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Finding Smart Beta in the Factor Zoo

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Factors are becoming so numerous and exotic that John Cochrane referred to the collection as a zoo.[1] While the concept is entertaining, the proliferation of factors is deeply troubling. The sheer number of factors suggests that it's better to have more factors than less, but how can investors determine how to use factors in their equity portfolios? The options are endless, particularly given the smart beta movement under way today. We believe one cannot make intelligent choices regarding smart betas without first understanding factors and their role in investment portfolios. Luckily for investors, most so-called factors can be ignored.

> *"Luckily for investors, most so-called factors can be ignored."*

KEY POINTS

1. The purported discovery of many new anomalies and the consequent proliferation of supposedly uncorrelated factors in recent years raises questions about the quality of financial research.
2. We find that the value, low volatility, and momentum anomalies are very significant; the market and illiquidity factors are significant; and other asserted factors, including various definitions of quality, are insignificant.
3. Among other characteristics, a factor is more likely to generate a return premium out-of-sample if it has survived over time, works outside the United States, stands up to minor definitional variations, has a credible explanation, and exceeds a higher-than-usual t-stat threshold to adjust for data-snooping.

Factor Proliferation

When we were in the Ph.D. program at UCLA, we were taught the four-factor model in our asset pricing class. The world was simple; there were the market risk factor and the value, small-cap, and momentum return factors.[2] The three non-market factors carried juicy return premia that could be had by investors willing to diversify into non-market exposures and exploit retail investors' behavioral biases.

Fifteen years later, we are shocked to learn that some quant shops now use an 81-factor model to build equity portfolios. This inflation in factors has certainly made us feel inadequate and has potentially eroded the real value of our paper diploma. Understandably, we are concerned with the relentless onslaught of shiny, exciting, and sexy new factors introduced by bright-eyed, bushy-tailed young financial engineers.[3]

Frankly, we expected the number of "accepted" factors to decrease rather than explode over time. We expected that at least one of the three documented anomalies would be revealed as a fluke—a data artifact that would disappear with better quality international data and with additional decades of out-of-sample data following the original discovery.

Indeed, that is what we have seen. The small-cap anomaly has not been observed in the United States since the early 1980s and does not exist outside the U.S. dataset (**Table 1**). This lack of "robustness" out-of-sample led Tyler Shumway and Vincent Warther to re-examine the small-cap anomaly; they concluded that it was likely driven by a mistake in how researchers treated missing data for delisted stocks. Apparently, missing returns for delisted stocks in the CRSP database created a systematic bias in the computed returns for small stocks, which are more likely to face delisting. When this bias is adjusted for, the small-cap anomaly is no longer observed (Shumway and Warther, 1999).

Oddly, the nullification of the small-cap anomaly has received scant notice. At the same time, between academia and the

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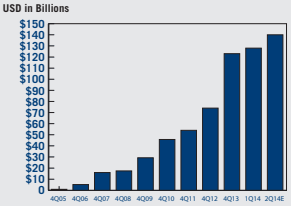

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Table 1. Small-Cap Anomaly

Region	Small-Cap Sharpe Ratio Improving Risk Characteristics	Large-Cap Sharpe Ratio	*P*-value of Sharpe Ratio Difference (Significant if below 5%)	Significant (Yes/No)
U.S.	0.40	0.41	83.73%	No
U.S. (post Banz (1981))	0.46	0.52	50.54%	No
U.K.	0.30	0.39	41.87%	No
Europe x U.K.	0.33	0.29	58.83%	No
Japan	−0.01	−0.02	94.19%	No

The time period for the United States is 1967–2013, and for the United Kingdom, Europe excluding U.K., and Japan, 1987–2013. The small-cap anomaly was documented in Banz (1981); we highlight the U.S. post-publication results for the period 1982–2013.

The small-cap anomaly is the empirical finding that the stocks of companies with small market capitalizations outperform large-cap stocks. We used the Fama and French (1993) approach, standard in the academic literature, to construct the portfolios.

The difference in the *P*-values of Sharpe ratios represents the probability that the Sharpe ratio of the small-cap and large-cap portfolios are from the same distribution. A *P*-value below 5% means the two Sharpe ratios are significantly different from each other. In this case all the values are well above 5%. The Sharpe ratios for small-cap stocks are no better than for large-cap stocks.

Source: Research Affiliates using CRSP/Compustat and Worldscope/Datastream data.

investment industry, the mining of new equity anomalies has yielded a great many new return factors that offer exotic and diversifying premia. Today, quantitative managers and smart beta solution providers peddle breathtaking Sharpe ratios from back-tested equity portfolios, which optimally hold uncorrelated "pure" factors. As providers rush to outdo each other, the number of shiny new factors and the resulting portfolio Sharpe ratios have both grown improbably large.

We can completely understand the providers' incentive to "factor-proliferate." Equally, we can sympathize with the investors' desire to believe that there might really be 81 unique factors which can be combined to provide an equity portfolio with a Sharpe ratio of 2. We have seen this very same phenomenon in the "alpha" space. Managers, consultants, and investors alike dream that lush dream of combining diversifying alpha portfolios to create an equity core with an information ratio of 2. For those of us who are skeptical of "alphas," this is our chance to dream that same dream in the smart beta space. Except, of course, we get to invoke the arbitrage pricing theory (APT) framework and throw around big words like multi-factors and optimization, which gives our version an added air of intellectual rigor and authority.

Now, in fairness to our academic colleagues and professors, we were warned. Recognizing the dangerous combination of cheap computing power and overzealous young finance Ph.D. students, our professors explained that if one runs 10,000 back-tests, one is bound to discover a few incredible factors which generate huge Sharpe ratios. These "data-mined" factors will unfortunately offer no future premia. Recognizing further that Ph.D. students tend to believe everything they read in finance journals, our professors quickly added that with 10,000 academics globally, each running one honest back-test a year, we would similarly end up with "data-snooped" factors, reported in top journals, which would have no greater probability of delivering future premia.[4] The first lesson is generally well understood in our industry; the second lesson is less widely understood. Now, given the proliferation in factors, academia is increasingly turning up the volume to warn against "factor" proliferation.

A Zoo of Factors

Perhaps the proliferation of new factors has hit the tipping point. McLean and Pontiff (2013) re-examined 82 factors published in tier-one academic journals. They were only able to replicate the reported results for 72 of them; at least 10 out of 82 factors were artifacts of reporting mistakes in the databases, which have now been corrected. Levi and Welch (2014) took the kitchen-sink approach and examined 600 factors from both the academic and practitioner literature. They found that 49% of the factors produced zero to negative premia out-of-sample, suggesting that investing based on the identified factors is only ever so slightly better than tossing coins. Of course, net of transaction and management fees, tragically, you will likely do worse than a monkey throwing darts.

Cam Harvey, past editor of the *Journal of Finance*, with co-authors Yan Liu and Heqing Zhu, studied 315 factors from top journal articles and highly regarded working papers. Adjusting for "data-snooping," Harvey, Liu, and Zhu (2014) conclude that only a handful of the factors in the zoo are actually statistically significant. Using this adjustment technique, our old friends the value, low volatility, and momentum anomalies are very significant; well-understood risk factors like market and illiquidity are significant;

and small-cap is insignificant, as are many of the newer and more exotic factors (such as idiosyncratic volatility and various definitions of quality[5] like default risk, ROE, and ROI).

So far, many of the re-examinations of equity factors have used U.S. data exclusively. Our research on factors used both U.S. and non-U.S. data to examine robustness. Our results corroborate what others have concluded using U.S. data. In **Table 2**, we find that value and low beta are two anomalies which also work in Europe and Japan, while small-cap and other factors such as ROE, profitability, etc., do not work outside the United States. This finding argues for the likelihood that many popular factors are more artifacts of U.S. data than real sources of return premia.

> *"The small-cap anomaly has not been observed in the United States since the early 1980s and does not exist outside the U.S. dataset."*

Table 2. International Evidence of Factor Performance

Region	Sharpe Ratios		*P*-value of Sharpe Ratio Difference (Significant if below 5%)	Significant (Yes/No)
	Value	Growth		
U.S.	0.49	0.23	0.55%	Yes
U.K.	0.40	0.27	29.53%	No
Europe x U.K.	0.41	0.19	4.96%	Yes
Japan	0.27	−0.23	0.00%	Yes
	Low Beta	High Beta		
U.S.	0.67	0.14	0.00%	Yes
U.K.	0.50	0.19	0.38%	Yes
Europe x U.K.	0.57	0.18	0.02%	Yes
Japan	0.13	−0.08	4.52%	Yes
	High Momentum	Low Momentum		
U.S.	0.58	0.05	0.00%	Yes
U.K.	0.65	−0.04	0.00%	Yes
Europe x U.K.	0.71	−0.02	0.00%	Yes
Japan	0.03	−0.04	57.72%	No
	High Gross Profitability	Low Gross Profitability		
U.S.	0.43	0.33	14.64%	No
U.K.	0.42	0.27	6.73%	No
Europe x U.K.	0.43	0.23	0.41%	Yes
Japan	0.06	−0.05	24.83%	No
	High ROE	Low ROE		
U.S.	0.38	0.29	14.34%	No
U.K.	0.42	0.29	7.37%	No
Europe x U.K.	0.35	0.25	7.73%	No
Japan	−0.01	−0.05	57.49%	No

The time period for the United States is 1967–2013; for the United Kingdom, Europe excluding U.K., and Japan, 1987–2013.

The *P*-value of Sharpe ratio differences represents the probability that the Sharpe ratios of the portfolios are from the same distribution. A *P*-value below 5% means that the two Sharpe ratios are significantly different from each other (at the 95% confidence level).

The value anomaly, documented in Basu (1983), is the finding that the stocks of companies with high book-to-market ratios (value) outperform the stocks of the companies with low ratios (growth). To construct the value and growth portfolios we follow again the Fama and French (1993) approach. In this particular study the U.K. sample is not statistically significant, most likely reflecting the randomness inherent in any anomalous outcome.

The low beta anomaly, first documented in Haugen and Heins (1975), is the finding that stocks with higher systematic risk do not outperform low-risk stocks. We follow the Frazzini and Pedersen (2014) approach for the construction of the long (low beta) and short (high beta) portfolios. In all four regions the low beta stocks provide significantly better risk/reward characteristics.

The momentum anomaly, first documented in Jegadeesh and Titman (1993), is the finding that recent winner stocks outperform recent loser stocks. In constructing the momentum factor we follow the Fama and French (2008) approach. Because momentum appears to work in many other asset classes, it is generally believed that the lack of a momentum premium in Japan is an outlier rather than evidence of a lack of robustness.

Gross profitability is the version of a "quality" factor that is most common in academic circles. Following Novy-Marx (2013), we use the gross-profitability-to-assets ratio to define the factor. Generally we observe little international evidence of a robust anomaly.

Source: Research Affiliates using CRSP/Compustat and Worldscope/Datastream data.

Again, we find value, low beta, and momentum to be robust… and we find other factors show significantly less robustness.

ROE, defined as the earnings-to-book-value ratio, is frequently used in practitioner settings to identify high-quality stocks. There is very little evidence of any premium associated with profitability.

> *"One cannot make intelligent choices regarding smart betas without first forming a view on which factors are 'for real.'"*

To further examine factor robustness, we explored the change in the measured factor premium due to small changes in the factor definition/construction. For example, we changed the value signal from book-to-price to earnings-to-price and changed the momentum signal from a 12-month look-back to a 6-month look-back. In **Table 3**, we report the impact on the factor premium arising from reasonable variations in factor definitions.

Table 3. Factor Responsiveness to Variations in Definitions

Factor	Sharpe Ratios		*P*-value of Sharpe Ratio Difference (Significant if below 5%)	Significant (Yes/No)
	Value	Growth		
Book-to-price	0.49	0.23	0.55%	Yes
Earnings-to-price	0.56	0.22	0.02%	Yes
Cashflow-to-price	0.53	0.22	0.11%	Yes
Dividends-to-price	0.61	0.24	0.03%	Yes
	Low Beta	High Beta		
Low Beta	0.67	0.14	0.00%	Yes
Low Volatility	0.64	0.03	0.00%	Yes
Low Beta 3 year	0.61	0.15	0.00%	Yes
Low Volatility 3 year	0.62	0.11	0.00%	Yes
	High Momentum	Low Momentum		
-2 to -12 months, 1 mo. hold	0.58	0.05	0.00%	Yes
-2 to -12 months, 3 mo. hold	0.51	0.08	0.01%	Yes
-2 to -6 months, 1 mo. hold	0.45	0.15	0.29%	Yes
-1 to -12 months, 1 mo. hold	0.54	0.11	0.02%	Yes
	High Quality	Low Quality		
Gross Profitability	0.43	0.33	14.64%	No
Return on Equity	0.38	0.29	14.34%	No
Gross Margins	0.39	0.37	79.92%	No
Book Leverage	0.38	0.34	46.53%	No

All simulations are for the United States in the period 1967–2013.

The *P*-value of Sharpe ratio differences represents the probability that the Sharpe ratios of the long and short portfolios are from the same distribution. A *P*-value below 5% is required to conclude that two Sharpe ratios are significantly different from each other (with 95% confidence).

After Fama and French (1992) and (1993), book-to-price became the generally accepted definition of the value factor. However, when defined by earnings-to-price, cash flow-to-price, or other fundamentals-to-price ratios, the value factor still delivers a premium. In this particular sample the dividends-to-price ratio does not product statistically significant results. Nonetheless, in all four definitions value stocks (long) provide meaningfully better Sharpe ratios than growth stocks (short).

For the standard definition of low beta we used the Frazzini and Pedersen (2014) approach, in which variance and correlation are computed separately. They use a one-year window of daily observations for variance and a five year window for correlations. For an alternative definition, we used one year of volatility (rather than beta) to sort stocks into less risky (long) and more risky (short) portfolios. In the two other variations, we used three-year windows of daily returns to estimate beta and volatility.

The normal definition of momentum uses the past one year return skipping the first month to avoid short-term mean reversion. In the table we denote it by a look-back period of "–2 to –12 months." The standard holding period is one month. If the definition is moderately perturbed we still observe the premium.

To test the robustness of the quality factor we used alternate definitions of profitability: gross profitability (gross-profits-to-assets ratio), return on equity (earnings-to-book ratio), and gross margins (earnings-to-sales ratio). We also used one definition that does not reflect profitability: book leverage (book value of equity-to-assets). This group shows little robustness to variations in factor definitions.

Source: Research Affiliates using CRSP/Compustat and Worldscope/Datastream data.

Smart Beta in the Factor Zoo

The smart beta movement makes it particularly important to understand this zoo of factors and how best to capture factor premia in an equity portfolio.

Equity smart beta indices are often described as portfolios which tilt toward various (combinations of) equity factors. Thus, one cannot make intelligent choices regarding smart betas without first forming a view on which factors are "for real" and which are data-mined or data-snooped. The academic literature provides useful guidance on decision heuristics that investors can lean on to ascertain whether a factor truly contains a return premium. Summarizing from the studies cited above, the following set of characteristics would constitute evidence of an actual factor:

1. The factor was discovered many decades ago; it has survived numerous database revisions as well as extensive out-of-sample data.
2. The factor has been vetted, replicated, and debated in top academic journals over decades.
3. The factor works in non-U.S. countries and regions.
4. The factor premium does not change materially due to minor variations in the factor definition/construction.
5. The factor has a credible reason to offer a persistent premium
   a. It is related to a macro risk exposure, or
   b. It is related to a deep-rooted behavioral bias that is present in a meaningful fraction of investors, or
   c. It is related to an institutional feature that cannot be easily changed.
6. The factor exceeds a more stringent *t*-stat threshold of 3.5 (preferably 4.0) instead of 2.0 to adjust for data-snooping and other biases evidenced by the recent explosion in factor proliferation.

Once investors have determined which factors they actually believe in, they then need to figure out how best to capture the factor premia in their equity portfolios. For example, which factor premia can be accessed in low cost, transparent, and formulaic smart beta indices and which are better accessed through high-fee actively managed products? It is generally believed that the momentum premium is best accessed through skilled active managers, who can trade carefully and get ahead of the crowd in buying and selling, given the short holding horizon and liquidity-taking nature of the strategy. If that hypothesis is true, a smart beta index chassis may fail to effectively capture the momentum premium.

> *"Which factor premia can be accessed in smart beta indices and which are better accessed through actively managed products?"*

Similarly, an illiquidity premium requires active managers with either market making capabilities or sophisticated trading skill, so an index replication approach is unlikely to be successful in capturing this premium. High-fee active management may be necessary. On the other hand, value and low beta strategies require no more than 10% and 20% annual turnover, respectively, and have very slow signal decay. These two premia are well-suited to be captured in low cost smart beta index products.

In determining an appropriate core equity portfolio, investors need to consider their measure of risk. For example, is tracking error to a cap-weighted policy benchmark the measure of risk? And, relatedly, is the value-added return relative to a benchmark the primary measurement of success? Or is portfolio volatility the dominant risk measure with absolute return the key success criterion?

Once investors define their portfolio "bull's-eye," it is relatively straightforward to determine which mix of smart beta index products and active products would lead to the desired equity holdings.

In Closing

We have become what we hated when we were in graduate school. We are now the curmudgeonly party poopers who scoff at the latest and greatest new factors discovered by enthusiastic financial engineers. We like to think we have become wiser and thus developed a healthy skepticism, not merely grown more cynical of academia and the industry. Fortunately, we seem to be in good company; the titans of academia have similarly grown weary of the factor proliferation, which has created a dizzying zoo of factors. The sheer variety seems to serve the purposes of publication for tenure and product creation more than better investor outcomes. We will gladly bet a simple blend of market, value, low beta, and momentum exposures against anyone's optimized 81-factor portfolio.

Endnotes

1. John Cochrane of the University of Chicago coined the term "zoo of factors" in his 2011 presidential address to the American Finance Association.
2. We use risk factor to mean factors whose premia are compensation for risk and behavioral factors to mean factors whose premia are excess returns from exploiting behavioral mistakes. We use return factor to mean factors which may be behavioral or risk in nature. The literature remains divided on whether factors like value and momentum are driven by risk or behavioral biases.
3. Harvey, Liu, and Zhu (2014) reported that 59 new factors were discovered between 2010 and 2012.
4. The phrase "data snooping" was coined by Lo and MacKinley (1990).
5. We have argued elsewhere that quality is not a factor in itself. On the other hand a value investor can benefit from knowing the financial and economic health of a company. See "The Moneyball of Quality Investing," Research Affiliates, June 2014.

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Performance Update

FTSE RAFI® Equity Index Series*

TOTAL RETURN AS OF 6/30/14	BLOOMBERG TICKER	YTD	12 MONTH	ANNUALIZED 3 YEAR	ANNUALIZED 5 YEAR	ANNUALIZED 10 YEAR	10 YEAR STANDARD DEV.
FTSE RAFI® All World 3000[1]	TFRAW3	7.43%	26.71%	10.97%	15.77%	10.22%	18.56%
MSCI All Country World[2]	GDUEACWF	6.50%	23.58%	10.85%	14.88%	8.02%	16.61%
FTSE RAFI® Developed ex US 1000[3]	FRX1XTR	6.77%	29.20%	7.79%	12.24%	8.59%	20.27%
MSCI World ex US[4]	MLCUWXUG	5.76%	24.39%	8.10%	12.20%	7.69%	18.24%
FTSE RAFI® Developed ex US Mid Small[5]	TFRDXUSU	7.83%	28.06%	8.58%	14.85%	10.74%	18.70%
MSCI World ex US Small Cap[6]	GCUDWXUS	7.06%	30.01%	9.15%	15.72%	9.13%	20.08%
FTSE RAFI® Emerging Markets[7]	TFREMU	7.01%	14.71%	−2.17%	8.18%	14.61%	24.22%
MSCI Emerging Markets[8]	GDUEEGF	6.32%	14.68%	−0.06%	9.58%	12.30%	23.77%
FTSE RAFI® 1000[9]	FR10XTR	7.66%	25.12%	17.45%	21.48%	9.71%	17.16%
Russell 1000[10]	RU10INTR	7.27%	25.35%	16.63%	19.25%	8.19%	15.00%
S&P 500[11]	SPTR	7.14%	24.61%	16.58%	18.83%	7.78%	14.70%
FTSE RAFI® US 1500[12]	FR15USTR	3.80%	25.55%	15.90%	23.53%	11.31%	21.76%
Russell 2000[13]	RU20INTR	3.19%	23.64%	14.57%	20.21%	8.70%	19.73%
FTSE RAFI® Europe[14]	TFREUE	7.80%	38.03%	8.69%	12.89%	8.90%	22.87%
MSCI Europe[15]	GDDLE15	5.95%	29.95%	9.33%	13.71%	8.15%	20.00%
FTSE RAFI® Australia[16]	FRAUSTR	8.85%	21.04%	8.26%	16.52%	13.10%	23.89%
S&P/ASX 200[17]	ASA51	8.70%	21.09%	5.84%	14.69%	12.37%	24.24%
FTSE RAFI® Canada[18]	FRCANTR	11.94%	26.53%	5.89%	14.20%	12.76%	21.06%
S&P/TSX 60[19]	TX60AR	11.91%	27.08%	3.99%	11.57%	11.51%	21.24%
FTSE RAFI® Japan[20]	FRJPNTR	1.46%	10.26%	7.45%	7.22%	4.39%	16.14%
MSCI Japan[21]	GDDLJN	0.85%	10.12%	7.81%	7.42%	3.39%	15.78%
FTSE RAFI® UK[22]	FRGBRTR	5.05%	27.45%	11.89%	14.63%	7.80%	19.63%
MSCI UK[23]	GDDLUK	5.19%	26.61%	10.57%	14.51%	7.31%	17.85%

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Russell Fundamental Index Series**

TOTAL RETURN AS OF 6/30/14	BLOOMBERG TICKER	YTD	12 MONTH	ANNUALIZED 3 YEAR	ANNUALIZED 5 YEAR	ANNUALIZED 10 YEAR	10 YEAR STANDARD DEV.
Russell Fundamental Global Index Large Company[24]	RUFGLTU	7.31%	26.66%	12.18%	16.60%	10.35%	16.89%
MSCI All Country World Large Cap[25]	MLCUAWOG	6.29%	23.42%	10.89%	14.46%	7.70%	16.31%
Russell Fundamental Developed ex US Index Large Company[26]	RUFDXLTU	7.66%	30.67%	9.04%	13.06%	9.17%	18.36%
MSCI World ex US Large Cap[27]	MLCUWXUG	5.48%	24.30%	8.09%	11.92%	7.47%	18.14%
Russell Fundamental Developed ex US Index Small Company[28]	RUFDXSTU	7.09%	27.35%	11.07%	15.52%	10.64%	17.99%
MSCI World ex US Small Cap[6]	GCUDWXUS	7.06%	30.01%	9.15%	15.72%	9.13%	20.08%
Russell Fundamental Emerging Markets[29]	RUFGETRU	5.76%	17.50%	0.68%	11.41%	15.75%	23.72%
MSCI Emerging Markets[8]	GDUEEGF	6.32%	14.68%	−0.06%	9.58%	12.30%	23.77%
Russell Fundamental US Index Large Company[30]	RUFUSLTU	7.30%	24.41%	17.50%	20.92%	10.01%	15.55%
Russell 1000[10]	RU10INTR	7.27%	25.35%	16.63%	19.25%	8.19%	15.00%
S&P 500[11]	SPTR	7.14%	24.61%	16.58%	18.83%	7.78%	14.70%
Russell Fundamental US Index Small Company[31]	RUFUSSTU	6.41%	28.10%	16.57%	24.50%	12.50%	20.72%
Russell 2000[13]	RU20INTR	3.19%	23.64%	14.57%	20.21%	8.70%	19.73%
Russell Fundamental Europe[32]	RUFEUTE	7.86%	36.81%	9.07%	14.50%	10.16%	21.28%
MSCI Europe[15]	GDDLE15	5.95%	29.95%	9.33%	13.71%	8.15%	20.00%

**To see the complete series, please go to: http://www.russell.com/indexes/data/Fundamental/About_Russell_Fundamental_indexes.asp.

Performance Update

Fixed Income/Alternatives

TOTAL RETURN AS OF 6/30/14	BLOOMBERG TICKER	YTD	12 MONTH	ANNUALIZED 3 YEAR	ANNUALIZED 5 YEAR	ANNUALIZED 10 YEAR	10 YEAR STANDARD DEV.
RAFI® Bonds US Investment Grade Master[33]	—	5.62%	7.12%	6.05%	7.82%	6.22%	5.70%
ML Corporate Master[34]	C0A0	5.95%	7.98%	6.25%	8.27%	5.94%	5.84%
RAFI® Bonds US High Yield Master[35]	—	4.91%	10.10%	8.86%	13.40%	9.50%	9.41%
ML Corporate Master II High Yield BB-B[36]	H0A4	5.55%	11.35%	8.99%	12.58%	8.26%	9.11%
RAFI® US Equity Long/Short[37]	—	0.54%	3.61%	3.72%	7.68%	4.61%	11.25%
3-Month T-Bill[38]	GB3M	0.02%	0.04%	0.05%	0.08%	1.54%	0.54%
FTSE RAFI® Global ex US Real Estate[39]	FRXR	5.86%	16.07%	7.23%	14.20%	—	—
FTSE EPRA/NAREIT Global ex US[40]	EGXU	6.97%	11.69%	7.30%	12.26%	—	—
FTSE RAFI® US 100 Real Estate[41]	FRUR	16.61%	15.58%	12.14%	25.95%	—	—
FTSE EPRA/NAREIT United States[42]	UNUS	17.82%	13.47%	11.73%	23.63%	—	—
Citi RAFI Sovereign Developed Markets Bond Index Master[43]	CRFDMU	5.33%	8.87%	3.59%	5.15%	5.93%	7.18%
Merrill Lynch Global Governments Bond Index II[44]	W0G1	5.01%	6.62%	1.65%	3.70%	4.87%	6.54%
Citi RAFI Sovereign Emerging Markets Local Currency Bond Index Master[45]	CRFELMU	5.90%	2.74%	—	—	—	—
JPMorgan GBI-EM Global Diversified[46]	JGENVUUG	5.99%	3.91%	—	—	—	—

Sources and Method: All index returns are calculated using total return data from Bloomberg and FactSet. Returns for all single country strategies and Europe regional strategies are in local currency. All other returns are in USD. Annualized returns are geometrically linked returns, calculated using monthly data. Annualized standard deviation is calculated using sample standard deviation and monthly return data.

Definition of Indices

(1) The FTSE RAFI® All World 3000 Index is a measure of the largest 3,000 companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value), across both developed and emerging markets.

(2) The MSCI All Country World Index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of developed and emerging markets.

(3) The FTSE RAFI® Developed ex US 1000 Index is a measure of the largest 1000 non U.S. listed, developed market companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value).

(4) The MSCI World ex US Index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of developed markets, excluding the United States.

(5) The FTSE RAFI® Developed ex US Mid Small Index tracks the performance of small and mid-cap companies domiciled in developed international markets (excluding the United States), selected and weighted based on the following four fundamental measures of firm size: sales, cash flow, dividends and book value.

(6) The MSCI World ex US Small Cap Index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of small cap developed markets, excluding the United States.

(7) The FTSE RAFI® Emerging Markets Index comprises the largest 350 Emerging Market companies selected and weighted using fundamental factors (sales, cash flow, dividends, book value).

(8) The MSCI Emerging Markets Index is an unmanaged, free-float-adjusted cap-weighted index designed to measure equity market performance of emerging markets.

(9) The FTSE RAFI® 1000 Index is a measure of the largest 1,000 U.S. listed companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value).

(10) The Russell 1000 Index is a market-capitalization-weighted benchmark index made up of the 1,000 highest-ranking U.S. stocks in the Russell 3000.

(11) The S&P 500 Index is an unmanaged market index that focuses on the large-cap segment of the U.S. equities market.

(12) The FTSE RAFI® US 1500 Index is a measure of the 1,001st to 2,500th largest U.S. listed companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value).

(13) The Russell 2000 is a market-capitalization weighted benchmark index made up of the 2,000 smallest U.S. companies in the Russell 3000.

(14) The FTSE RAFI® Europe Index is comprised of all European companies listed in the FTSE RAFI® Developed ex U.S. 1000 Index, which in turn is comprised of the largest 1,000 non U.S. listed developed market companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value).

(15) The MSCI Europe Index is a free-float adjusted market capitalization weighted index that is designed to measure the equity market performance of the developed markets in Europe.

(16) The FTSE RAFI® Australia Index is comprised of all Australian companies listed in the FTSE RAFI® Developed ex U.S. 1000 Index, which in turn is comprised of the largest 1,000 non U.S. listed developed market companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value).

(17) The S&P/ASX 200 Index, representing approximately 78% of the Australian equity market, is a free-float-adjusted, cap-weighted index.

(18) The FTSE RAFI® Canada Index is comprised of all Canadian companies listed in the FTSE RAFI® Developed ex U.S. 1000 Index, which in turn is comprised of the largest 1,000 non U.S. listed developed market companies, selected andweighted using fundamental factors; (sales, cash flow, dividends, book value).

(19) The S&P/Toronto Stock Exchange (TSX) 60 is a cap-weighted index consisting of 60 of the largest and most liquid (heavily traded) stocks listed on the TSX, usually domestic or multinational industry leaders.

(20) The FTSE RAFI® Japan Index is comprised of all Japanese companies listed in the FTSE RAFI® Developed ex U.S. 1000 Index, which in turn is comprised of the largest 1,000 non U.S. listed developed market companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value).

(21) The MSCI Japan Index is an unmanaged, free-float-adjusted cap-weighted index that aims to capture 85% of the publicly available total market capitalization of the Japanese equity market.

(22) The FTSE RAFI® UK Index is comprised of all UK companies listed in the FTSE RAFI® Developed ex U.S. 1000 Index, which in turn is comprised of the largest 1,000 non-U.S. listed developed market companies, selected and weighted using fundamental factors; (sales, cash flow, dividends, book value).

(23) The MSCI UK Index is an unmanaged, free-float-adjusted cap-weighted index that aims to capture 85% of the publicly available total market capitalization of the British equity market.

(24) The Russell Fundamental Global Index Large Company is a measure of the largest companies, selected and weighted using fundamental factors; (adjusted sales, retained cash flow, dividends + buybacks), across both developed and emerging markets.

(25) The MSCI All Country World Large Cap Index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of developed and emerging markets.

(26) The Russell Fundamental Developed ex US Large Company is a subset of the Russell Fundamental Developed ex US Index, and is a measure of the largest non-U.S. listed developed country companies, selected and weighted using fundamental factors; (adjusted sales, retained cash flow, dividends + buybacks).

(27) The MSCI World ex US Large Cap Index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of large cap-developed markets, excluding the United States.

(28) The Russell Fundamental Developed ex US Index Small Company is a subset of the Russell Fundamental Developed ex US Index, and is a measure of small non-U.S. listed developed country companies, selected and weighted using fundamental factors; (adjusted sales, retained cash flow, dividends + buybacks).

(29) The Russell Fundamental Emerging Markets Index is a measure of Emerging Market companies, selected and weighted using fundamental factors; (adjusted sales, retained cash flow, dividends + buybacks).

(30) The Russell Fundamental U.S. Index Large Company is a subset of the Russell Fundamental US Index, and is a measure of the largest U.S. listed companies, selected and weighted using fundamental measures; (adjusted sales, retained cash flow, dividends + buybacks).

(31) The Russell Fundamental US Index Small Company is a subset of the Russell Fundamental US Index, and is a measure of U.S. listed small companies, selected and weighted using fundamental measures; (adjusted sales, retained cash flow, dividends + buybacks).

(32) The Russell Fundamental Europe Index is a measure of European companies, selected and weighted using fundamental factors; (adjusted sales, retained cash flow, dividends + buybacks).

(33) The RAFI® Bonds US Investment Grade Master Index is a U.S. investment-grade corporate bond index comprised of non-zero fixed coupon debt with maturities ranging from 1 to 30 years issued by publicly traded companies. The issuers held in the index are weighted by a combination of four measures of their fundamental size—sales, cash flow, dividends, and book value of assets.

(34) The Merrill Lynch U.S. Corporate Master Index is representative of the entire U.S. corporate bond market. The index includes dollar-denominated investment-grade corporate public debt issued in the U.S. bond market.

(35) The RAFI® Bonds US High Yield Master is a U.S. high-yield corporate bond index comprised of non-zero fixed coupon debt with maturities ranging from 1 to 30 years issued by publicly traded companies. The issuers held in the index are weighted by a combination of four measures of their fundamental size—sales, cash flow, dividends, and book value of assets.

(36) The Merrill Lynch Corporate Master II High Yield BB-B Index is representative of the U.S. high yield bond market. The index includes domestic high-yield bonds, including deferred interest bonds and payment-in-kind securities. Issues included in the index have maturities of one year or more and have a credit rating lower than BBB-/Baa3, but are not in default.

(37) The RAFI® US Equity Long/Short Index utilizes the Research Affiliates Fundamental Index® (RAFI®) methodology to identify opportunities that are implemented through long and short securities positions for a selection of U.S. domiciled publicly traded companies listed on major exchanges. Returns for the index are collateralized and represent the return of the strategy plus the return of a cash collateral yield.

(38) The 3-Month T-bill return is calculated using the Bloomberg Generic 3-month T-bill. The index is interpolated based off of the currently active U.S. 3 Month T-bill and the cash management bill closest to maturing 90 days from today.

(39) The FTSE RAFI® Global ex US Real Estate Index comprises 150 companies with the largest RAFI fundamental values selected from the constituents of the FTSE Global All Cap ex U.S. Index that are classified by the Industry Classification Benchmark (ICB) as Real Estate.

(40) The FTSE EPRA/NAREIT Global ex US Index is a free float-adjusted index, and is designed to represent general trends in eligible listed real estate stocks worldwide, excluding the United State. Relevant real estate activities are defined as the ownership, trading and development of income-producing real estate.

(41) The FTSE RAFI® US 100 Real Estate Index comprises of the 100 U.S. companies with the largest RAFI fundamental values selected from the constituents of the FTSE USA All Cap Index that are classified by the Industry Classification Benchmark (ICB) as Real Estate.

(42) The FTSE EPRA/NAREIT United States Index is a free float-adjusted index, is a subset of the EPRA/NARIET Global Index and the EPRA/NAREIT North America Index and contains publicly quoted real estate companies that meet the EPRA Ground Rules. EPRA/NARIET Index series is seen as the representative benchmark for the real estate sector.

(43) The Citi RAFI Sovereign Developed Markets Bond Index Series seeks to reflect exposure to the government securities of a universe of 22 developed markets. By weighting components by their fundamentals, the indices aim to represent each country's economic footprint and proxies for its ability to service debt. Performance may be positive or negative. Past performance is not an indication of future results. Historical data used from index inception date of 09/30/2001 (index = 100) until 12/31/2011. Live data used since 01/01/2012.

(44) The Merrill Lynch Global Government Bond Index II tracks the performance of investment grade sovereign debt publicly issued and denominated in the issuer's own domestic market
and currency.

(45) The Citi RAFI Sovereign Emerging Markets Local Currency Bond Index Series seeks to reflect exposure to the government securities of a universe of 15 emerging markets. By weighting components by their fundamentals, the indices aim to represent each country's economic footprint and proxies for its ability to service debt. Performance may be positive or negative. Past performance is not an indication of future results. Historical data used from index inception date of 09/30/2011 (index = 100) until 12/31/2011. Live data used since 1/1/2012.

(46) The JPMorgan GBI-EM Diversified Index seeks exposure to the local currency sovereign debt of over 15 countries in the emerging markets.

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