The Two Sigma Factor Lens

Category		Factor	Description*
Macro Factors	Core Macro	Equity	Exposure to the long-term economic growth and profitability of companies
		Interest Rates	Exposure to the time value of money (interest rates and inflation risk)
		Credit	Exposure to corporate default and failure-to-pay risks specific to developed market corporate bonds
		Commodities	Exposure to changes in prices for hard assets
	Secondary Macro	Emerging Markets	Exposure to the sovereign and economic risks of emerging markets relative to developed markets
		Foreign Currency	Exposure to moves in foreign currency values versus the portfolio's local currency
		Local Inflation	Exposure to inflation-linked rates relative to fixed nominal rates within the local currency area (only available in USD or GBP)
		Local Equity	Exposure to home bias (the tendency to invest in domestic over foreign equity)
Style Factors	Macro Styles	Equity Short Volatility	Negative exposure to the moves in equity market volatility
		Fixed Income Carry	Exposure to high-yielding 10-year bond futures funded by low-yielding 10-year bond futures
		Foreign Exchange Carry	Exposure to high-yielding G10 currencies funded by low-yielding G10 currencies
		Trend Following	Long-short exposure to multi-asset-class futures based on 6- to 12-month trailing returns
	Equity Styles	Low Risk	Long exposure to stocks with low market betas and residual volatility and short exposure to higher-risk stocks.
		Momentum	Long exposure to stocks that have outperformed recently and short exposure to recently underperforming stocks.
		Quality	Long exposure to stocks with low leverage and high profitability, and short exposure to lower-quality stocks.
		Value	Long exposure to stocks with low prices relative to accounting fundamentals and short exposure to higher-priced stocks relative to fundamentals.
		Small Cap	Long exposure to stocks with smaller market caps and short exposure to larger-cap stocks.
		Crowding	Short exposure to U.S. stocks that are widely shorted by the investment community, and long exposure to those stocks that are not as widely held short.

*Additional descriptions are included below

Introduction to factors

What are factors?

Risk factors are discrete, describable sources of common or systematic risk and return across a diverse set of investments.

What are examples of common factors?

Macro factors like Equity, Interest Rates, and Credit are commonly found risk exposures in an institutional investor's portfolio due to their high liquidity and capacity.

How do we classify factors?

Macro: High-capacity risk factors shown to correspond to the principal drivers of asset class returns. Macro risk factors are broadly known, widely accessible at a relatively low cost, and can explain most risk in long-biased, diversified institutional portfolios. Examples include Equity and Interest Rates.

Style: Lower-capacity risk factors shown to correspond to sizeable common risk drivers across individual securities but with lower correlations to asset class returns. Academic financial research has identified multiple style factors that appear to have long-term return premia resulting from investor behavioral biases or risk aversion to certain asset characteristics.[1] Style factors require skill to capture and manage but have relatively higher capacity and lower investment costs than alpha. Examples include Value and Momentum.

Residual: Idiosyncratic sources of risk (i.e., uncorrelated to other known factors) that are limited in capacity and have historically commanded higher fees. These risks generally appear as "residual" in a returns-based statistical factor analysis

What is a "risk premium"?

Factors with strong empirical evidence and/or fundamental justification for a long-term return premium are considered to have a "risk premium," which may reward investors for holding exposure to that risk factor over time. Not all identifiable risk factors carry a corresponding risk premium.

Why can "risk premia" exist?

A risk premium may compensate investors for bearing certain risks such as undiversifiable market risk, mandate constraints, operational complexity, or behavioral biases like risk/loss aversion, herding mentality, or recency bias.

What are examples of factors with a historical risk premium?

The Equity factor, which represents exposure to fundamental risks such as macroeconomic growth and corporate profitability, is an example of a macro factor that has historically delivered a positive long-term return in excess of the risk-free rate. The Momentum factor, which represents exposure to investor behavioral biases such as initial under-reaction to fundamental news about companies, is an example of a style factor that has historically delivered a positive long-term return in excess of the risk-free rate.

What is a risk lens?

A risk lens represents a complementary set of factors selected for a particular analytical task, such as identifying risk and return drivers in a diversified institutional portfolio or when evaluating an individual investment.

How can a risk lens be used?

A thoughtfully chosen and constructed risk lens can offer a unified framework and measurement tool to enhance allocation decisions in a portfolio. Top-down analysis can help allocators better understand the total magnitude of the largest risk drivers in a portfolio by estimating the total factor risk contributions across the portfolio. This allows for pro forma and optimization analyses of portfolio changes, which can better align overall risk exposures with an allocator's forward-looking views on factor returns.

In addition, a factor lens can help bottom-up manager selection by estimating the risk factor overlap of adding new holdings to an existing portfolio and helping separate idiosyncratic risk of a manager from identified macro or style factor risk.

How can a risk factor lens help with portfolio construction?

A risk factor lens composed of orthogonal risk factors can estimate the contribution of *independent, uncorrelated* risk and return drivers in a portfolio. This can provide a more accurate measure of diversification than an asset-class-based analysis.

How does risk factor diversification compare to traditional asset class diversification?

Although traditional asset allocation diversifies across many asset classes, it can obfuscate risks that drive correlation across asset classes. Different asset classes may have exposure to the same risk factors. For example, high yield corporate bonds and stocks have exhibited a long-run positive correlation due to each having exposure to the Equity risk factor (i.e. corporate profitability and economic growth). In fact, an analysis using the Two Sigma Factor Lens of the Bloomberg Global High Yield Index indicated that only 24% of the index's risk was driven by the Credit factor, whereas an additional 44% of the risk was driven by the Equity factor.[2] Using factors can help allocators identify the common risk and return drivers across asset classes and security types to achieve diversification more effectively.

Approach to factors

How do we approach factor construction for the Two Sigma Factor Lens?

The factors in the Two Sigma Factor Lens were constructed with the aim of accurately and intuitively describing risk and return drivers in institutional investor portfolios. The Two Sigma Factor Lens is intended to be:

Holistic: by capturing the large majority of cross-sectional and time-series risk for typical institutional portfolios

Parsimonious: by using as few factors as possible

Orthogonal: with each risk factor capturing a statistically uncorrelated risk across assets

Actionable: such that desired changes to factor exposure can be readily translated into asset allocation changes

Why do we seek a parsimonious lens?

Applying fewer, relatively independent factors to portfolio or manager analysis in a “less-is-more” approach can reduce the chance of overfitting on potentially spurious and/or highly correlated factors. We balance this with our desire for a holistic lens that includes as many of the potentially relevant factors as possible for any analysis.

How are our factors orthogonalized?

Though some factors are naturally orthogonal, we residualize our less liquid macro factors against more liquid ones to attempt to reduce correlations. In particular:

- The Credit and Commodities factors are residualized against both the Equity and Interest Rates factors
- Certain secondary macro factors (Emerging Markets, Foreign Currency, and Local Inflation) are residualized against the four core macro factors (Equity, Interest Rates, Credit, and Commodities)
- The Local Equity, Equity Short Volatility, and Foreign Exchange Carry factors are residualized against only the Equity factor
- The Fixed Income Carry factor is residualized against only the Interest Rates factor

Our equity style factors are constructed to be equity market-neutral and have generally low correlations to other factors without additional residualization.

Which indices does the Two Sigma Factor Lens use in constructing the macro factors?

Please view this article for information on the indices used to construct the macro factors.

Are modifications made to the underlying indices to create the macro factors?

Yes, multiple modifications are made to the underlying indices in construction of the macro factors, including:

- The following factors in the Two Sigma Factor Lens are calculated as returns to the index in excess of the risk-free rate (short-term sovereign yields) in USD: Equity, Interest Rates, Credit, Commodity, Emerging Markets, Equity Short Volatility.
- The Local Equity factor is calculated as returns to the index in excess of the short-term sovereign yields in the local currency (as set for the workspace).
- Where highly correlated to any core factor, a factor is residualized to the appropriate Equity, Interest Rates, Commodities, and/or Credit factors. See above for an additional explanation of orthogonalization.
- All macro factors are intended to be currency-agnostic wherever possible. For most factor inputs, currency-hedged excess returns are used. In cases where underlying indices are relative to a single currency (e.g., for commodity futures, emerging market bonds, and emerging market equity indexes in USD), we construct the excess returns hedged to the USD by subtracting the return of the USD relative to the market cap-weighted basket of G10 currencies.
- All macro factors (excluding the Equity, Interest Rates, and Local Equity factors) are volatility-standardized using a longer return time series.[3] This can allow a subscriber to directly compare exposures in any regression.

What are the definitions of the macro style factors, and how are they weighted?

Factor	Index/Definition(s)*
Equity Short Volatility	CBOE S&P 500 PutWrite Index
Fixed Income Carry	**Term Spread**: Exposure to bond futures with high differences between the 10-year and 3-month yields in a particular country/region **Roll Down**: Exposure to bond futures that have achieved high returns by holding a 10 year maturity bond for 3 years, assuming there is no change in the yield curve
Foreign Exchange Carry	**Interest Rate Differential**: Exposure to currencies with high one year interest rate differentials relative to the USD
Trend Following	**6 Month**: Exposure to positively trending macro-asset-class futures over the past 6 months **12 Month**: Exposure to positively trending macro-asset-class futures over the past 12 months

*The definitions, which represent the security attributes considered when constructing certain macro style factors, are equally weighted. The definitions and weighting scheme will change over time.

What are some key aspects of our approach to the macro style factors?

Each macro style factor targets discrete, systematic characteristics shown by academic finance research[4] to generate positive returns over time in macro asset classes. Each macro style factor is constructed a bit differently from the other:

- The Equity Short Volatility factor is constructed with an underlying index, similar to the construction of the core and secondary macro factors.
- The Fixed Income Carry factor represents returns of a portfolio of 10-year bond futures in the following 6 countries/regions: United States, United Kingdom, Canada, Australia, Japan, and Europe. The factor is designed to be duration-neutral. The bond futures are weighted primarily by how much each exhibits Fixed Income Carry characteristics (i.e., exposure to high-yielding 10-year bond futures funded by low-yielding 10-year bond futures).
- The Foreign Exchange Carry factor represents returns of a portfolio of G10 currencies that is designed to be USD-neutral. The currencies are weighted primarily by how much each exhibits the Foreign Currency Carry characteristic (i.e., exposure to high-yielding G10 currencies funded by low-yielding G10 currencies).
- The Trend Following factor represents returns of a long-short portfolio of futures contracts across fixed income, commodities, equities, and currencies. The factor can take on long or short directional risk in any given factor at different times but is constructed to be market neutral over a market cycle. The futures contracts are weighted primarily by how much the

contract exhibits Trend Following characteristics (i.e., long-short exposure to multi-asset-class futures based on 6- to 12-month trailing returns) taking into account a liquidity adjustment to tilt the portfolio toward larger positions in contracts with greater trading volume and lower volatility.

All macro style factors are volatility-standardized using a longer return time series.

What are the definitions of the equity style factors, and how are they weighted?

Factor	Definition(s)**
Low Risk	**Beta:** Exposure to stocks with low betas to the global equity market **Residual Volatility:** Exposure to stocks with low residual return volatility
Momentum	**Momentum:** Exposure to stocks that have outperformed over the past 12 months
Quality	**Profitability**: Exposure to stocks with high profitability ratios (such as cash flow over assets) **Leverage:** Exposure to stocks with low leverage
Value	**Book to Price:** Exposure to stocks with low prices relative to book value **Earnings Yield:** Exposure to stocks with low prices relative to trailing and forecast earnings measures **Dividend Yield:** Exposure to stocks with low prices relative to trailing dividends
Small Cap	**Market Capitalization:** Exposure to stocks with small market capitalizations
Crowding	**Residual Short Interest:** Short exposure to U.S. stocks that are widely shorted by the investment community

**The definitions, which represent the stock attributes considered when constructing each equity style factor, are equally weighted. The definitions and weighting scheme will change over time.

What are some key aspects of our approach to the equity style factors?

Each equity style factor represents returns of a portfolio of global stocks that is designed to be market-neutral and region-neutral, except the Crowding factor, which is U.S.-focused. To construct the equity style factors, we first create our estimation universe by looking at global stocks (except Crowding, which is U.S. equities only) that are sufficiently large and liquid to model by employing selection criteria such as price activity, liquidity capitalization, free-float and other business logics. Within this universe, the weight of a security is primarily determined by how much the security exhibits characteristics of that equity style factor as well as a liquidity adjustment to tilt the portfolio toward larger positions in stocks with greater trading volume and lower volatility. Additional adjustments are made to encourage the factor portfolios to remain close to market-neutral and to slow portfolio turnover in an effort to make the style factors more actionable for

global institutional investors. All factors except Crowding are also built to be region neutral. More specifically, we build the factor return for each of the regions (developed and EM for EMEA, Asia-Pacific and Americas) and combine them by scaling each region by the region's liquidity measures.

What are some ways we make the equity style factors more actionable?

Equities that are traded on exchanges that have restrictions on access by foreign investors (such as the China A-shares market) are down-weighted or excluded to increase accessibility.

Does the Two Sigma Factor Lens account for transaction, financing, and similar costs?

The factor portfolios in the Two Sigma Factor Lens are not actually traded. As such, their returns are not reduced for transaction, financing, or any similar costs. However, we consider transaction and financing costs when constructing our factor portfolios by making various adjustments, including, for example, tilting the equity style factor portfolios toward more heavily traded stocks, slowing the implicit trading of equity style factor portfolios by smoothing the incorporation of new stock data, and applying certain constraints on the equity style factors' investment universes such as eliminating certain thinly traded and illiquid equities. These methods are not necessarily reflective of any actual or potential costs and will at times result in understated or overstated residual return estimates for managers who follow similar strategies when analyzed through the Two Sigma Factor Lens.

What base currencies does the Two Sigma Factor Lens support?

The Two Sigma Factor Lens supports the following base currencies:

- Australian Dollar (AUD)
- British Pound (GBP)
- Canadian Dollar (CAD)
- European Euro (EUR)
- Japanese Yen (JPY)
- New Zealand Dollar (NZD)
- Norwegian Krone (NOK)
- Swedish Krona (SEK)
- Swiss Franc (CHF)
- U.S. Dollar (USD)

How did we approach the Foreign Currency factor construction?

The Foreign Currency factor for each currency is represented by the return of a market cap weighted basket of the other G10 (major developed markets) currencies funded by a short position in the local currency, accounting for both changes in spot exchange rates and the relative short-term interest rates in each currency.

Why does the Foreign Currency factor use market cap weighting instead of GDP weighting?

We believe market-cap weighting more accurately represents positioning of market participants.

Why is the Local Inflation factor only available in U.S. Dollars and British Pounds?

We believe the Local Inflation factor is difficult to generalize across currencies since inflation can be an inherently local phenomenon (e.g., driven by monetary supply, economic production, trade policy, and myriad other factors). Our Local Inflation factor, therefore, attempts to capture the cost of hedging a fixed-income portfolio against local currency inflation. We believe this cost can be appropriately calculated where deep and liquid markets of inflation-linked bonds exist and the values fluctuate with realized local currency inflation.

Both the United States and the UK markets have a deep market of inflation-linked bonds with decades of historical data, allowing us to build daily returns to the cost of hedging local inflation risk.

Factor Analysis on Venn

How does Venn use factors?

Venn uses factors to help institutional investors better understand the risk composition of their portfolios, strategies, and investments. Exposures to factors are calculated using a sequence of regressions on returns.

How can Venn help allocators?

We believe Venn can help allocators learn more about the potential factor exposure of their portfolios (absolute or relative to benchmark) based on the return histories of their current portfolio holdings. Venn displays the estimated exposures and contribution to risk and return for each factor identified in any return stream.

We also believe Venn can assist in allocation decisions by analyzing and estimating the historical marginal impact of adding, eliminating or reweighting an investment in your portfolio.

What types of portfolios is the Two Sigma Factor Lens designed to analyze?

The Two Sigma Factor Lens is designed to aid in the analysis of institutional investor portfolios whose investments span multiple asset classes.

How does Venn calculate factor exposures?

Venn uses a two-step regression process to calculate factor exposures:

Step 1: First, the full factor lens is run through a Lasso regression to balance model fit with the number of factors and the R-squared. Factors with 0 beta coefficients after the Lasso regression are considered irrelevant and are excluded from the analysis. This step can improve the interpretation of risk drivers and enhance the accuracy of the analysis by discarding the noise from irrelevant factors, while also reducing potential overfitting or false positives. Furthermore, if the R-squared based on factors selected is negative, we will exclude all factors from the analysis.

Step 2: The second step is the ordinary least squares (OLS) regression, which applies the selected factors as independent variables against each return stream. The final Betas and t-stats from this step are displayed in Venn. For t-stats, a value greater or less than +/-1.96 is considered statistically significant. Within the selected factors from step 1, Venn will highlight those that are both statistically significant and explain more than 1% of risk.

Please note that for daily data, Venn runs the regressions on rolling 5-day average returns for both factor returns and portfolio/fund returns to minimize impact of market asynchronicity. Newey-West correction is applied to the t-stat to correct for the heteroskedasticity and autocorrelation in the time series data.

Why does Venn use a lasso regression?

Allowing too many variables/factors into statistical analyses can make results harder to interpret and increase the chance of including spurious factors. Lasso regression aids our analysis by selecting a relevant subset of factors for each return stream that each appear to provide meaningful explanatory power.

How does a lasso regression work?

Lasso regressions use a regularization parameter to filter the independent variables (factors, in this case) included in the final model. Smaller regularization parameters cause the lasso to include more variables in the explanatory model (i.e. behaving more like an OLS regression), while larger regularization parameters restrict the model to a smaller subset of the most relevant independent variables.

How is the regularization parameter of Venn's lasso specified?

The lasso regularization parameter in Venn is specified using a modified version of the Akaike Information Criterion with small-sample correction (AICc) to penalize the in-sample fit of the lasso regression for the number of factors included. This statistical procedure accounts for the number of returns available and the unique information added by each factor to select a subset that collectively matches the investment or portfolio returns, weighing the in-sample explanatory power of adding new factors versus the expected out-of-sample error from potential false discoveries.

Venn's particular approach selected has the added benefit of correcting for small sample sizes, which is quite common in the institutional space where many investments only report monthly returns.

Why doesn't Venn use a stepwise regression?

Stepwise regression requires running a large number of sequential tests to determine which factors best explain the remaining return stream (or which factor provides the least explanatory power). One drawback to this approach is the difficulty in accounting for the degrees of freedom implicit in this repeated fitting and determining when the marginal factor provides a significantly better fit than chance alone might suggest. Lasso regression, on the other hand, examines all potential factors at once and uses a regularization parameter as described above to select the model that appears to provide the best balance of explanatory power versus the risk of false positives with any number of potential factors included.

Why do some factors that are not statistically significant appear on Venn?

Venn uses a lasso regression to select factors that appear to provide greater explanatory power than would be expected from a similar number of random return streams. However, the results from this statistical criterion can differ from traditional measures of single-factor statistical significance (such as the t-statistic) in regressions. This means that some factors selected may not appear statistically significant when subsequently run through an OLS regression.

Are there other factor lenses on Venn?

No, the only factor lens on Venn is the Two Sigma Factor Lens.

More Information

Who provides the Two Sigma Factor Lens?

We license the Two Sigma Factor Lens from Two Sigma Investments, LP ("TSI"), an affiliate of ours. Please note that TSI and other affiliates of ours use, construct, and maintain different factors or methodologies from those we use on Venn, including when making investment decisions on behalf of or when trading for purposes of their investable products.

Will the Two Sigma Factor Lens change?

Yes. We anticipate a growing and changing factor lens as research continues to update existing risk factors and address additional risk factors. Changes to the factor lens may affect prior analyses on Venn. The lens may also change under the terms of our license with TSI.

Our Form ADV, publicly available on Venn, also contains important information about the use of factors on Venn as well as our licensing relationship with TSI.

Please see below for additional details on factor research.

Recommended advanced reading on the lasso method used by Venn for factor subset selection:

Tibshirani, R. (1996). Regression shrinkage and selection via the lasso. *J. Royal. Statist. Soc B.*, Vol. 58, No. 1, pages 267-288.

Efron, B., Johnstone, I., Hastie, T. and Tibshirani, R. (2002). Least angle regression. *Annals of Statistics*, Vol. 32, No. 2, pages 407-499.

Cavanaugh, J. E. (1997). “Unifying the derivations of the Akaike and corrected Akaike information criteria”, *Statistics & Probability Letters*, Vol. 33, No. 2, pages 201-208.

[1] Eugene F. Fama and Kenneth R. French “Common risk factors in the returns on stocks and bonds” Journal of Financial Economics, 33, Issue 1 (February 1993): 3-56.

[2] Venn Analysis, December 2019

[3] Volatility-standardization involves scaling the factor returns to achieve a desired volatility level.

[4] Example research:

Fixed Income Carry:

Ilmanen (1995) "Time-Varying Expected Returns in International Bond Markets"

https://www.jstor.org/stable/2329416

Koijen, Moskowitz, Pedersen, and Vrugt (2018) “Carry”
https://www.sciencedirect.com/science/article/abs/pii/S0304405X17302908

Foreign Exchange Carry:

Bilson (1981) "The 'Speculative Efficiency' Hypothesis"

https://www.jstor.org/stable/2352347

Hodrick and Srivastava (1984) "An Investigation of Risk and Return in Forward Foreign Exchange"

https://www.sciencedirect.com/science/article/pii/0261560684900275

Koijen, Moskowitz, Pedersen, and Vrugt (2018) “Carry”
https://www.sciencedirect.com/science/article/abs/pii/S0304405X17302908

Trend Following:

Moskowitz, Ooi, and Pedersen (2011) “Time Series Momentum”
https://ssrn.com/abstract=2089463

[5] The factor portfolios have liquidity-weighted sub-portfolios that are built within the following 6 regions: Developed and Emerging versions in the Americas, Europe, and Asia-Pacific.

[6] See recommendations for additional academic literature on lasso regression at the end of this FAQ.

This document highlights certain aspects of this analytic. As an overview, it does not discuss all material facts or assumptions. Please see Important Disclosure and Disclaimer Information.