MSCI FaCS METHODOLOGY

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INTRODUCTION

Factors are important systematic sources of risk and return in equity portfolios. They have been documented extensively in academic research and are used widely in active portfolio management. Recently, factor indexes have also been developed to provide a transparent and efficient method to seek exposure to factors. Given the pervasive use of factors in the active investment process and the growing popularity of factor investing through indexed strategies, a standard approach is needed for defining factors and evaluating the factor characteristics of portfolios.

We introduce MSCI FaCS, a classification standard and framework for analyzing and reporting style factors in equity portfolios. The standard is based on the factor structure in the latest global Barra equity factor risk model, the Barra Global Total Market Equity Model for Long-Term Investors (GEMLT, Morozov, 2016). The standard organizes the 16 style factors of GEMLT into eight factor groups – Value, Size, Momentum, Volatility, Quality, Yield, Growth and Liquidity.

MSCI FaCS creates a common language and definitions around style factors, for use by asset owners, managers, advisors, consultants and investors. Managers can use the framework to analyze and report factor characteristics, while investors and consultants can use the data to compare funds and monitor exposures over time using common definitions.

In the following sections, we describe MSCI FaCS from the bottom up – from how we construct individual factors and descriptors, to how we combine them into groups. We also explain how to interpret the exposures at both the security and portfolio level.

CONSTRUCTION OF A FACTOR

All style factors in the Barra GEMLT and other Barra fundamental equity factor models are constructed in five primary steps:

1. Calculate descriptor values. Raw values of each descriptor going into the factor are calculated.
2. Drop extreme outliers and winsorize[1] the remaining values to be within three standard deviations from the mean.
3. Standardize the raw descriptor values, so that each descriptor has a market-cap-weighted mean of zero and unit standard deviation.

[1] Winsorization limits extreme values in the data to reduce the effect of outliers.

4. Linearly combine descriptors. The standardized scores of the descriptors are linearly combined, with weights that are determined by a combination of intuition and statistical metrics from the factor model.
5. Re-standardize the descriptor combination (the factor) to have a market cap-weighted mean of zero and unit standard deviation.

We first calculate the raw descriptor values. This process can be as simple as taking the ratio of two numbers or can be considerably more complicated, such as conducting a regression or other processing of a multi-year time series of a security. The next step is to remove extreme outliers and winsorize the remaining values. This involves calculating a robust mean and standard deviation of the raw descriptor distribution, which are determined iteratively. We use the robust mean and standard deviation to winsorize the descriptor values to be within three standard deviations of the mean. Outlier removal and winsorization aim to prevent extreme values from having an undue influence on the final standardized descriptor values.

After removing outliers and winsorizing, we standardize the descriptor values to have a market-cap-weighted mean of zero and an equal-weighted standard deviation of one. This completes the standardization process. The Barra GEMLT model estimation universe, which is based on the MSCI ACWI IMI universe, is used to determine the parameters in the winsorization and standardization processes, but they are applied to the entire coverage universe.

We use the market-cap-weighted mean to standardize descriptor values, so that a well-diversified cap-weighted global index, such as MSCI ACWI IMI, has approximately zero exposure to all style factors. For the standard deviation, however, we use equal weighting to prevent large-cap constituents from having an undue influence on the overall scale of the exposures.

In GEMLT, descriptors and factors based on price, such as momentum, beta and residual volatility, are standardized on the global universe. Descriptors based on fundamental data, such as book-to-price, profitability and earnings yield, are standardized with a country-specific mean but a global standard deviation. We find that using country-specific standard deviations can result in undesirable and unintended instability in the descriptor values, particularly for countries with small numbers of stocks. We standardize fundamental descriptors with a country-specific mean because values of some fundamental descriptors tend to be systematically low or high in some countries. In the end, each descriptor is standardized to a common scale, which makes combining descriptors into a factor straightforward.

In creating each factor, we seek to incorporate and combine similar descriptors. We examined the academic and practitioner literature, and conducted our own research to identify descriptors that complement each other and that thoroughly capture a theme. For example, the profitability factor in the quality group contains four descriptors, each of which captures slightly different elements of profitability – asset turnover, gross margin, gross profit relative to assets and return on assets. Although each of these descriptors has significant explanatory power on its own, naively including them as separate factors in a factor model may lead to serious multi-collinearity problems. Combining these descriptors into a single style factor overcomes this difficulty, creates a factor that is more comprehensive and powerful, and also leads to a more parsimonious factor structure.

To calculate a factor, we linearly combine the appropriate standardized descriptors using a weighting scheme that is Bayesian in nature and determined by a combination of intuition and statistics. Our starting point is always equal weighting. However, we will modify the weights accordingly if we identify strong reasons why we should deviate from equal weighting. Such adjustments could stem from examining factor volatilities, t-stats, information ratios (IRs), marginal added explanatory power, our intuition behind the “essence” of a particular style factor and investors’ expectations, or other measures. When deviating from equal weighting, we are conservative, and keep the weights to round numbers. We used the same process for setting the weights in the MSCI FaCS factor groups.

The final step is to re-standardize the descriptor combination to have a market-cap-weighted mean of zero and unit standard deviation. This re-standardized descriptor combination is then the factor.

SECURITY AND PORTFOLIO LEVEL FACTOR EXPOSURES

Given that each factor is standardized, the concept of factor exposure for a security is straightforward. A security's exposure represents how far away from the market-cap-weighted average a given security is, and the units are in number of standard deviations. Values above zero indicate the security has a value higher than the market-cap-weighted average on the given factor, and exposures below zero indicate the security scores below that average on the given factor. For example, an exposure of +2 indicates that the security is two standard deviations higher than the average for the particular factor.

Calculating the exposure (to a descriptor, factor or factor group) of a portfolio is also straightforward. The exposure of a portfolio is simply the weighted average exposure of all the holdings in the portfolio, where the weights are identical to the portfolio weights.

When considering the magnitude of the exposure and identifying what would constitute a "large" or "significant" exposure for a portfolio, and to identify when exposures are likely to be intentional and not likely to occur simply from a random selection of securities, one can use the statistics of combinations of identically distributed independent random variables. Expressing these concepts mathematically, the portfolio exposure of n stocks is defined as:

Portfolio exposure = $\sum_{i=1}^{n} w_i X_i$

where the w_i are the individual stock weights and the X_i are the individual stock exposures.

Assuming stock exposures are independent and have identical distributions, if we take the variance of the above equation we get:

Var(Portfolio exposure) = $\sum_{i=1}^{n} w_i^2 Var(X_i) = \sum_{i=1}^{n} w_i^2$

since Var(X_i) = 1

For an equal-weighted portfolio of n stocks (each stock has weight = 1/n), the variance of the portfolio exposure is simply:

$$\sum_{i=1}^{n} \left(\frac{1}{n}\right)^2 = n\left(\frac{1}{n}\right)^2 = \frac{1}{n}$$

The standard deviation of an equal-weighted portfolio of n stocks is then $\frac{1}{\sqrt{n}}$

We can also generalize this result to a portfolio with arbitrary security weights using a measure of the effective number (EN) of securities in the portfolio based on the Herfindahl-Hirschman Index (HHI). The effective number of stocks is a measure of portfolio concentration and ranges between 1 (for a single stock) and the number of stocks in the portfolio (for an equal-weighted portfolio), and is given by the inverse of the sum of squares of the weights of the portfolio:

EN = 1 / $\sum_{i=1}^{n} w_i^2$

Thus, the variance of a portfolio exposure is simply 1/EN. For a typical portfolio with EN ~100, this implies a portfolio standard deviation of exposure of 0.1. For such a portfolio, a two sigma exposure would be about 0.2, and therefore we adopt the threshold of 0.2 as constituting a “significant” portfolio exposure for a typical portfolio. In a well-diversified portfolio, exposures outside of [-0.2, 0.2] are unlikely to have been produced by a random selection of securities, but can readily be generated, and are most likely to have been generated, by intentional positioning and tilts.

CONSTRUCTION OF MSCI FaCS

In constructing MSCI FaCS, we sought to combine factors of a common theme together. The classification standard structure is displayed in Exhibit 1. In assigning the weights, we used the same methodology as when assigning weights to the descriptors of a factor – a combination of factor statistics and our intuition of the factor group. The factor statistics we explored included the factor returns, volatilities, information ratios (IRs), t-statistics and R^2 from cross-sectional regressions. Definitions of these statistics are provided in the Appendix.

Exhibit 1. Structure of MSCI FaCS

VALUE	SIZE	MOMENTUM	QUALITY	YIELD	VOLATILITY	GROWTH	LIQUIDITY
Book-to-Price (30%) Earnings Yield (60%) LT Reversal (10%)	Mid Cap (10%) Size (90%)	Momentum (100%)	Leverage (12.5%) Investment Quality (25%) Earnings Variability (12.5%) Earnings Quality (25%) Profitability (25%)	Dividend Yield (100%)	Beta (60%) Residual Volatility (40%)	Growth (100%)	Liquidity (100%)

The 16 factors of Barra GEMLT are combined into eight factor groups.

When assigning weights to factors in each factor group, we put more emphasis on factor returns and IRs for Systematic Equity Strategy (SES)[2] factor groups (quality and value), and more emphasis on factor volatilities, t-stats and cross-validated (CV) R^2 gain for the non-SES factor groups (i.e., the size and volatility factor groups).

Within the quality group, for example, our multi-variate cross-sectional regression statistics, provided in Exhibit 2, also show that the three SES quality factors of earnings quality, investment quality and profitability generated significantly higher factor returns and IRs than the non-SES quality factors of leverage and earnings variability. Variants of the SES quality factors have also been extensively discussed in the academic literature – see Sloan (1996) for the earnings quality factor, and Fama and French (2015) and Novy-Marx (2013) for the profitability and investment quality factors – as providing explanatory power in the cross section of stock returns and generating risk premia over long horizons.

Exhibit 2 shows that the non-SES factors generated t-stats, factor volatilities and CV R^2 gains comparable to those of the SES quality factors. These results demonstrate that the non-SES quality factors added explanatory power to the cross section of security returns, even though their annualized factor returns were not as large as those of the SES quality factors.

Therefore, we assigned a 25% weight to each of the three SES quality factors and a -12.5% weight to each of the other two quality factors.[3]

[2] See Bayraktar (2013) for a detailed description of SES factors.

[3] Leverage and earnings variability received negative weight because *low* leverage and *low* earnings variability are associated with *high* quality companies.

Exhibit 2. Factor Statistics from Multi-variate Cross-sectional Regressions in GEMLT

Factor Group	Factor	Mean |t-stats|	Annual Return (%)	Annual Volatility (%)	IR	CV R^2 Gain (bp)	Weight in FaCS group
Value	Earnings Yield	2.17	3.64	1.74	2.09	3.21	**60%**
	Book-to-Price	2.03	2.18	1.59	1.38	2.38	**30%**
	LT Reversal	1.96	1.42	1.36	1.05	1.69	**10%**
Size	Size	4.32	-0.05	2.26	-0.02	19.92	**90%**
	Mid Cap	2.21	0.04	1.48	0.03	3.44	**-10%**
Quality	Leverage	1.70	-0.18	1.01	-0.18	1.11	**-12.5%**
	Earnings Var	1.71	-0.37	1.13	-0.32	0.99	**-12.5%**
	Profitability	1.67	1.17	1.12	1.05	0.49	**25%**
	Earnings Qual	1.47	1.41	0.81	1.73	0.03	**25%**
	Investment Qual	1.48	1.16	0.82	1.42	0.12	**25%**
Volatility	Beta	6.99	0.20	5.93	0.03	44.18	**60%**
	Residual Vol	3.94	-2.28	3.05	-0.75	13.18	**40%**
Momentum	Momentum	4.74	4.38	3.54	1.24	22.69	**100%**
Yield	Div Yield	1.85	0.91	1.26	0.72	1.81	**100%**
Growth	Growth	1.72	0.89	1.12	0.80	0.78	**100%**
Liquidity	Liquidity	3.18	-1.13	2.15	-0.53	8.33	**100%**

Sample period is 1995 to 2016.

For the factor groups composed of more than one factor – value, size, volatility and quality – we re-standardize the factor combination using the same standardization methodology as for the individual factors. Each factor group is standardized to have market-cap-weighted mean of zero and unit equal-weighted global standard deviation. The volatility group is standardized using a global mean while the size, value and quality groups are standardized using a country-specific mean and a global standard deviation.

As an example of the MSCI FaCS calculation, we evaluated Microsoft Corp.'s exposure to the quality factor group. On Sept. 29, 2017, Microsoft's factor exposures for profitability, investment quality, earnings quality, earnings variability and leverage were 0.169, -0.055, 0.403, -0.442, and 0.289, respectively. Combining these factor exposures with the quality weights listed in Exhibit 2 gives us the raw, pre-standardized quality group combination:

$$0.25*0.169 + 0.25*(-0.055) + 0.25*0.403 - 0.125*(-0.442) - 0.125*0.289 = 0.148$$

For all U.S. companies in the MSCI ACWI Investable Market Index (IMI), the raw, pre-standardized quality group combination had a market-cap- weighted mean of 0.000 and a global equal-weighted standard deviation of 0.513 on this date. Thus, our final MSCI FaCS quality group exposure for Microsoft on this date was 0.288, calculated as

(0.148 – 0.000)/0.513

ANNUAL REVIEWS

MSCI FaCS is based on an extensive, yet parsimonious, set of factors that explain global long-term risk and risk premia. We recognize that other factors do exist, such as those that are more regional or narrow in focus and/or short-term in nature.

Indeed, a number of other factors and categories of factors exist in regional, country, and short-term trading versions of Barra models. For example, trading versions of some Barra models contain high-turnover sentiment factors constructed from analyst revisions, news, short interest and/or options data. Further, the latest European Barra model includes an ESG factor, as today we find it to be an important contributor to explaining risk and return in Europe. While it is not currently included in GEMLT or MSCI FaCS, these models are regularly updated.

We expect that just like GICS®,[4] MSCI FaCS will evolve slowly over time. Factors or factor groups may be added, modified or removed. We will conduct annual reviews of the standard to ensure it accurately reflects a robust set of factors and factor groups that explain global long-term equity risk and return at a given point in time.

[4] GICS is the global industry classification standard jointly developed by MSCI and Standard & Poor's.

REFERENCES

Bayraktar, M., S. Radchenko, K. Winkelmann and P. Zangari. (2013). “Employing Systematic Equity Strategies: Distinguishing Important Sources of Risk from Common Sources of Return.” MSCI Research Insight.

Fama, E. and K. French. (2015). “A Five-factor Asset Pricing Model.” *Journal of Financial Economics*, Vol. 16, pp. 1-22.

Morozov, A., S. Minovitsky, J. Wang and D. Barrera. (2016). “Barra Global Total Market Equity Model for Long Term Investors, Empirical Notes.” MSCI Model Insight.

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

Rao, A., R. A. Subramanian and D. Melas. (2017). “Bridging the Gap: Adding Factors to Passive and Active Allocations.” MSCI Research Insight.

Roisenberg, L., R. A. Subramanian and G. Bonne. (2017). “Anatomy of Active Portfolios: How Factor Exposures Affect Fund Performance.” MSCI Research Insight.

Sloan, R. (1996). “Do Stock Prices Fully Reflect Information in Accruals and Cash Flows about Future Earnings?” *The Accounting Review,* Vol. 71, pp. 289-315.

APPENDIX

DEFINITIONS OF FACTOR STATISTICS

Annual Factor Return. Component of security returns attributed to a factor as determined by a multi-variate, cross-sectional regression, accounting for the market factor, other style factors, industries and countries, expressed on an annualized basis. It can be interpreted as the return to a factor given a unit exposure to the factor and zero exposure to all other factors.

Annual Factor Volatility. Standard deviation of factor return, expressed on an annualized basis. A high factor volatility indicates that at times stocks make large moves due to the factor, indicating that the factor is an important contributor to explaining the cross section of security returns.

Factor Information Ratio (IR). Annualized factor return divided by annualized factor volatility.

Mean |t-stat|. Average of the absolute value of the t-statistic of the regression coefficient to a factor in the multi-variate cross-sectional regressions.

CV R^2 Gain. Gain in R^2 in multi-variate, cross-sectional regressions due to adding the factor, when all other factors are present in the regression, as determined through hold-one-out cross validation (CV).

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