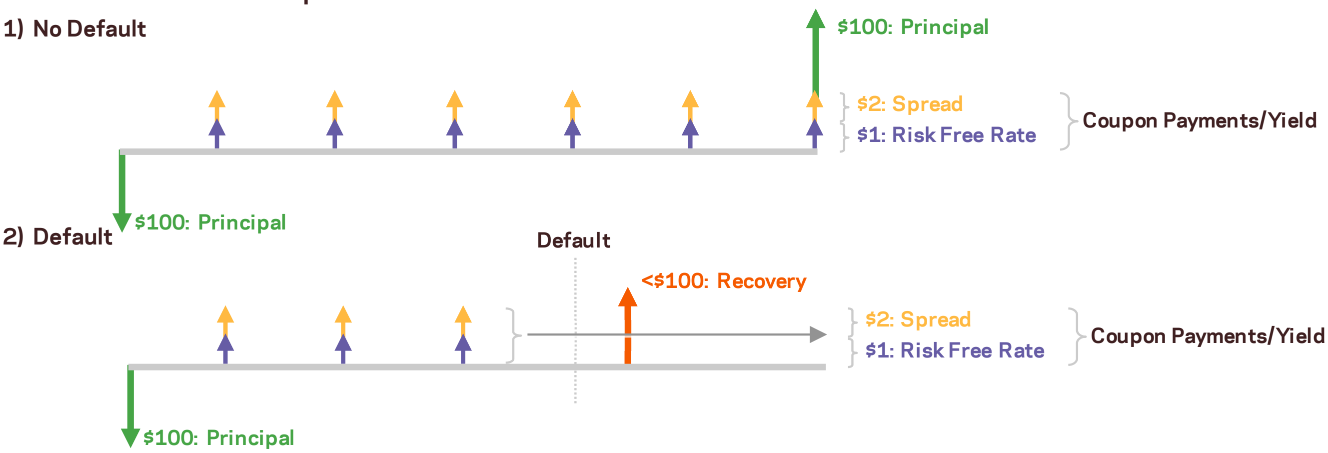
[2] This is a general mapping and specific exceptions will likely occur.

[3] For highly rated bonds, credit risk mainly materializes as spread widening risk or rating downgrade risk, but these can be tied back to the default risk, however remote.

[4] The credit spread and probability of default are measured over the same horizon.

[5] Correia, Kang and Richardson (2015) note that 55% of cross sectional

Exhibit 2: Illustrative Corporate Bond Cash Flows



Source: AQR. For illustrative purposes only.

Exhibit 3: Return Decomposition of U.S. Corporate Investment Grade and U.S. Corporate High Yield Bonds

August 1988–December 2014

	U.S. Corporate Investment Grade			U.S. Corporate High Yield		
	Rates Return	Credit Excess Return	Total Return	Rates Return	Credit Excess Return	Total Return
Annualized Return	6.9%	0.5%	7.4%	6.0%	2.5%	8.5%
Annualized Volatility	5.0%	3.9%	5.3%	4.5%	9.6%	8.8%

Source: AQR, Barclays. Total returns are those of the Barclays U.S. Corporate Investment Grade and U.S. Corporate High Yield indices. Credit Excess Returns are the index returns in excess of duration matched treasury returns. Rates Returns are the simple differences between total and credit returns. Past performance is not a guarantee of future performance. Please read important disclosures at the end of this paper.

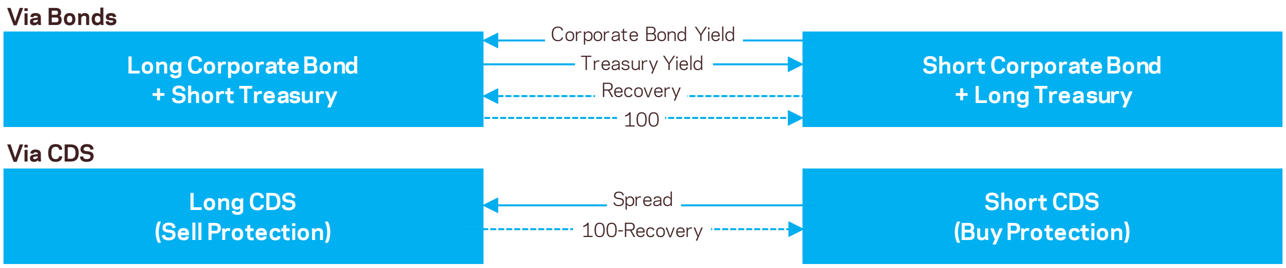
While default-risk-bearing bonds such as corporate bonds are ubiquitous credit instruments, credit is not the only risk they are exposed to. As Exhibit 1 illustrates, the yield, and hence the price, of a corporate bond is not only influenced by its credit spread, but also by the risk-free interest rate. Exhibit 2 illustrates cash flows from a corporate bond issued at par, with down arrows representing payments from the bond investor to the issuer and up arrows indicating payments from the bond issuer to the investor. The first figure shows a bond with no default, while the second shows one where a default occurs. The contractual coupon payments are made up of the risk-free interest rate and the spread components. Thus, a corporate bond, for example, is exposed to both interest rate and credit risk. This can present challenges for investors' portfolios. Investors who want credit exposure from corporate bonds must understand that they also have interest rate exposure unless it is explicitly hedged out; investors who want interest rate exposure may not also want the credit risk that some bonds in their portfolio may have.

Exhibit 3 decomposes the return and volatility of corporate bonds into interest rate and credit components using aggregate indices of U.S. corporate investment grade and high yield bonds since 1988. The interest rate is a significant component of returns and volatilities for both investment grade and high yield bonds and therefore must be hedged out if we only want the exposure to the credit excess returns.[6] This can be

variation of credit spreads can be explained by variables related to expected default loss.

[6] Rates exposure accounts for a larger portion of returns for investment grade bonds than high yield bonds because investment grade bonds i) have lower credit risk, and ii) they are able to issue longer dated debt. As such, the duration of investment grade bonds tends to be larger than that

Exhibit 4: Getting Pure Credit Exposure



Source: AQR. The CDS covers the same period as the bond. For illustrative purposes only.

done by holding a corporate bond and selling short a Treasury bond with the same cash flow and maturity profile. This way, we have canceled out the interest rate exposure and still receive the spread component of the yield, which is the credit exposure to the corporate bond issuer.

Over the past decade, another class of instruments has been increasingly used to gain exposure to credit risk: credit default swaps, or CDS. The market for these instruments has become sufficiently developed to make CDS a meaningful asset class in its own right. A key benefit of a CDS contract is its pure exposure to credit risk — there is no interest-rate risk that must be hedged out. The "spread" on a CDS contract is analogous to the spread on the corporate bond.[7] Exhibit 4 shows the mechanics of gaining pure credit exposure via corporate and Treasury bonds versus CDS: the boxes on the left represent credit investors; the solid arrows represent regular cash flows when there is no default; the dashed arrows represent cash flows when there is a default. CDS can be particularly useful for relative-value and tactical strategies, as these explicitly look to take views on only the credit component.

Part 2: A Framework for Understanding Credit Excess Returns

To effectively benefit from credit investing, it is important to understand the components of credit excess returns. Equation (2) gives a first order approximation of monthly credit excess returns:[8]

$$\begin{aligned} &\mathit{Credit\ Excess\ Return}_t \\ &= \frac{1}{12}\mathit{Spread}_{t-1} - \mathit{Spread\ Duration}_{t-1} \times (\mathit{Spread}_t - \mathit{Spread}_{t-1}) \quad (2) \end{aligned}$$

This simply states that monthly credit excess returns are driven by two components: (i) level of credit spread, and (ii) change in credit spread.[9]

Credit Default Swaps

It is useful to put the term "CDS" in context for the investor who is new to the credit asset class. Corporate CDS is an insurance contract that provides protection against a corporation defaulting on its debt obligation. While a CDS contract can technically be written on any issuer, the most liquid ones are those written on the largest corporations with the most liquid bonds. These are the same corporations that you would typically find in the S&P 500 or the Russell 1000 indices. The underlying default risk of a CDS contract is one and the same as that of a corporate bond. Today, CDS contracts are standardized across issuers, making relative-value comparisons easier. Investors are wise to be wary of some structured products, such as certain MBS, ABS and CDOs that may be opaque and illiquid, but CDS contracts are transparent and tend to be relatively liquid.

of high yield bonds resulting in a larger impact of rate return for investment grade bonds.

[7] While there can be differences between the "spread" on a bond and the CDS "spread," commonly referred to as basis, for the purposes of this article and illustrating how credit risk is priced in different markets they can be viewed as approximately equivalent.

[8] This is an approximation, and ignores potential convexity effects.

[9] Losses from defaults are included in the change in credit spread component in our analysis.

Exhibit 5: Return Decomposition of Credit Excess Returns
February 1994–December 2014

	U.S. Corporate Investment Grade			U.S. Corporate High Yield		
	Carry	Spread Change	Credit Excess Return	Carry	Spread Change	Credit Excess Return
Annualized Return	1.4%	-0.9%	0.5%	5.3%	-3.0%	2.3%
Annualized Volatility	0.3%	4.3%	4.4%	0.8%	10.1%	10.1%

Source: AQR, Barclays. As in Exhibit 3, this data is based on the Barclays U.S. Corporate Investment Grade and U.S. Corporate High Yield indices. Credit Excess Returns are the index returns in excess of duration matched Treasury returns. Carry returns are calculated as the index option-adjusted spread (OAS) at the beginning of the month divided by 12. Spread Change returns are the differences between credit and carry returns. This analysis starts in 1994 because we do not have the index OAS data before that date. Past performance is not a guarantee of future performance.

The first component represents the "carry" portion of credit excess return, which is equal to the initial credit spread level at the start of the month. This is the return the investor would receive if the credit spread remains unchanged during the month. The second component captures the effect of the change in credit spread over the month. Positive changes in spread contribute negatively to credit excess returns because price and spread are inversely related, holding the risk-free rate constant. The duration term in Equation (2) reflects the fact that the further out you bear credit risk exposure, the more sensitive the credit excess return is to changes in spreads.[10]

Exhibit 5 decomposes credit excess returns on corporate bonds into carry and spread change components using aggregate indices of U.S. corporate investment grade and high yield bonds since 1994 (this is a shorter time period than examined in Exhibit 3 because we do not have index option-adjusted spread data prior to 1994).[11] Both carry and spread changes are significant components of the credit excess returns. However, spread changes account for almost all of the risk in credit excess returns.

Part 3: The Credit Risk Premium

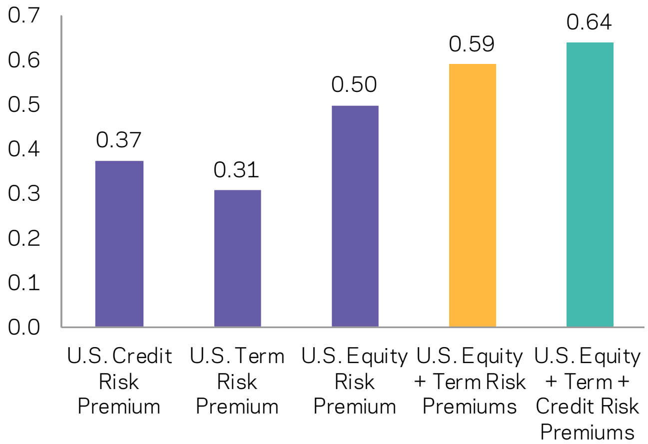
In this section, we discuss the existence of a credit risk premium and show how a passive exposure to credit (without interest rate risk) has the potential to offer positive risk-adjusted returns and is additive to a portfolio of other traditional assets.

We define the credit risk premium as the difference between total returns on a portfolio of corporate bonds and the total return to a portfolio of Treasury securities with the same effective duration. This is the same as the credit excess return on a portfolio of corporate bonds. While there is vast evidence supporting the existence of an equity risk premium, it has been more challenging to document evidence of a credit risk premium. This is due, in part, to the challenges of sourcing clean historical corporate bond returns. While such data exists and has been examined previously (e.g., Ibbotson and Sinquefield (1976)), there are two issues with this historical data. First, the corporate bonds that were issued in the past tended to be from very safe corporations with AAA/AA ratings, and as such they do not bear much exposure to default risk. Second, the specific details for bonds included in older datasets are quite limited, and as a result it is hard to ensure an appropriate matching of the duration of the corporate bonds with the duration of the Treasury securities used to compute excess returns. Empirical evidence suggests that the corporate bonds in the sample have lower effective durations than the Treasury bonds. Simply taking the difference between corporate and Treasury bond total returns as a measure of credit excess returns without accounting for this duration mismatch will result in underestimating the credit risk premium. Ilmanen (2011) and

[10] Spread duration is the sensitivity of the underlying instrument's market value to changes in its spread.

[11] Option-adjusted spread (OAS) is the spread relative to a benchmark yield (usually a risk-free Treasury rate), that takes into account an embedded option for the issuer to call or redeem the bond prior to its maturity.

Exhibit 6: Comparison of Sharpe Ratio
January 1936–December 2014



CORRELATION	Credit Risk Premium	Term Risk Premium	Equity Risk Premium
Credit Risk Premium	1		
Term Risk Premium	0.00	1	
Equity Risk Premium	0.29	0.10	1

Sources: AQR, Ibbotson, Barclays. The U.S. Credit Risk Premium (Credit) is the excess return of U.S. corporate bonds over duration-matched U.S. Treasuries. The U.S. Term Risk Premium (Term) is the excess return of U.S. Treasuries over 30-day T-bills. The U.S Equity Risk Premium (Equity) is the excess return of U.S. large cap equities over 30-day T-bills. See Appendix A for more details on the construction of the three return series. Equity + Term and Equity + Term + Credit are equal risk combinations of the listed constituents, based on trailing 12-month realized standard deviations. Sharpe ratios are based on these monthly excess returns and their volatilities. Diversification does not eliminate the risk of experiencing investment losses. Past performance is not a guarantee of future performance. Hypothetical data has inherent limitations, some of which are discussed in the disclosures.

Hallerback and Houweling (2013) discuss these two issues, both of which are expected to cause a downward bias, in the context of the long run evidence for the credit risk premium. This difficulty in computing historical credit excess returns may have played a role in limiting credit's use in investor portfolios.

To more effectively evaluate the credit risk premium, we use a new series based on the work by Asvanunt and Richardson (2016). They construct a reliable return series to evaluate the credit risk premium using a combination of Ibbotson's U.S. Long-Term Corporate Bond series from 1926 to 1988 and the Barclays U.S. Corporate Investment Grade index from 1988. For the Ibbotson series, they appropriately [12] remove duration-matched Treasury bond returns to construct a credit excess return series back to 1936. [13] This provides a long time series of corporate bond excess returns to more reliably evaluate the credit risk premium.

Exhibit 6 shows the Sharpe ratio of this credit risk premium versus those of other market risk premia from 1936 through 2014. Over this period, the Sharpe ratio of the credit risk premium (credit excess return of U.S. corporate investment grade bonds) was 0.37, not out of line with 0.31 for the term premium (return of U.S. Treasuries over cash, which is pure rate risk) and 0.50 for the equity risk premium (return of U.S. equities over cash).[14] These Sharpe ratios are based on returns that are gross of transaction costs and fees. Exhibit 6 also shows the correlations among the three risk premia. It reveals that the credit risk premium has on average been uncorrelated to the term premium and positively correlated to the equity risk premium. The latter observation is not surprising since credit and equity instruments are linked through the corporations that issue them. Even with this connection, however, the series have realized only a modest correlation of 0.3 over the 1936 through 2014 period.

Strong risk-adjusted returns in conjunction with low correlations to the term and equity risk premia raise the question of the potential benefits of adding credit market exposure to a portfolio.

[12] "Appropriately" being still an approximation, but they argue an unbiased one.

[13] Per Asvanunt and Richardson (2016), the first 10 years of data are lost because the empirical durations are estimated using 10-year rolling regressions.

[14] As mentioned in footnote 13, the credit excess return starts in January 1936 because of the 10 years of data required to estimate empirical durations. To estimate the magnitude of credit risk premium during 1926-1936, which includes the Great Depression, Asvanunt and Richardson (2016) use in-sample regression over the same period for empirical durations to estimate credit excess returns. Including this first 10 years, the 1926-2014 Sharpe ratios for the credit, term and equity risk premia were, respectively, 0.50, 0.34, and 0.42. Sharpe ratios of Markit CDX North America Investment Grade and High Yield indices since their inception in 2004 through 2014 were 0.45 and 0.68, respectively.

To assess the extent to which the credit risk premium can be additive to a portfolio of equity and term risk premia, we construct two simple equally risk-balanced portfolios from the individual market risk premia proxies already discussed: one with equity and term risk premia, and another with equity, term and credit risk premia. Exhibit 6 shows the Sharpe ratios of these two simple risk-balanced portfolios. The three-asset portfolio with corporate investment-grade bonds has a higher Sharpe ratio than the two-asset portfolio and each of the individual risk premia, suggesting that the credit risk premium is additive to other traditional risk premia. The specific level of risk-adjusted return shown here from allocating risk across credit, term and equity premia may be better than can be achieved in practice as returns are gross of transaction costs and fees and also assume equal risk-bearing capacity (i.e., trading volumes and/or open interest) across the three markets.[15] Still, it is clear that the composite portfolios offer attractive diversifying returns.

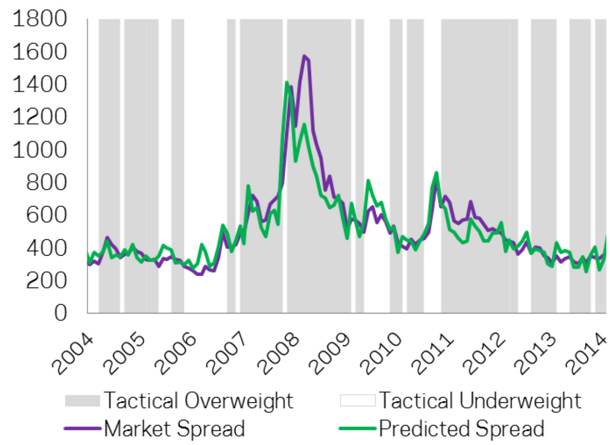
To more formally test the additivity, Asvanunt and Richardson (2016) regress credit excess returns onto Treasury bond excess of cash returns and equity excess of cash returns. They find that the intercept is positive (7 bps/month) and significant (2.17 test statistic), again suggesting that the credit risk premium may be additive to other traditional risk premia.

Asvanunt and Richardson (2016) also document how the magnitude of the credit risk premium varies across macroeconomic regimes. As expected, they find that credit performs well during periods of positive growth and declining default rates. This suggests that tactically timing exposure to credit markets should be guided by some ability to forecast economic growth and/or

[15] Another assumption is the willingness to use leverage to hit estimates of risk.

Exhibit 7: Tactical Timing Illustration

March 2004–December 2014



Source: AQR, Markit, Bloomberg, Compustat. The Market Spread is the spread of the Markit CDX.NA.HY index. The Predicted Spread is the spread implied by the aggregate default rate forecast based on our structural default probability model. See Appendix B for more details on the structural default probability model. For illustrative purposes only.

aggregate default rates (but like all such things nothing is a guarantee).

Equation (1) provides a framework for timing credit market exposure based on forecasting aggregate default rates. It shows a simple relationship between an issuer's credit spread and expected probability of default, which also holds true at the index level, where expected default probability becomes the aggregate default rate forecast for the index. Exhibit 7 compares the market spread of the Markit CDX.NA.HY index with the spread implied by the aggregate default rate forecast. The index is considered to be "cheap" when its spread is higher than the level implied by the default rate forecast. During such times (shaded grey in Exhibit 7), it may be beneficial to have a tactical overweight in HY credit as investors are over compensated for bearing default risk. This is similar to the "value" investment style that we will discuss in the next section of this paper. While we have seen empirical evidence supporting the efficacy of tactically timing credit market exposure, we still caution the reader that market timing, in general, is difficult. We believe that market timing should represent only a moderate fraction of active risk in a portfolio.

Part 4: Relative Value Opportunities Within Credit

Here we discuss how to access returns via relative value opportunities in credit markets.

For these insights, we turn to well-known styles that have proven to be pervasive across asset classes. We find that our usual suspects of value, momentum, defensive and carry are measurable for credit and useful in identifying robust sources of credit excess returns.[16] A full review of styles within credit can be found in Israel, Palhares and Richardson (2016). The measurement of value is more specific to credit than to other styles such as momentum, defensive and carry. As such, we focus our discussion on "value" within credit as an example.

The idea of value in credit will sound familiar: seek exposure to credit risk for instruments that are cheap and seek to avoid exposure to credit risk for instruments that are expensive. But the identification of what is rich or cheap in credit differs from the traditional equity value metrics. In stock selection the typical measure of value is X/P, where X could be earnings, cash flows, sales, book value or some other fundamental measure. When X/P is high you are getting more of the fundamental measure per unit of price (it looks "cheap") and when X/P is low you are getting less of the fundamental measure per unit of price (it looks "expensive").

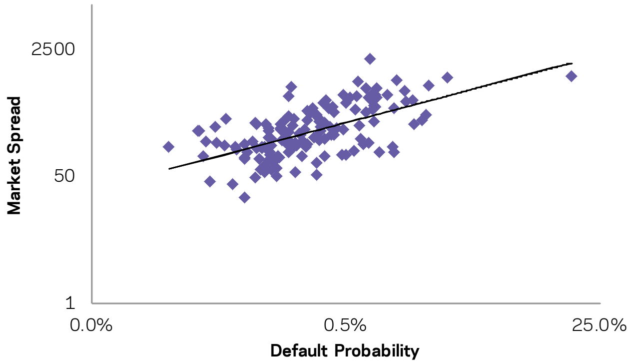
In credit selection we also desire a fundamental anchor to observed prices, but must adjust our approach. First, the trading convention in credit markets is in terms of spreads rather than prices, so we must invert our language. In credit selection, we label an issuer as "cheap" if the spread is greater than what we think it should be, and we label an issuer "expensive" if the spread is less than what we think it should be. Then, we must use a fundamental measure to guide us in identifying issuers whose spreads are too wide (cheap) or too tight (expensive).

We turn again to Equation (1) for a simple and intuitive way to think about what a fundamental anchor could be for credit selection. As spreads are positively related to default probabilities and loss given default, we can use expected default rates and recovery rates to construct a fundamental value measure for credit instruments. This approach can be applied to identify "value" opportunities for any credit instrument as long as its default risk can be reasonably estimated. Investors are rewarded for avoiding expensive credits and seeking cheap credits. Correia, Richardson and Tuna (2012) document this phenomenon and provide extensive evidence on the efficacy of value investing in credit markets. Past research has shown that corporate defaults can be reasonably forecasted by a variety of models. Correia, Richardson and Tuna (2012) show that credit spreads in the market often deviate from the default probabilities implied from these forecasting models, and that the differences are highly mean-reverting. This implies that future spread changes may be predicted by this deviation. Similar to intuition in Exhibit 7, Exhibit 8 illustrates how market spreads can deviate from fundamentals, but this looks at the relative value differences across individual credit securities at a point in time rather than looking at the overall valuation of the credit market as a whole through time. The horizontal axis is the expected default rate from our structural default probability model. The vertical axis is the market spread. "Cheap" securities fall above the fair value spread indicated by the blue line, and "expensive" securities fall below.

As mentioned previously, other styles have more analogous implementations to equities and thus

[16] For additional information on these "usual suspects" see Asness, Ilmanen, Israel and Moskowitz (2015).

Exhibit 8: Relative Value Illustration
December 31, 2014



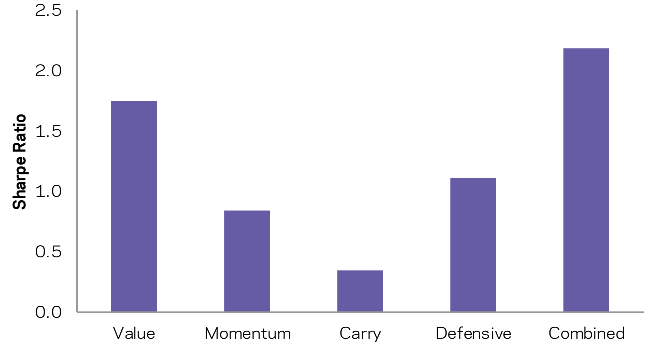
Source: AQR, Markit, Bloomberg, Compustat. This plots market spreads versus default probabilities from our structural default probability model (in log-log scale) of the most liquid corporate single name CDS in North America. The line is the linear trend line of the data. See Appendix B for more details on the structural default probability model and Appendix C on the liquid CDS universe. For illustrative purposes only. Please read important disclosures at the end of this paper.

might be more familiar. Momentum is the tendency for an asset's recent relative performance to continue in the near future. For credit this means looking at price-based measures using, for example, 6 to 12 months of historical credit excess returns, preferring the securities that have outperformed relative to those that have underperformed. Carry is the tendency for higher yielding assets to provide higher returns than lower yielding assets — the return you expect to receive from the passage of time holding all else constant. For corporate bonds, one way to measure carry is the option-adjusted-spread over treasury yield.[17] Defensive is the tendency for lower risk and higher quality assets to generate higher risk-adjusted returns than higher risk and lower quality assets. As an example, low leverage can be used as a measure of quality for corporate bonds.

Exhibit 9 shows evidence of style investing across investment grade and high yield corporate bonds documented in Israel, Palhares and Richardson (2016). The four styles are lowly correlated to one another (see bottom of Exhibit 10), and the combination has historically delivered attractive

[17] Note that this is different from value as it does not have a fundamental anchor.

Exhibit 9: Evidence of Style in Credit
January 1997–April 2015



CORRELATION	Value	Momentum	Carry	Defensive	Combined
Value	1.00				
Momentum	-0.33	1.00			
Carry	0.17	-0.36	1.00		
Defensive	0.30	0.49	-0.12	1.00	
Combined	0.45	0.40	0.23	0.80	1.00

Source: AQR, Bank of America Merrill Lynch. Sharpe ratios of long/short portfolios targeting constant 5% volatility using trailing 24-month realized standard deviations. These long/short portfolios are inherently excess of any cash rate. Portfolios are constructed from a universe of U.S. corporate investment grade and high yield bonds. The Combined portfolio is formed using equal risk weighted scores from the four styles. See Appendix D for more details. Past performance is not a guarantee of future performance. Diversification does not eliminate the risk of experiencing investment losses. For illustrative purposes only and not based on an actual portfolio AQR manages. Hypothetical data has inherent limitations, some of which are discussed in the disclosures.

risk-adjusted returns. As before, these risk-adjusted returns may be better than can be achieved in practice as they are gross of transaction costs, financing charges and fees, and, as with any study that involved past data, are subject to the pitfalls of data mining. Also, these returns are done in the context of a long/short portfolio, whereas sometimes these factors are only used to "tilt" a long-only portfolio in a more traditional setting. Still, it is clear that this composite portfolio harvesting style exposures across the breadth of credit instruments in a systematic manner offers potentially attractive risk adjusted returns.[18]

Part 5: Systematic Credit Investing

Credit markets have evolved substantially over the last 20 years. The advent of TRACE (Trade Reporting and Compliance Engine) has brought

[18] Israel, Palhares and Richardson (2016) demonstrate the efficacy and diversification benefits of multi-style long-only corporate bond portfolios that account for estimates of transaction costs and other real-world portfolio constraints.

Exhibit 10: Hypothetical High Yield Credit Strategy Excess Performance and Correlations
November 2004–December 2014

	Passive			Active			
	Rates Beta	Credit Beta	Total Beta	Timing	Rel Val	Total Active	Portfolio
Annualized Return	1.1%	2.1%	3.1%	0.3%	3.6%	3.9%	7.0%
Annualized Volatility	1.7%	5.9%	5.3%	0.7%	5.8%	5.9%	7.7%
Sharpe	0.63	0.35	0.59	0.40	0.62	0.66	0.90
				Correlations			
	Rates Beta	Credit Beta	Total Beta	Timing	Rel Val	Total Active	Portfolio
Passive: Rates Beta	1.00						
Passive: Credit Beta	-0.50	1.00					
Passive: Total Beta	-0.24	0.96	1.00				
Active: Timing	-0.07	0.10	0.09	1.00			
Active: Rel Val	0.16	-0.09	-0.04	0.03	1.00		
Active: Total Active	0.15	-0.07	-0.03	0.14	0.99	1.00	
Portfolio	-0.04	0.60	0.65	0.17	0.72	0.73	1.00
U.S. Treasuries	0.98	-0.50	-0.25	-0.10	0.14	0.12	-0.07
U.S. Equities	-0.28	0.73	0.73	0.15	-0.15	-0.13	0.40
HFRI: FI CORP	-0.35	0.85	0.85	0.16	-0.08	-0.06	0.53

Sources: AQR, Barclays, Markit Partners. Total Beta is the total return of the Barclays U.S. Corporate High Yield index. Credit Beta is the credit excess return of the same index. Rates Beta is difference between the Total Beta and the Credit Beta. Timing is based on the Markit CDX.NA.HY index. The Rel Val universe consists of the most liquid corporate single name CDS within North America (see Appendix C for more details). Total Active consists of 10% tactical timing (Timing) and 90% relative-value (Rel Val) strategies; both active strategies are systematic. The hypothetical Portfolio has 50% of risk from Total Beta and 50% of risk from Total Active. Sharpes are based on returns in excess of 3-month LIBOR. For illustrative purposes only and not based on an actual portfolio AQR manages. Hypothetical data has inherent limitations, some of which are discussed in the disclosures. Past performance is not a guaranatee of future performance.

transparency to the previously opaque over-the-counter corporate bond market.[19] Transaction-

level data are now available for investors to carefully assess liquidity. Recent developments in the CDS market have also been a major contributor to opening up the market. The CDS market has evolved from consisting largely of bespoke bilateral contracts in the early 2000s to completely standardized, fungible contracts since 2009. Today, clearing is mandatory for CDS indices and is available for most single names. Electronic trading has become the norm for indices, but it is still at the early stage for single names. We believe these developments in credit markets have created a unique opportunity to take a *systematic* approach to credit investing now.

The improved transparency and availability of reliable data have made it possible to deploy systematic investment strategies in credit markets. Systematic strategies allow investors to take advantage of potential diversification benefits. Factors or signals from multiple investment themes can be used to evaluate timing and relative-value opportunities among a large number of securities across industries and geographies. These timing and relative value strategies can be implemented in a long/short vehicle with minimal long term beta to the markets, or they can be used in conjunction with or on top of a strategic passive allocation to credit risk premium in a long-only portfolio construct.

Exhibit 10 summarizes the performance of a hypothetical portfolio that is designed to combine the various topics covered in this article. We have shown that the credit asset class may offer a diversifying risk premium, and that the magnitude of this risk premium varies over time (i.e., the credit risk premium pays off more when aggregate defaults are lower than what was expected). We have also shown evidence of the applicability of style investing within the credit asset class. Our hypothetical portfolio, shown in Exhibit 10, therefore combines (i) passive credit market exposure (inclusive of rate and spread components), (ii) active risk from timing that credit market exposure, and (iii) active risk from exploiting cross-sectional investment

[19] TRACE captures all secondary market transactions for U.S. corporate bonds since 2002.

opportunities *within* the credit market. The data used for this hypothetical portfolio covers the time period November 2004 through December 2014. The hypothetical portfolio allocates risk equally across the passive and active components. The passive exposure is implemented via high yield corporate bonds, so we break out the contributions into Rates Beta and Credit Beta. The interest rate and credit excess returns are additive (1.1% + 2.1% = 3.1%) while their combined volatility is reduced due to their significant negative correlation. The risk in the active component is 10% high yield timing (Timing) and 90% relative value credit selection strategies (Rel Val). [20] Both are implemented via CDS and CDS indices. The weightings are already applied to the individual strategies, such that the returns for the Total Active are the sum of Timing and Rel Val returns. Note that our choice of weights between timing and relative value strategies reflect our earlier comment that market timing is difficult and should only be used moderately. The total portfolio (Portfolio) is the sum of Total Beta and Total Active. Returns, again, are additive. Volatility, however, is significantly less than the sum, as the passive and active strategies are uncorrelated, so there are significant diversification benefits to combining them. Consequently, the Sharpe ratio of the Portfolio is 0.90, which is significantly higher than the 0.59 of Total Beta and the 0.66 of Total Active.

The bottom 3 rows in Exhibit 10 show the correlations between each of the components and U.S. Treasuries, U.S. Equities and the HFRI: Fixed Income Corporate indices.[21] As expected Rates Beta is highly correlated to Treasuries, and Credit Beta is highly correlated to equities. We also find that Credit Beta is highly correlated to the HFRI: Fixed Income Corporate index, suggesting that many credit managers incorporate a significant amount of credit beta into their portfolios, similar to how many hedge funds have significant equity betas (see, e.g., Israel, Palhares and Richardson (2016)). Total Active is lowly correlated to all three indices and hence systematic credit investing provides potential diversification benefits to traditional and alternative portfolios.

Conclusion

Institutional and retail investors continue to seek diversifying sources of returns across multiple asset classes and investment strategies. We introduce credit as a distinct asset class and show that it offers a diversifying risk premium. We illustrate how investors may improve performance of their portfolio by adding a passive allocation to the credit risk premium. We also show that investors may be able to further enhance performance by engaging in systematic active management of credit instruments. The recent development of liquid credit markets has opened up a new opportunity to apply systematic investing techniques to credit investing, allowing for significant diversification within active credit strategies in addition to the potential for meaningful performance benefits. The continuing evolution of credit markets is also leading to greater understanding of the sources of credit return and active research is ongoing.

[20] Hypothetical monthly returns are discounted by subtracting 50% of the full sample average. Discounting is applied to active strategies only. These returns are net of transaction costs, gross of fees.

[21] U.S. Treasuries is the Barclays U.S. Treasury Index, U.S. Equities is the S&P 500 index.

References

Asness, C., A. Illmanen, R. Israel, and T. J. Moskowitz (2015). "Investing with Style," *Journal of Investment Management*, 13(10), 27-63.

Asvanunt, A. and S. Richardson (2016). "The Credit Risk Premium," *Journal of Fixed Income*, forthcoming.

Beaver, W. H., M. Correia, and M. McNichols (2012). "Do Differences in Financial Reporting Attributes Impair the Predictive Ability of Financial Ratios for Bankruptcy." *Review of Accounting Studies*. doi: 10.1007/s11142012918 67.

Correia, M., J. Kang and S. Richardson (2015). "Does Fundamental Volatility Help Explain Credit Risk?" working paper.

Correia, M., S. Richardson and I. Tuna (2012). "Value Investing in Credit Markets," *Review of Accounting Studies*, 17, 572-609.

Hallerbach, W. G. and P. Houweling (2013). "Ibbotson's Default Premium: Risky Data," *The Journal of Investing*, Summer, 95-105.

Ibbotson, R.G. and R. Sinquefield (1976). "Stocks, Bonds, Bills and Inflation: Year-by-Year Historical Returns," *The Journal of Business*, 49 (1), 11-47.

Ilmanen, A. (2011). *Expected Returns: An Investor's Guide to Harvesting Market Rewards*,

Wiley Finance.

Israel, R., D. Palhares and S. Richardson (2016). "Common Factors in Corporate Bond and Bond Fund Returns," working paper.

Merton, R. (1974). On the pricing of corporate debt: The risk structure of interest rates. *Journal of Finance*, 29, 449-470.

Novy-Marx, R. (2013). "The Other Side of Value: The Gross Profitability Premium," *Journal of Financial Economics*, 108(1), 1-28.

Related Studies

Elton, E. J., M. J. Gruber, D. Agrawal and C. Mann (2001). Explaining the rate spread on corporate bonds. *Journal of Finance*, 56 (1), 247-277.

Gebhardt, W. R., S. Hvidkjaer, and B. Swaminathan (2005a). The cross-section of expected corporate bond returns: betas or characteristics? *Journal of Financial Economics*, 75, 85-114.

Gebhardt, W. R., S. Hvidkjaer, and B. Swaminathan (2005b). Stock and bond market interaction: does momentum spill over? *Journal of Financial Economics*, 75, 651-690.

Giesecke, K., F. A. Longstaff, S. Shaefer and I. Strebulaev (2011). Corporate bond default risk: A 150-year perspective. *Journal of Financial Economics*, 102, 233-250.

Houweling, P., and J. van Zundert (2014). Factor investing in the corporate bond market. Working paper, Robeco Quantitative Strategies.

Huang, J-Z. and M. Huang (2012). How Much of the Corporate-Treasury Yield Spread Is Due to Credit Risk?. *The Review of Asset Pricing Studies*, 2 (2), 153-202.

Kozhemiakin, A. (2007). The risk premium of corporate bonds. *Journal of Portfolio Management*, Winter, 101-109.

Kwan, S. H. (1996). Firm-specific information and the correlation between individual stocks and bonds. *Journal of Financial Economics*, 40, 63-80.

Ng, K-Y, and D. D. Phelps (2011). Capturing credit spread premium. *Financial Analysts Journal*, 67 (3), 63-75.

Van Luu, B. and P. Yu (2011). The credit risk premium: Should investors overweight credit, when, and by how much? *The Journal of Investing*, Winter, 132-140.

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Appendix A

The U.S. corporate bond excess returns are based on Ibbotson's data from January 1936 through July 1988 and Barclays' data from August 1988 through December 2014. This measure of credit excess returns is with respect to duration matched government bond returns. The U.S. Treasuries excess returns are the difference between either Ibbotson's U.S. Long-Term Government bonds for the January 1936 through December 1972 period or Barclays U.S. Treasury index for the January 1973 through December 2014 period and the U.S. 30-day Treasury Bill returns. The U.S. large cap equity excess returns are the difference between the returns of the S&P Composite index, which later becomes the S&P 500 index and the U.S. 30-day Treasury Bill returns. See "The Credit Risk Premium" by Asvanunt and Richardson (2016) for more details.

Appendix B

Our structural default probability model is built upon the theoretical framework of Merton (1974). The inputs to our model are from Compustat and Bloomberg and include equity market capitalization, face and market value of debt, asset volatility and market risk premium for the period March 2004 to December 2014. The output from the model is the distance-to-default, which we empirically map to default probability using historical corporate default events (rather than assuming a normal distribution as in Merton). Corporate default events combine bankruptcy data from Beaver et al. (2012); bankruptcy.com; Mergent FISD; and Lynn Lo Pucki's bankruptcy database. We also use the structural default probability model to forecast aggregate default rate by modeling the aggregate market as a representative firm.

Appendix C

We define the "most liquid" CDS to be the top 250 names, where available, determined by liquidity scores constructed from various data sources and metrics over time, based on data availability. Before 2009 the score is based on staleness of quotes and number of dealers submitting quotes to Markit. From January 2009 through March 2010 the score is based on CDS notional outstanding (from DTCC, Depository Trust & Clearing Corporation, section 1) and number of dealers submitting quotes to Markit; and from April 2010 through July 2011 the score is based on CDS notional outstanding (from DTCC section 1), number of dealers submitting quotes to Markit and bid-ask spread. Since 2011, the score is based on CDS trading volume (from DTCC section 4), number of dealers submitting quotes to Markit and bid-ask spreads.

Appendix D

The analysis is based on all constituents of the Bank of America Merrill Lynch (BAML) investment grade and high-yield corporate bond indices. Value uses the credit spread as the market measure, two measures of fundamental value and a cross-sectional regression of the logarithm of spread on the respective fundamental anchors. Momentum is based on two measures: the trailing six-month bond excess return; the six-month equity momentum of the bond issuer. Carry is the Option Adjusted Spread as reported in the BAML bond database. Defensive is based on three measures: the value of net debt divided by the sum of the value of net debt and market value of equity; gross profitability as defined in Novy-Marx (2013); low duration. Each long-short style portfolio is constructed by first ranking the entire universe of corporate bonds based on the style measures and then assigning each bond into one of five quintiles. Each bond within each quintile is weighted according to its outstanding market value. The long-short portfolio is then the bottom quintile subtracted from the top quintile. The combined portfolio is formed by first making equal risk weighted scores from the four styles, then ranking bonds based on the combined scores to form quintile portfolios, and finally subtracting the bottom from the top quintile as described above. See "Common Factors in Corporate Bond and Bond Fund Returns" by Israel, Palhares, and Richardson (2016) for full specifics on all measures and a more detailed investigation on style investing in the corporate bond market.

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