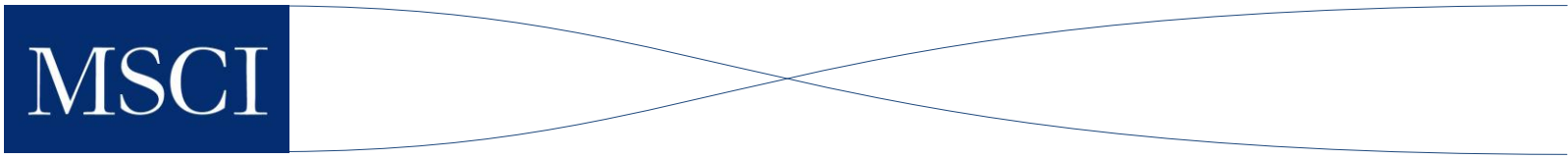

Harvesting Risk Premia for Large Scale Portfolios

Analysis of Risk Premia Indices for the Ministry of Finance, Norway

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Table of Contents

I. Executive Summary

An accumulating body of empirical research has found positive gross excess returns from exposure to risk factors (or risk premia) such as Value, Momentum, Low Size (Small firms), and Low Volatility stocks. The studies show that these factors historically have improved return-to-risk ratios. Over time, increasing attention has been given to the important practical questions facing investors who wish to implement exposure to one or more of these factors in actual portfolios. However, factor investing for very large-scale portfolios has not been well studied.

On this basis, MSCI was engaged by the Norwegian Ministry of Finance to analyze simple rules-based factor strategies, with emphasis on risk, performance, and investability. Simple rules-based strategies provide a good starting point for evaluating exposure to various risk factors.

Our analyses focused on existing and new MSCI Risk Premia Indices, which are designed to represent the performance of long-term risk premia or factors. MSCI Risk Premia Indices utilize rules-based transparent methodologies based on key characteristics of equity risk factors. We developed a set of risk premia indices for which the starting point is market capitalization weights. The weight on each security was then slightly adjusted towards the risk premia in question. This approach – using a broad-based equity index with a risk factor tilt – emphasizes investability than for other, more focused approaches to factor investing.

We evaluated the risk premia indices along the dimensions of risk, return, investability, and diversification. Exhibit 1 shows key metrics for the simulated indices over the period November 1992 to August 2012 using the MSCI World Index constituents as the universe. (This universe consists of large and mid cap stocks in developed equity markets. Our results for emerging markets, discussed later in the report, are generally consistent with the results for the developed markets.)

Exhibit 1: Key metrics of Simulated Risk Premia Indices and Select Portfolio Combinations (November 1992 to August 2012)[1]

		Individual Risk Premia Indices				*Combinations of Risk Premia*	
	WORLD STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Volatility Tilt/Size Tilt/Value Tilt	Value Tilt/ Size Tilt/ Volatility Tilt/ Momentum
Annualized Return*	7.2%	8.4%	7.9%	8.2%	8.1%	8.1%	8.1%
December 1992 to December 2002	6.7%	8.9%	6.5%	7.9%	8.2%	7.6%	7.8%
December 2002 to August 2012	7.8%	7.9%	9.4%	8.4%	8.0%	8.7%	8.5%
Annualized Risk	15.5%	16.1%	15.7%	13.2%	15.8%	14.9%	15.0%
Return/Risk	0.47	0.51	0.50	0.62	0.51	0.55	0.54
Sharpe Ratio	0.23	0.29	0.27	0.34	0.28	0.30	0.30
Annualized Active Return (bps)		116	66	91	81	90	90
December 1992 to December 2002		218	-22	115	143	90	106
December 2002 to August 2012		11	160	66	18	91	74
Tracking error		3.2%	2.6%	3.4%	3.6%	2.2%	1.4%
Information Ratio		0.32	0.25	0.27	0.22	0.41	0.62
Max no. of consecutive years of underperformance**		3	6	2	2	3	2
Tradability of the Strategy							
Weighted Average Days to Trade***	3.1	4.7	5.5	5.0	11.1	3.1	3.5
Replication Costs							
Avg. Annual Turnover (%)****	4.3%	18.6%	12.4%	12.5%	41.0%	12.0%	12.9%
Performance Drag in bps (at 50 bps)	4.3	18.6	12.4	12.5	41.0	12.0	12.9

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012
** Out of 19 Calendar Years (1993 to 2011 inclusive)
*** Average annual one-way index turnover from 30/11/1992 to 31/08/2012
**** Weighted average of the days to trade for all stocks in the portfolio during rebalancing; average of the last four rebalancings ending Jun 2012. Assumes fund size of USD 100 billion and a trade limit of 10% of daily volume

[1] *Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012. ** Out of 19 Calendar Years (1993 to 2011 inclusive). *** Average annual one-way index turnover from 30/11/1992 to 31/08/2012. **** Weighted average of the days to trade for all stocks in the index during rebalancing; average of the last four rebalancings ending Jun 2012. Assumes fund size of USD 100 billion and a trade limit of 10% of daily volume in each security.

We observed that the risk premia indices for the factors ***Value, Momentum, Low Size[2], and Low Volatility*** exhibited significant excess returns relative to the market capitalization-weighted MSCI World Index over the period November 1992 to August 2012. Broadly speaking, the level of risk (as measured either by annualized volatility, market beta or maximum drawdown) for the risk premia indices was similar to the market capitalization-weighted World Index. In this period, the risk premia indices demonstrated higher Sharpe Ratios. We emphasize that all calculations in this report are based on historical figures and do not predict or attempt to predict future expected returns.

Investability is an important focus of our study. Investability is a key determinant of transaction costs (including market impact). Factor investing may entail high costs and significantly reduce net return on the portfolio, in particular when the portfolio is large. We considered a range of measures of investability that may be closely related to transaction costs, including measures of tradability, liquidity, turnover, cost of replication, and capacity. Our results indicate that several risk premia indices had strong investability for portfolios of considerable size (USD 100 billion). The more scalable risk premia indices were ***Value, Low Size, and Low Volatility.*** At the same time, we stress that transaction costs are not explicitly analyzed here and the actual costs of implementing risk premia strategies are not easy to estimate. Trading costs and other implementation-related issues, including most importantly the potential market impact, remain outside the scope of this study and a topic for future analysis. On the other hand, techniques such as liquidity-oriented constraints and multi-period rebalancing could potentially improve the investability of risk premia indices, possibly reducing implementation costs.

While Exhibit 1 summarizes metrics for the entire time period, time variation of risk premia indices is equally important. The performance of risk premia indices have varied significantly over time, and the indices undergo periods of weak performance across all factors. The factors ***Value*** and ***Low Size*** have underperformed the market capitalization-weighted benchmark over multi-year consecutive periods. For the factors ***Value, Momentum,*** and ***Low Volatility***, most of the excess return was captured in the first half of the period of 1992 to 2012, while the opposite was the case for the factor ***Low Size.*** Factor investing thus requires strong governance structures (e.g., clear investment beliefs, strong board support) to withstand the periods of underperformance while aiming to benefit from the potential premia over a full cycle.

We observed that combining exposure to several risk factors may at times provide substantial diversification benefits. In addition, combining multiple risk factors also at times provided cost benefits as crossing of trades between different factors reduced turnover in the portfolio.

This exploration into risk premia indices could be used as a starting point for tackling factor strategies in large funds like the Government Pension Fund Global. There are few examples of equity portfolios of the size of that of the Government Pension Fund Global which have actually implemented such strategies on a considerable scale. Therefore, evidence from actual experience is limited. It is clear that for equity portfolios of USD 100 billion and greater, investability is a key constraint that may be equally important as return and risk in the design of risk factor strategies.

[2] We use the term "Low Size" to be consistent with the way we name the other risk factors. In the literature, this factor is called the "Size premium", "Small cap premium", or "Size anomaly." The indices we use in this analysis are based on a universe comprising large and mid cap stocks only. Therefore technically speaking, we are evaluating the return to mid cap stocks relative to large cap stocks, and not the return to small cap stocks.

II. Risk Premia in the Literature

Models of equity returns have changed since the early days of financial theory. The first model of equity returns was the Capital Asset Pricing Model (CAPM) which became the foundation of modern financial theory in the 1960s (Lintner, 1965; Mossin, 1966; Sharpe, 1964 and Treynor, 1961). In the CAPM, securities and portfolios have only two main drivers: systematic risk and idiosyncratic risk. Systematic risk in the CAPM is the risk that arises from exposure to the market and is captured by beta, the sensitivity of a security's return to the market. Since systematic risk cannot be diversified away, investors are compensated with returns for bearing this risk.

In subsequent decades after the CAPM, the notion of systematic risk steadily expanded to multiple equity factors (or risk premia). While multi-factor models can be traced as early as the 1970s[3] possibly the best known effort in this space is that by Eugene Fama and Kenneth French. In the early 1990s, Fama and French (1993) put forward a model explaining US equity market returns with three factors: the "market" (based on the traditional CAPM model), the size factor (large vs. small capitalization stocks) and the value factor (low vs. high book to market). This area of research has been very prolific since then.

In general, a factor can be thought of as a specific characteristic relating a group of securities that is statistically significant in driving their risk and returns (i.e. have substantial explanatory power for stock returns). While the most widely researched factors have been Value, Size, and Momentum, many additional factors from earnings-related metrics to accounting variables have found empirical support.[4]

Why do risk premia persist over time? From a theoretical standpoint, there are two main views resulting from different perspectives of market efficiency.[5] According to subscribers of efficient markets, these systematic sources of returns are risk factors. They are compensation to investors for bearing a particular risk. For instance, some have argued that the small cap premium is return earned for exposure to companies that are less liquid, less transparent, and more likely to be distressed. Because investors perceive excess returns as compensation for bearing risks, there are periods in which these risks are realized and these factors underperform the market capitalization-weighted benchmark. Additionally the magnitude of the compensation varies as a result of how "risky" market participants deem such exposures. Hence, excess returns can ebb and flow as investors' risk-taking behavior changes.

In contrast, believers in the so-called behavioral school of finance have proposed that these systematic sources of returns are the result of investors' behavioral biases. Behavioral biases include common mistakes (or deviations from rationality) that investors may make due to cognitive or emotional weaknesses. Typical examples are chasing winners or preferring "familiar" investments such as securities of the companies they work for or the country they live in ("home bias"). These types of behavioral biases may produce the return anomalies we observe in practice if arbitrage is costly, limiting the ability of rational investors to fully exploit the resulting mispricing of stocks.[6]

[3] See Merton (1973) and Ross (1976) among others.

[4] Subrahmanyam (2010) provides a comprehensive survey of the last 25 years of literature on determinants of stock returns.

[5] See Ilmanen (2011) and Ang (2012) for an in depth discussion of these perspectives and their implications.

[6] The cost of arbitrage is closely related to the existence and persistence of the various risk premia (or return anomalies) we discuss here. Some have argued that the return to risk premia observed in the data is roughly equal to the cost of arbitrage; see Shleifer and Vishny (1997). In practice, institutional investors may have

Related to these behavioral theories, some researchers have argued that return anomalies may arise due to aspects of the investment process. For instance, Baker et al. (2011) cite the use of institutional benchmarks, and the subsequent preference for relative returns, as one reason why the low volatility premium exists. Or as another example, Dasgupta, Prat and Verardo (2011) argue that reputation concerns cause managers to herd, and this generates momentum under certain assumptions.[7]

In this paper, we focus on four well-known risk premia: ***Value, Momentum, Low Size, and Low Volatility***. Each of these risk premia has been written about in great length by academics and practitioners alike. We summarize the salient points for each below.

Value

The Value factor captures the positive link between stocks that have low prices relative to their fundamental value and returns in excess of the capitalization-weighted benchmark. A value strategy consists of buying stocks that have low prices normalized by some indicator of company fundamentals (such as book value, sales, earnings, or dividends, etc.) and selling stocks that have high prices (also normalized). Value investing has been widely discussed since Graham and Dodd first wrote about it 1934 ("*Security Analysis*"). It was later formalized by Basu (1977), who identified price to earnings ratios as predictors of subsequent performance, whereby high price to earnings stocks underperformed their low price to earning counterparts. There are several explanations for the existence of this effect. In the efficient markets view, value companies may be perceived as riskier companies and therefore should offer some compensation to investors. Some studies in this vein are Zhang (2005) and Cochrane (1991, 1996). The main argument is that contrary to their leaner more flexible growth counterparts, value firms have less flexibility to adapt to unfavorable economic environments and therefore offer investors a premium. From a behavioral perspective, the premium may exist as a result of loss aversion and mental accounting biases; see Barberis and Huang (2001).

Low Size

The Size factor captures the excess returns of smaller firms (by market capitalization) relative to their larger counterparts even after adjusting for betas and other factors like Value. This result was first discovered by Banz (1981), and triggered a vast literature on the topic. There are several theories explaining this phenomenon, and the debate continues today. In the efficient market view, Fama and French (1992, 1993) originally hypothesized that small caps have higher systematic risk which earns them a higher return premium. Subsequent researchers suggested that size may proxy for other unobservable and underlying risk factors associated with smaller firms such as liquidity (Amihud, 2002), information uncertainty (Zhang, 2006), financial distress (Chan and Chen, 1991) and default risk (Vassalou and Xing, 2004). From the behavioral perspective, small caps may be mispriced by investors due to common mistakes of naïve investors such as their tendency to extrapolate the past into the future (Lakonishok, Shleifer, and Vishny, 1994). The small cap premium (or "size anomaly") has been found to exist even after influences are controlled for: market beta, the value effect, the momentum effect, liquidity effects, leverage, and so forth. Moreover, the phenomenon has been identified across the world in both developed and emerging markets; see Rizova (2006).

Momentum

The Momentum factor reflects future excess returns to stocks with stronger past performance. In other words, stock prices tend to exhibit trend over certain horizons; winners continue to win and losers continue to lose. Jegadeesh and Titman (1993) produced one of the first seminal studies on momentum

different costs of arbitrage; thus their ability to exploit certain return anomalies may vary as well. Institutions with low costs of arbitrage may be able to exploit mispricings which average investors may not. These points should likely be factored into an evaluation of risk premia or factor-based investing by large institutions.

[7] Specifically that the market makers trading with the managers are either monopolistic or myopic.

for the US market between 1965 and 1989. Rowenhorst (1998) found a similar result for Europe. In his study on mutual funds returns Carhart (1997) added momentum to the Fama and French (1993) model. His work demonstrated the validity of the momentum factor as an explanatory variable of the cross section of stock returns.

The main indicator used to capture Momentum is past returns, though different authors vary in the number of months employed. The time period over which the returns are calculated usually range from three to twelve months. Typically the last month is dropped to avoid an empirically documented 1-month "reversal" effect. Momentum stocks tend to turn over relatively quickly, compared to the other well-known factors.

The theory underlying this premium is still matter of extensive discussion. The most widely cited theories are behavioral. For instance, momentum may arise because of the biased way investors interpret or act on information. Investors either over-react to news (Barberis, Shleifer and Vishny, 1998 and Daniel, Hirshleifer and Subrahmanyam, 1998) or under-react to news (Hong and Stein, 2000). Both phenomena may lead to the momentum effect under varying assumptions. The behavioral biases which tie into this over-reaction or under-reaction include overconfidence, conservatism, and aversion to realizing losses.

More recently, Vayanos and Woolley (2011) propose a framework based on the dynamics of institutional investing rather than individual biases. In their framework, momentum and value effects jointly arise because of flows between investment funds. Negative shocks to assets' fundamental values trigger outflows from funds holding those assets while outflows cause asset sales, which amplify the shocks' negative effects. If the outflows are gradual because of institutional constraints or inertia, then momentum effects arise. Moreover, because flows push prices away from fundamental value, value effects also arise.

Low Volatility

The Low Volatility factor captures excess returns to stocks with lower than average volatility, beta, and/or idiosyncratic risk. The empirical evidence for this factor is a puzzle since it is clearly at odds with one of the most basic principles in finance, that higher volatility is associated with higher returns (Blitz and Vliet, 2007). While the CAPM model asserts that riskier assets should earn higher returns, research around the Low Volatility factor shows that the opposite is true--less risky stocks outperform the market.

Haugen and Baker's (1991) critique of capitalization-weighted benchmarks was the first to document the effect. They showed that for the 1972 to 1989 period, low volatility stocks in the US performed better than the capitalization-weighted alternative. Later, Chan, Karceski and Lakonishok (1999), Schwartz (2000), Jagannathan and Ma (2003) and Clarke, daSilva and Thorley (2006) confirmed these results for the US market using a range of volatility measures. Geiger and Plagge (2007), Nielsen and Subramanian (2008) and Poullaouec (2008) all find qualitatively similar results for global markets. Ang et al (2006, 2009) found that the low volatility effect persists both in the US and globally, based on extensive periods of time (for US stocks, 1963 to 2003, and for international stocks, 1980 to 2003). Metrics used for identifying low volatility stocks range along a broad spectrum, with realized volatility on one end and forecast volatility and correlations on the other. Some operationalize low volatility as low beta. Results appear robust to changes in indicator. The time frame over which the realized volatility is measured also varies. Explanations behind the low volatility effect focus on behavioral biases leading to excess demand for higher risk stocks, combined with limits on arbitrage (Baker et al, 2011).

So far we have provided a brief overview of the literature on factors and risk premia. Our goal was not to be exhaustive but merely to highlight ideas behind why these risk premia may exist. Next, we look at the transformation of this theoretical work into the real-world implementation of investable indices.

III. From Theory to Implementation: Investable Risk Premia Portfolios

The Limitations to Theoretical Factor Portfolios

The standard framework used by Fama and French and subsequent researchers entails several assumptions that in practice make the portfolios they study very difficult if not impossible to actually implement. These assumptions become critical when assessing the viability of implementing the risk premia for funds of large scale. The key assumptions in these studies that limit investability are:

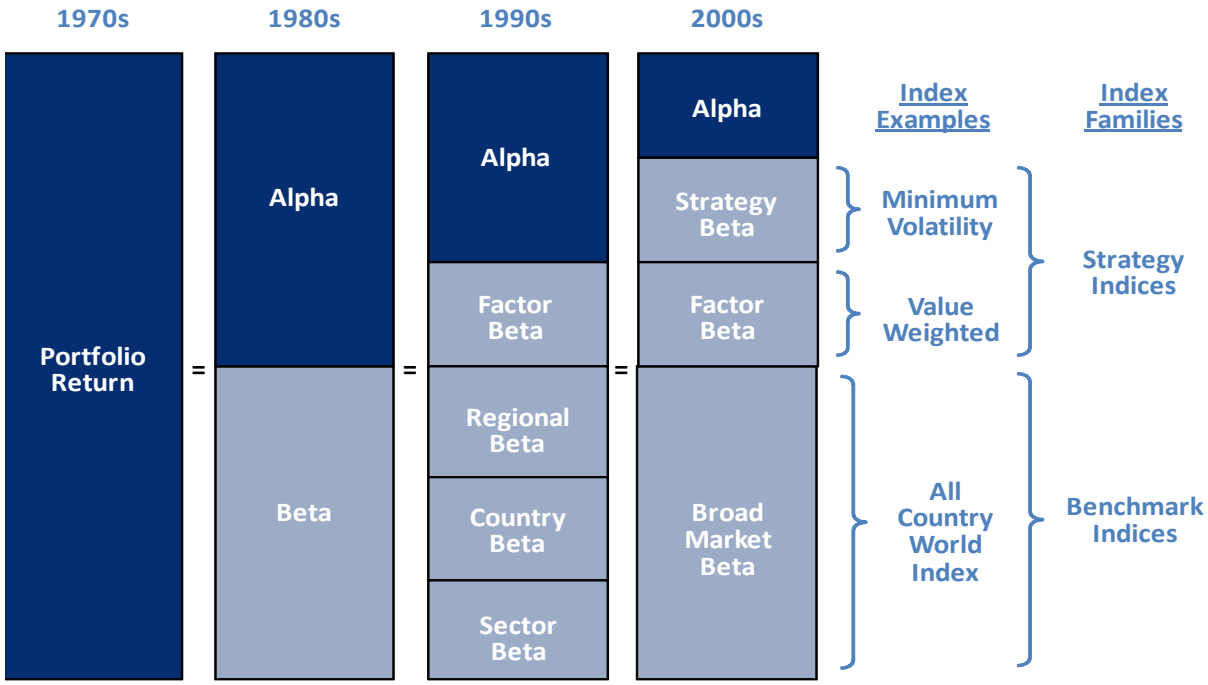
- **Long/Short Portfolios:** Theoretical factor portfolios such as those of Fama and French are based on long/ short portfolios with no accommodation to the size of short positions which in practice may be difficult or impossible to hold.
- **Monthly Rebalancing:** Theoretical factor portfolios are rebalanced monthly which leads to turnover that is considerably higher than institutional benchmarks.
- **Inclusion of Small Caps and Equal Weighting Within Portfolios:** Theoretical factor portfolios are typically constructed using all available stocks in a universe, including small caps. (Fama and French for instance use all stock listed on the NYSE and AMEX in their seminal US studies). Moreover, because stocks are equally weighted within the factor portfolios, this introduces a significant bias towards smaller capitalization stocks.
- **No Explicit Liquidity or Capacity Constraints:** Theoretical factor portfolios are not constructed with any explicit liquidity or capacity constraints. On the other hand, in index construction, capping constraints on stocks with extreme values (i.e., outliers) are not uncommon.

In other words, the extraordinary excess returns documented in most academic studies do not consider several features that are key to actual implementation: transactions costs, liquidity, investability, capacity. For very large portfolios, these issues with theoretical factor portfolios are of critical importance. In this study, we investigate risk premia in the context of real investable portfolios that have sizable assets. We use USD 100 billion as the baseline for our analysis.

Building Investable Risk Premia Indices

Before we delve into a discussion of how we build risk premia indices, we first highlight the evolution over time of how investors have viewed the sources of equity returns. As illustrated in Exhibit 2, traditionally portfolio returns were viewed as being composed two parts: market return and specific return (or alpha). In this CAPM-based view, alpha was any return that could not be attributed to the market. As the industry has evolved, and ways to capture alternative forms of beta have become more accessible, the notion of alpha and betas has also changed. Beta has been refined to include sources of return that are excess of the market, such as factors or risk premia.

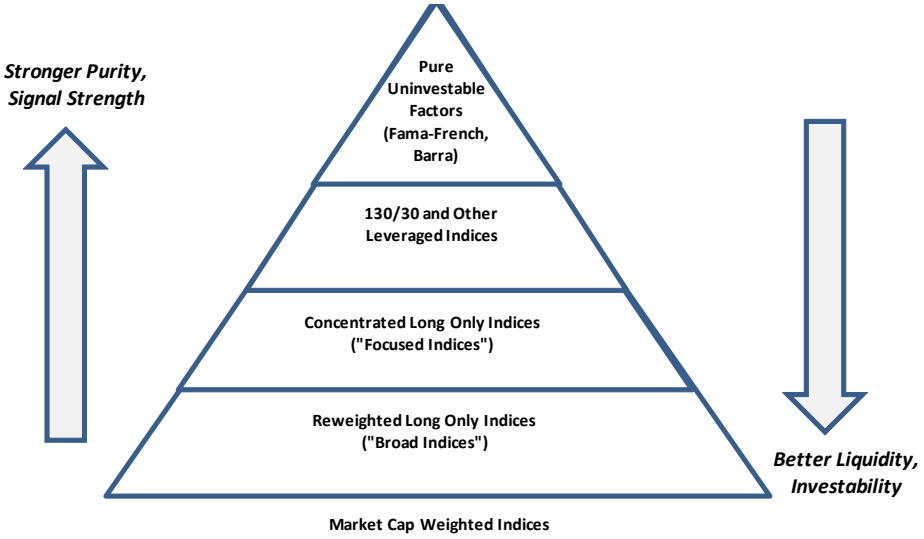
Exhibit 2: Evolution in Implementation: Today's Alpha is Tomorrow's Beta



For many decades, the ability to capitalize on risk premia could only reasonably be done by active managers. The ability to capture systematic risk premia through indexation has expanded in recent years as index providers have created methodologies to capture risk premia while keeping in mind investability concerns. Passive tracking of risk premia indices has become a lower cost alternative to active management for institutional investors seeking added return.

What are the challenges to building risk premia indices? As shown in Exhibit 3, tradeoffs exist between the purity of the risk premia signal and the investability of a risk premia portfolio. The most investable index is one whose weights are proportional to free float adjusted market capitalization, the bottom part of the pyramid. As we consider ways to capture the risk premia, moving up the pyramid, the investability of the index generally diminishes as signal strength improves. In other words, the purity of the index (relative to the theoretical risk premia or factor at the top of the pyramid) can be increased usually only by sacrificing investability.

Exhibit 3: Tradeoffs in Risk Premia Index Construction



Source: MSCI

In addition, it should be noted that market capitalization-weighted indices are the only macro consistent indices. All other index weighting schemes cannot be held by *all* investors. This puts natural bounds on the capacity of a risk premia allocation. As an index increasingly deviates from a market capitalization-based index, it becomes less and less investable, particularly for funds of very large size.

The risk premia indices we analyze in this report do in fact show similar patterns as the risk premia used in the academic literature (e.g. Fama-French). However, while the patterns are similar, the actual magnitude of returns can be different, typically smaller. Appendix K presents comparisons with the Fama-French Global factors. We suspect that the inclusion of small caps, and sometimes micro caps, in the majority of academic studies, are important in explaining the differences in returns. Since our primary focus is on investability, we confine our analysis to large and mid cap stocks.

Methodology for the Simulated Indices

Given the size of the Government Pension Fund Global, for this study we consider long-only portfolios as we believe shorting costs and availability of stocks to short, would be prohibitive for a fund of this size. We focus on the bottom two categories in Exhibit 3--*broad indices* and *focused indices*.

All indices use the constituents of the MSCI Standard Indices as the universe of stocks. As highlighted by Melas, Briand, and Urwin (2011), it is important to use a consistent set of liquid, investable and widely held securities for all risk premia indices. The MSCI Standard Indices comprise large and mid cap stocks and are determined on a country-by-country basis (except for Europe) using an innovative approach to capturing broad market coverage without sacrificing size integrity. Our choice of excluding small caps is based on the considerations of very large investors. While small caps are not necessarily uninvestable for certain levels of funding, it makes sense to start with the large and mid cap segments which are by nature more investable with the possibility of extending our analysis to small caps in later work. The MSCI large and mid cap segments are non-overlapping and cover approximately 80-90% of cumulative free float market capitalization within each country. All stocks must meet additional liquidity criteria to be included in the MSCI equity universe. For additional details behind the MSCI equity universe and the identification of Standard Index constituents, please refer to the MSCI Global Investable Market Indices Methodology (GIMI) (2012).

We analyze several universes. The MSCI World Index, which comprises developed countries, is our baseline universe. We also analyze the following regions: MSCI Emerging Markets, USA, Europe, and Pacific.[8] All risk premia indices are built using the same constituents as the relevant market capitalization-weighted index.

All indices are rebalanced semi-annually, in May and November, along with the market capitalization-weighted indices. Research at MSCI has shown that semi-annual rebalancing generally captures market changes in a timely manner while keeping index turnover low. For further details on the rebalancing methodology, please refer to the MSCI GIMI methodology paper.

A summary of the simulations for the main analysis are shown in Exhibit 4. Note that Exhibit 4 also includes selected combinations of risk premia.

[8] MSCI World comprises 24 developed market countries. MSCI Europe and Pacific span developed markets in the respective regions and are subsets of the MSCI World. There are 17countries in MSCI Europe (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and UK) as of January 2013. There are five countries in MSCI Pacific: Australia, Hong Kong, Japan, New Zealand, and Singapore. The remaining two countries in the MSCI World Index country list are the US and Canada. The MSCI Emerging Markets Index covers 21 markets: Brazil, Chile, Colombia, Mexico, Peru, Czech Republic, Egypt, Hungary, Morocco, Poland, Russia, South Africa, Turkey, China, India, Indonesia, Korea, Malaysia, Philippines, Taiwan, and Thailand. For the purposes of this report, we do not consider the individual regions within Emerging Markets (Americas, Europe/Middle East & Africa, and Asia).

Exhibit 4: Summary of Simulated Indices

Risk Premia
Value
Low Size
Momentum
Low Volatility
*Low Liquidity***
Combinations*
Value & Momentum
Value & Low Size
Value & Low Volatility
Low Volatility & Momentum
Value, Low Size & Momentum
Value, Low Volatility & Momentum
Value, Low Volatility & Low Size
Value, Low Size, Low Volatility & Momentum
Geographic Units
MSCI World
MSCI Emerging Markets
MSCI USA
MSCI Europe
MSCI Pacific
Types*
Broad
Focused

*Shown for the World Index Only

** Select results for the Low Liquidity Index appear in the Appendix

We note that in simulating the risk premia indices, we can view the preceding discussion as one that ultimately leads to a set of decision variables to consider. The three most critical decisions are:

- Choice of Stock Universe
- Choice of Weighting Scheme
- Rebalancing Frequency

The implications of the first decision concerning the universe were previously discussed since it has a first-order impact on the investability of the portfolio. The second decision around the choice of weighting scheme is discussed next. The third decision around rebalancing frequency is one which for parsimony, we leave out of the scope of this paper. We do however point out that our use of semi-annual rebalancing, following MSCI's capitalization-weighted indices, is supported by past MSCI research.

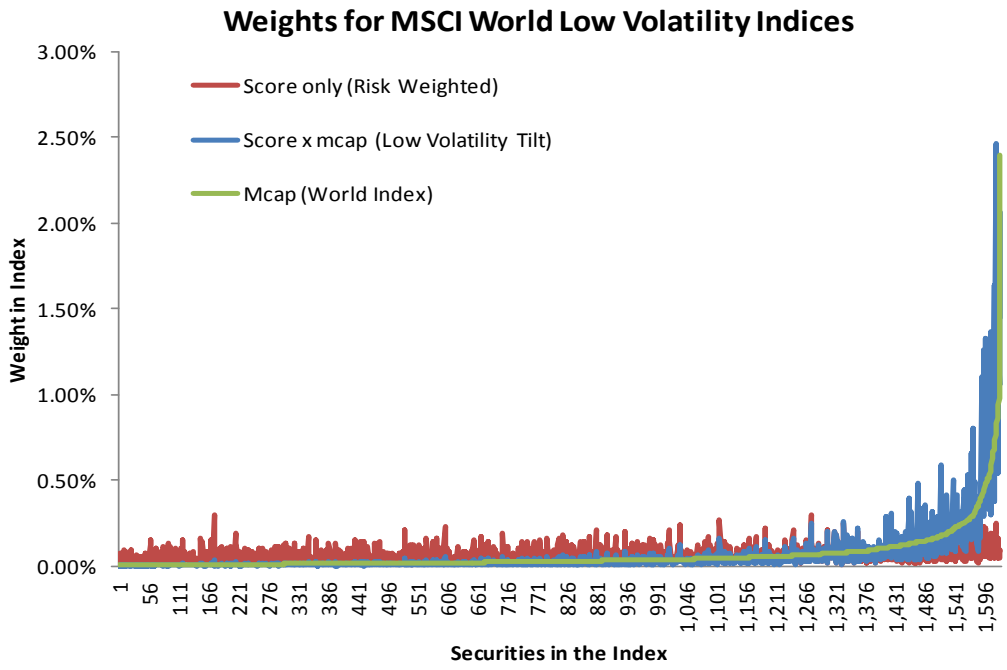
Choosing a Weighting Scheme for Large Scale Portfolios

A key index construction decision is the choice of weighting scheme. The weighting scheme ultimately determines the exposures of a portfolio or index. There are several options available for portfolio weighting schemes. If we use the whole universe of constituents, we must select a weighting scheme that "tilts" the portfolio towards the risk premia in question. We can do this by weighting stocks based on the fundamental ratio itself (for instance, price to book value) or we can create standardized z-scores based on the desired trait and either base the weight on the score alone or scale the score by market capitalization.

Because of our focus on investability, we choose a weighting scheme based on free-float adjusted market capitalization times score. (See Appendix A for details.) That is, weights are proportional to market capitalization but also reflect the underlying risk premia or factor. We compare this scheme to the market capitalization-weighted index. In two cases—Low Size and Low Volatility, we also compare our results to a weighting scheme based on the risk premia alone ("score only"). This comparison is meant to illustrate how much more investable it is to use a "score times market cap" approach. Another rationale for multiplying scores by market capitalization weights is that arguably larger cap stocks tend to have less idiosyncratic risk (more systematic) and therefore more of the risk premia would be captured by more exposure to large caps (Menchero, 2010). Free-float market capitalization is used in all cases.

To illustrate the score times market cap approach, we compare the different weighting schemes in Exhibit 5. Each stock in the MSCI World Index is plotted from left to right based on its free float market capitalization. The largest cap stocks are on the right. Each stock's weight in two simulated Low Volatility Indices is shown. The score times market cap approach increases capacity for the MSCI World Low Volatility Indices by pushing up larger cap stocks' weights relative to a score-only weighted index.

Exhibit 5: Comparison of Weighting Schemes for a World Low Volatility Index



All simulated indices with their accompanying weighting schemes and raw variables/descriptors are shown in Exhibit 6 below. The precise calculations behind all the indices appear in Appendix A. Note that the score times market capitalization weighting scheme is applied to both broad and focused indices. The only difference between the two categories of indices is the universe of stocks. For the focused indices, we restrict the indices to the top 300 stocks ranked by the characteristic.

Exhibit 6: Simulated Index Names, Weighting Schemes, and Raw Variables Used

Risk Premia	Index	Score	Weighting Scheme*	Outlier Data Truncated
Value	Value Tilt	Average of sales, earnings, cash earnings, book value	Approximates score x market cap	No
Low Size	Low Size Tilt	Square Root of Market Cap (Free Float)	Approximates score x market cap	No
Momentum	Momentum Tilt	1 year price returns (daily, local)	Score * market cap	Yes
Low Volatility	Low Volatility Tilt	Inverse of variance	Score * market cap	Yes
Low Size	Equal Weighted (EW)	Weight is 1/n stocks	Score only	No
Low Volatility	Risk Weighted (RW)	Inverse of variance	Score only	Yes

* Details on weighting schemes appear in the appendix

We note that Exhibit 6 shows various methods of constructing scores. While Appendix A has additional detail around the rationale behind the score definitions, we highlight that for each index, our approach to the definition of score and/or weighting scheme is partly based on past MSCI research as well as certain guiding principles (e.g., transparency, ease of interpretation, distribution and variability of the raw score, etc.) Alternative definitions are also possible; our goal is not to comprehensively cover all alternatives, nor to find one optimal one, but to find a straightforward definition or scheme that is sensible without being unnecessarily complex.

Furthermore, regarding currency effects, it should be noted that local currencies are typically used. The Momentum Tilt Index is constructed using stocks' local returns. The Low Size Tilt Index uses market capitalization in local currency. The Low Volatility Tilt Index employs local returns. Once the indices are constructed, we can show their performance in any currency. For simplicity, we show all results in USD.

We note that some of the indices in Exhibit 6 are "official" commercially-available MSCI Risk Premia Indices: the Value Tilt Indices, (called the MSCI Value Weighted Indices), the Risk Weighted Indices, and the Equal Weighted Indices. The mappings to commercially available indices and the naming conventions are shown in Appendix B.

Data Description

All data including prices, returns, and fundamental variables are maintained and calculated by MSCI and are sourced from multiple primary and secondary sources. MSCI began publishing annual fundamental data for developed market companies in 1969 and for emerging market companies in 1988. MSCI has accumulated a large volume of historical fundamental data during this period.[9] As highlighted by Melas, Briand, and Urwin (2011), using a single source of "as reported" fundamental data implies consistency across the data for different countries and ensures that the results are free from "look-ahead bias" that may affect strategy simulations based on back-filled databases.

[9] See "MSCI Fundamental Data Methodology" (May 2011) for a complete description of variables.

All simulated indices begin in November 1992 with the following exceptions. Emerging markets indices begin in November 1995. Note that return history for several of the indices are available prior to November 1992: MSCI World Value Index in December 1978 and MSCI World Risk Weighted Index in November 1979.

Dimensions for Analysis

While investability is our primary focus, we also aim to evaluate the risk premia indices in terms of performance, risk, and characteristics (valuation, sector and country exposures, etc.) We organize our analysis into four key dimensions: **Return, Risk, Investability, and Diversification in a Portfolio Context**. Metrics we analyze within these areas are listed in Exhibit 7.

Exhibit 7: Four Main Dimensions of Analysis

Dimensions	Sample Metrics
Return / Performance	• Return (Total, Active) • Sharpe Ratio, Information Ratio
Risk	• Historical and Forecast Measures of Market Risk • Long-Term and Short-Term Measures of Market Risk • Normal and Extreme Measures of Market Risk • Exposures to Systematic Sources of Risk • Concentration • Valuation Metrics • Regime-dependent performance • Correlations
Investability	• Tradability (Liquidity)-Related Measures • Turnover and Replication Costs • Capacity-Related Measures • Degree of Active Tilt
Diversification in a Portfolio Context	• Return Diversification Reflected by Correlation with Other Risk Premia and Other Asset Classes • Diversification of Systematic Sources of Risk • Turnover reduction

Most readers will be familiar with the return/performance and risk metrics shown in Exhibit 7. For measures of systematic risk, sources of risk, and forecast measures of risk, we use the Barra Global Equity Model (GEM2). Details of the model are discussed in Appendix C including the list of factors in the model, the half-life of the model, and the universe and weighting scheme.

A Framework for Assessing Investability

What has received less attention in the literature is how to assess the investability of the risk premia indices. Prior research on risk premia indices has focused more on performance rather than investability. For investability, we leverage many of the metrics used for assessing the investability and liquidity of indices in general. Traditionally, there have been different dimensions of investability that index researchers utilize. The key ones are:

- **Tradability/Liquidity**: Quantifies how liquid the stocks are in the portfolio and how tradable the portfolio is. Metrics include days to trade individual stocks at rebalancings and during the initial construction and days to trade a certain portion of the portfolio (given a certain size portfolio and a set limit to the amount traded on a single day). Also includes ATVR (Annual Traded Value Ratio) and Frequency of Trading.
- **Turnover/Cost of Replication:** Measures the turnover of the index at rebalancing which scales with costs. The higher the turnover, the higher the cost of trading.
- **Capacity:** Quantifies (for a given size fund) the percentage of a stock's free float or full market capitalization the fund would own. Combined with a limit on percentage ownership, the capacity of the fund (i.e., the total amount that could be invested given the limits) could be calculated

Also related to investability is the notion of the degree of active tilt. The degree to which a portfolio or index is "active" relative to the index has been traditionally used by many active asset managers to characterize their active strategies performance. Metrics like active share and maximum strategy weight capture this. This concept can also be applied to indices, reflecting the degree to which the risk premium index deviates from the capitalization-weighted index. In so far as the capitalization-weighted index represents what is most investable, the degree of active tilt is also a way to assess investability. All measures are further defined in Appendix D.

All four categories along with the metrics we report on here are listed in Exhibit 8.

Exhibit 8: A Framework for Investability

Category	Focus	Key Metrics
Tradability of the Strategy	•Tradability •Stock level liquidity •Position size •Allowable trade limits	• Weighted average ATVR • Days to Trade (Total, Periodic rebalancing) • Days to complete 95% of Trading (Periodic Rebalancing) • Days to Trade (Relative to Benchmark, Periodic rebalancing) • Days to complete 95% of Trading (Relative to Benchmark, Periodic Rebalancing)
Replication Costs	•Rebalancing Frequency •Replication cost •Impact on Ex post return	• Index turnover • Performance drag
Capacity of the Strategy	•Portfolio weights •Position Size	• Stock Ownership (Percentage of Float Market Cap) • Stock Ownership (Percentage of Full Market Cap)
Degree of Active Tilt	•Investability •Selection and Weighting •Portfolio Weights •Extent of tilts / Signal Strength	• Active Share • Average Weight Multiplier • Max Weight Multiplier • Max strategy weight • Active Target Factor Exposure

It is important to highlight that actual trading costs experienced by institutional investors are highly dependent on the implementation avenue. Transaction costs can vary widely across institutions employed to execute the actual trades. For funds of large scale, there is generally a higher risk of market impact which reflects the changes in asset prices due to the fund's trades. Market impact costs, also called implementation shortfall costs, can have a sizable impact on costs. ITG, for instance, reports estimates of implementation shortfall costs at 30.6, 52.1, and 86.9 basis points for US large, mid, and small caps, respectively, for 2012Q2 ("ITG's Global Cost Review 2012/Q2").[10] These are on the order of 3-5 times higher than commission costs (6, 10.2, and 18.4 bps for US large, mid, and small caps) which are more precisely measurable. A discussion of market impact is currently outside the scope of this study but deserves further consideration.

[10] See http://www.itg.com/news_events/papers/ITGGlobalCostReview_2012Q2Final.pdf.pdf. For details on the methodology please refer to ITG Research.

IV. World Broad Risk Premia Indices

Key Results

- All four risk premia indices exhibit moderate to strong returns relative to the market capitalization-weighted index. Active annual gross returns (before costs) for the November 1992 to August 2012 period range from 65 bps annually for the World Low Size Tilt Index to 116 bps for the World Value Tilt Index.
- The World Low Volatility Tilt Index had the highest Sharpe ratio (0.34 compared to 0.23 for the World Index) while the World Value Tilt Index had the highest Information ratio during the period.
- Three of the risk premia (Value, Low Size, and Low Volatility) appear to be scalable for very large portfolios. For a USD 100 billion portfolio, their weighted average days to trade range between 4.7 to 5.5 days compared to 3 days for the World Index. Annual turnover since 1992 has ranged between 12.4% to 18.6% compared to 4.3% for the World Index.
- Momentum appears to be less scalable. The weighted average days to trade is 11.1 days, double that of the other three risk premia. Annual turnover has averaged 41% since 1992, resulting in a performance drag of 41 bps annually assuming a 50 bps fixed transaction cost.
- For scalable versions of the risk premia indices, a score times market capitalization weighting scheme is suggested as opposed to a score-only weighting scheme.

In this section we present the results of the simulated risk premia indices. We organize the results by three key dimensions:

- Return
- Risk
- Investability

The fourth dimension, diversification in the portfolio context, is discussed in Section V.

Returns

Exhibit 9 summarizes the historical annualized returns to the simulated risk premia indices. All risk premia indices meaningfully outperformed the MSCI World Index during the periods shown. The gross return (before costs) outperformance for the four "score x market cap" indices range from 66 basis points annually (Low Size) up to 116 bps annually (Value) for the period December 1992 to August 2012. The Value Tilt Index and the Low Volatility Tilt Index exhibited the strongest and most persistent active returns. The Momentum Tilt Index also displayed positive active return though the magnitude of outperformance was slightly lower. The Low Size Tilt Index exhibited the highest active return over the last decade but was marred by a long period of underperformance in the 1990s.

Exhibit 9: Annualized Returns to Simulated Risk Premia Indices (December 1978 to August 2012)

		Score x mcap				*Score only*	
	World	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt	World Equal Weighted	World Risk Weighted
Total Returns							
December 1978 to August 2012	10.1%	11.4%	--	--	--	--	--
December 1992 to August 2012	7.2%	8.4%	7.9%	8.2%	8.1%	8.3%	9.6%
December 1998 to August 2012	3.4%	4.4%	5.2%	4.7%	4.1%	6.6%	7.8%
Subperiods							
Dec 1992 to Dec 2002	6.7%	8.9%	6.5%	7.9%	8.2%	6.1%	8.4%
Dec 2002 to August 2012	7.8%	7.9%	9.4%	8.4%	8.0%	10.7%	11.2%
Active Returns (basis points)							
December 1978 to August 2012		130	--	--	--	--	--
December 1992 to August 2012		116	66	91	81	109	235
December 1998 to August 2012		104	175	131	65	318	443
Subperiods							
Dec 1992 to Dec 2002		218	-22	115	143	-63	164
Dec 2002 to August 2012		11	160	66	18	295	345

All figures are annualized USD Gross returns using longest available time period.

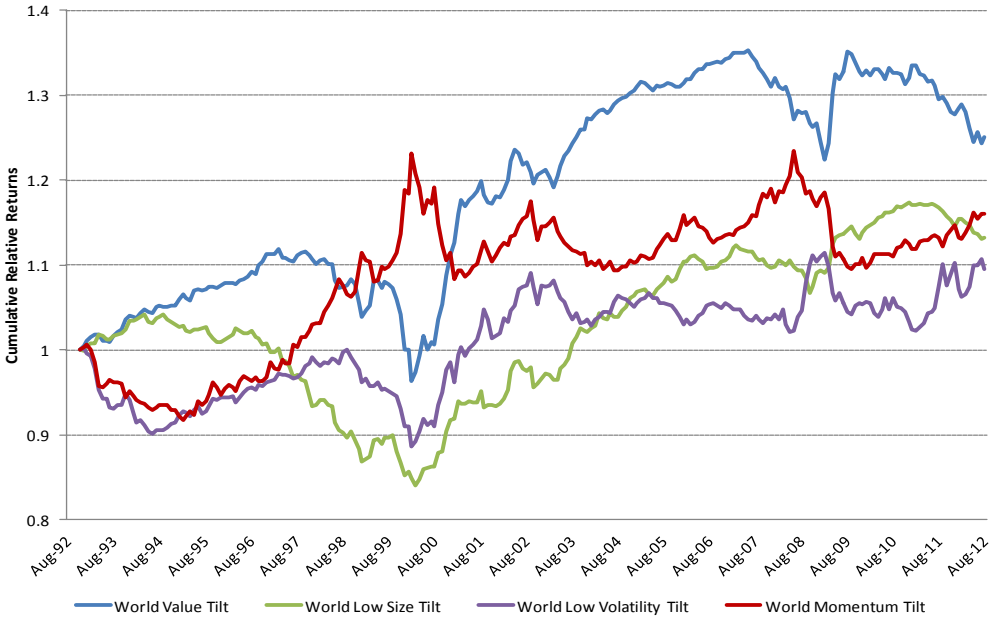
How do these returns compare to those found in prior academic research? For comparison, the Fama and French Global (Developed) factor portfolios posted gross returns of 60 bps annually (Size), 490 bps (Value), and 650 bps (Momentum) for the period November 1992 to June 2012.[11] While these are not directly comparable to our simulated indices, because they are long-short portfolios and include smaller stocks, they do however provide an interesting point of reference. In short, the spread between the Fama-French factors and our simulated indices reflects the performance slippage when moving from a theoretical factor portfolio to a long-only investable portfolio.

Exhibit 10 plots the cumulative active returns from November 1992 to August 2012 for the four indices and highlights the long cycles risk premia can be subject to. Value, as reflected by the active return to the World Value Tilt Index, has generally trended upwards over time but has witnessed three main periods of underperformance (1998-1999, 2007-2008, and 2010-2012). Since Value reflects companies with low quality and lower expected growth (but at a lower price), the Value premium tends to reverse in periods when investors' risk aversion increases and when uncertainty rises. Historically this has been on the eve of bubble peaks (the "Dot-Com Collapse" and "Financial Crisis"). Momentum on the other hand has generally performed well when Value did not, and vice versa. Stocks with high momentum are less likely to be value stocks since by definition they have experienced large gains in price. As a

[11] The excess market return (adjusted for the risk-free rate) was 3.9% annually for this period.

consequence, with high momentum stocks being less value-like and low momentum stocks being more value-like, Momentum and Value risk premia tend to move in opposite directions. Meanwhile in contrast to both Value and Momentum, the Low Size premium endured two distinct multi-year regimes during this period, first declining for the second half of the 1990s and subsequently trending strongly through the 2000s.

Exhibit 10: Cumulative Active Returns for Simulated Risk Premia Indices (November 1992 to August 2012)



We further note that the "Dot-Com bubble" had a large impact on the returns to the various risk premia indices. The Value, Low Size and Low Volatility Tilt Indices underperformed when expensive growth stocks with large market capitalization outperformed at the end of the millennium.

In order to accommodate the long cycles risk premia can undergo, we stress that investing in risk premia strategies requires strong governance structures (e.g., clear investment beliefs, strong board support) to withstand the periods of underperformance and benefit from the premium over a full cycle.

Risk

Historically, the overall level of risk (as measured by annualized volatility, market beta or maximum drawdown) for the risk premia indices is broadly similar to, if not lower than, the market capitalization-weighted benchmark. Exhibit 11 displays a range of risk measures for the simulated risk premia indices. We show risk measures using total returns and active returns separately. In terms of absolute volatility, the indices are fairly similar except for the World Low Volatility Tilt Index which exhibits significantly lower volatility than the other indices.[12]

[12] Using total returns, measures of downside tail risk such as expected shortfall and Value-at-Risk are also similar in that the World Low Volatility Tilt Index exhibits much lower downside tail risk. This is consistent with Melas, Briand, and Urwin (2011) who point out that the MSCI World Risk Weighted Index has historically offered downside protection during periods of market turmoil.

In terms of tracking error (i.e., the volatility of active returns relative to the MSCI World Index), the four main risk premia indices are all in the 2.6% to 3.6% range which is consistent with low tracking error active mandates.[13] The MSCI World Momentum, Low Volatility, and Value Tilt Indices have the highest tracking error (in descending order).

Generally, using active returns, the other measures follow the same order as tracking error with one notable exception. Extreme downside measures, or tail measures, such as Expected Shortfall at the 99% confidence level or maximum drawdown, point to the Value Tilt Index being significantly more risky than the Momentum Tilt and Low Volatility Tilt Indices. The Low Size Tilt Index additionally has the highest maximum drawdown (reflecting the long period of underperformance in the 1990s).

Risk-adjusted returns, Sharpe Ratios, and Information Ratios are also shown in Exhibit 11, all measures of performance once risk has been accounted for. Here it is worth pointing out that all four indices historically delivered significant improvement in these metrics.

Exhibit 11: Risk and Risk-adjusted Return Metrics for Simulated Risk Premia Indices (November 1992 to August 2012)

		Score x mcap				*Score only*	
Statistics from 30/11/1992 to 31/08/2012	WORLD STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Total Return Performance							
Annualized Return (%)*	7.2%	8.3%	7.9%	8.2%	8.1%	8.3%	9.6%
Annualized Risk (%)	15.5%	16.1%	15.7%	13.2%	15.8%	16.3%	13.9%
Return/Risk	0.47	0.51	0.50	0.62	0.51	0.51	0.69
Sharpe Ratio	0.23	0.29	0.27	0.34	0.28	0.29	0.43
Correlation		0.98	0.99	0.98	0.97	0.95	0.94
Historical Beta		1.02	1.00	0.84	0.99	1.00	0.84
Ann. Downside Deviation (%)	10.8%	11.0%	10.9%	9.1%	11.0%	11.1%	9.4%
Sortino ratio	0.67	0.75	0.73	0.90	0.73	0.75	1.02
95 percentile Var (%)	-8.3%	-8.3%	-8.1%	-6.5%	-7.8%	-8.0%	-6.6%
99 percentile Var (%)	-12.0%	-12.1%	-12.8%	-10.0%	-13.5%	-13.0%	-10.7%
Expected Shortfall @ 95%	-10.5%	-11.4%	-11.0%	-9.2%	-10.5%	-11.4%	-9.9%
Expected Shortfall @ 99%	-16.1%	-16.6%	-17.1%	-14.4%	-16.3%	-17.8%	-15.9%
Max Drawdown (%)	53.6%	57.3%	54.6%	49.3%	53.6%	54.8%	50.8%
Max Drawdown period (in months)	16	16	16	16	16	16	16
Skewness	-0.76	-0.66	-0.80	-0.87	-0.78	-0.72	-0.93
Kurtosis	4.49	5.12	5.14	4.95	4.40	5.33	6.02
Active Return Performance							
Tracking error (%)		3.2%	2.6%	3.4%	3.6%	5.1%	5.3%
Information Ratio		0.32	0.25	0.27	0.22	0.21	0.44
Ann. Downside Deviation (%)		2.1%	1.8%	2.4%	2.5%	3.5%	3.5%
Sortino ratio		0.55	0.36	0.20	0.30	0.29	0.57
95 percentile Var (%)		-1.3%	-1.3%	-1.6%	-1.7%	-2.5%	-2.5%
99 percentile Var (%)		-2.2%	-2.1%	-2.6%	-3.0%	-4.4%	-4.4%
Expected Shortfall @ 95%		-2.0%	-1.8%	-2.2%	-2.5%	-3.6%	-3.6%
Expected Shortfall @ 99%		-3.8%	-2.3%	-2.8%	-3.7%	-4.6%	-4.9%
Max Drawdown (%)		13.8%	19.4%	11.5%	12.0%	37.5%	34.2%
Max Drawdown period (in months)		35	66	86	11	66	71
Skewness		0.37	0.07	0.11	-0.08	-0.16	0.17
Kurtosis		8.20	4.92	4.10	6.04	4.71	6.00

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

[13] Kang, Nielsen, and Fachinotti (2011) show that median tracking error using eVestment data for the period March 2000 to March 2010 are: 4.5% for US Large/Mid cap managers, 4.6% for EAFE/World ex US managers, 6.1% for World managers, and 4.8% for Emerging Market managers. In the same study, the median tracking error manager within the bottom quartile by tracking error is as follows: 3.1% for US large/mid cap, 3.3% for EAFE/World ex US, 3.6% for World, and 3.3% for Emerging Market managers.

The standard measures of volatility shown in Exhibit 11 should be viewed alongside longer term measures of risk. In Exhibit 12, we show annual returns during over the 19-year period 1993 to 2011. We calculate the number of years of underperformance and the number of years of consecutive underperformance. We find that the risk premia indices underperform the broad market index in the range of 7 to 9 years. The World Low Volatility Tilt and Momentum Tilt Indices experienced at most only 2 consecutive years of underperformance, while the World Value Tilt Index experienced 3 years of consecutive underperformance during the 1997 to 1999 period inclusive. In contrast, the World Low Size Tilt Index underperformed the World Index over the 6 year period 1994 to 1999 inclusive.

Viewed this way, multi-period years of underperformance is a risk institutional investors should be aware of. Investing in risk premia strategies requires strong governance structures to withstand the periods of underperformance and benefit from the premium over a full cycle. Moreover, as we discuss later, multiple risk premia indices can be considered to help diversify risk given risk premia's long cycles.

Exhibit 12: Long-Term Risk Reflected in Annual Returns (1993 to 2011)

Statistics from 30/11/1992 to 31/08/2012	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Average Annualized Relative Relative Returns	1.0%	0.7%	0.9%	0.8%	1.1%	2.3%
Annual Relative Returns (to MSCI World Index)						
1993	3.5%	3.6%	-6.0%	-5.2%	13.4%	8.2%
1994	1.2%	-0.5%	-2.8%	-2.4%	-0.5%	-1.2%
1995	2.2%	-2.1%	3.2%	2.0%	-5.5%	-2.0%
1996	3.4%	0.0%	1.8%	2.2%	-0.1%	0.5%
1997	-0.5%	-7.4%	3.1%	6.4%	-17.0%	-10.0%
1998	-4.7%	-5.4%	-1.5%	6.5%	-11.2%	-10.2%
1999	-5.2%	-3.4%	-6.9%	8.3%	-5.6%	-13.1%
2000	11.1%	7.6%	8.3%	-6.2%	11.3%	18.1%
2001	6.2%	1.8%	3.3%	-0.3%	5.0%	8.2%
2002	2.5%	3.5%	5.7%	3.1%	6.7%	16.1%
2003	5.2%	5.6%	-3.6%	-4.0%	11.6%	6.7%
2004	2.6%	4.2%	1.4%	0.3%	7.9%	10.1%
2005	0.3%	2.9%	-1.2%	3.7%	4.8%	2.7%
2006	2.5%	0.9%	1.6%	-0.7%	1.6%	4.7%
2007	-0.3%	-0.1%	-0.3%	0.8%	-0.6%	-1.0%
2008	-3.4%	-0.6%	6.5%	-1.8%	0.2%	5.2%
2009	4.5%	4.4%	-4.6%	-5.3%	7.9%	1.3%
2010	-0.2%	3.2%	-2.0%	1.5%	5.2%	3.0%
2011	-3.3%	-2.4%	6.8%	2.0%	-4.3%	1.5%
Summary Metrics						
Number of years of underperformance (out of 19)	7	9	9	8	8	6
Number of years of outperformance (out of 19)	12	10	10	11	11	13
Max Number of consecutive years of underperformance	3	6	2	2	6	3
Max Number of consecutive years of outperformance	7	7	3	5	7	7
Lowest annual return	-5.2%	-7.4%	-6.9%	-6.2%	-17.0%	-13.1%
Highest annual return	11.1%	7.6%	8.3%	8.3%	13.4%	18.1%

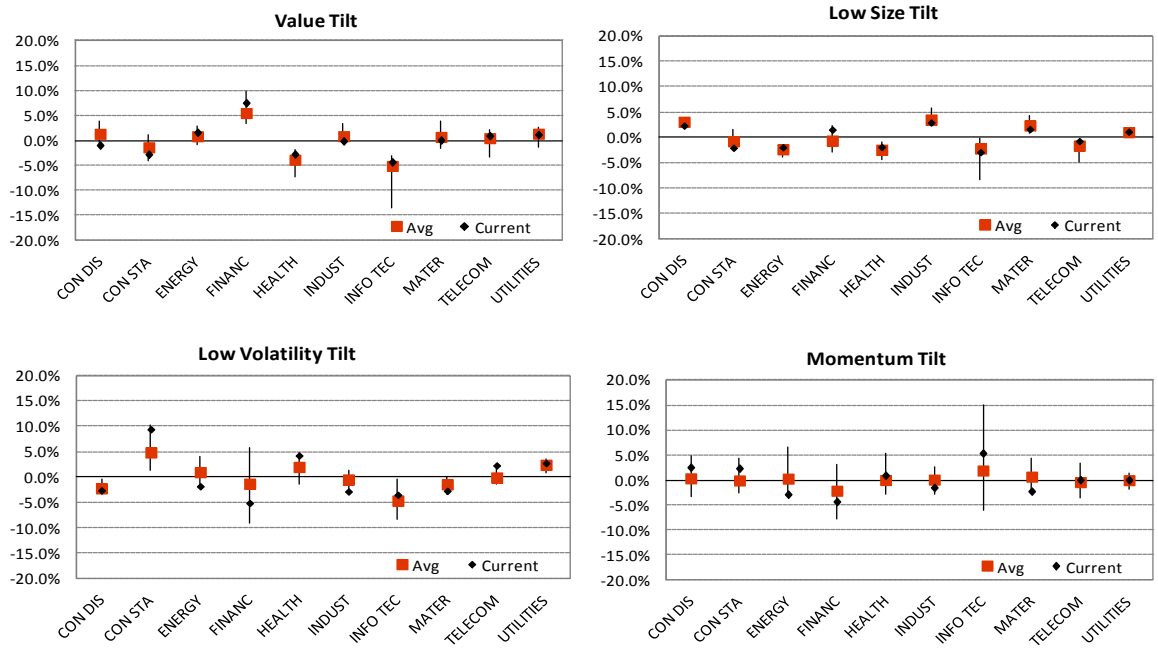
Highlighted cells denote negative active returns

Risk Exposures

Next we assess the relative tilts of the risk premia indices. These include country and sector overweights and underweights as well as exposures to commonly known factors. For the factors, we use the Barra Global Equity Model (GEM2), described in Appendix C. It is important to understand these active tilts or exposures as these could be important return drivers of the risk premia indices as well as sources of risk. In past crises, for instance, factors or systematic sources of risk have been shown to be contribute a bigger share of overall volatility than idiosyncratic or stock specific risk.

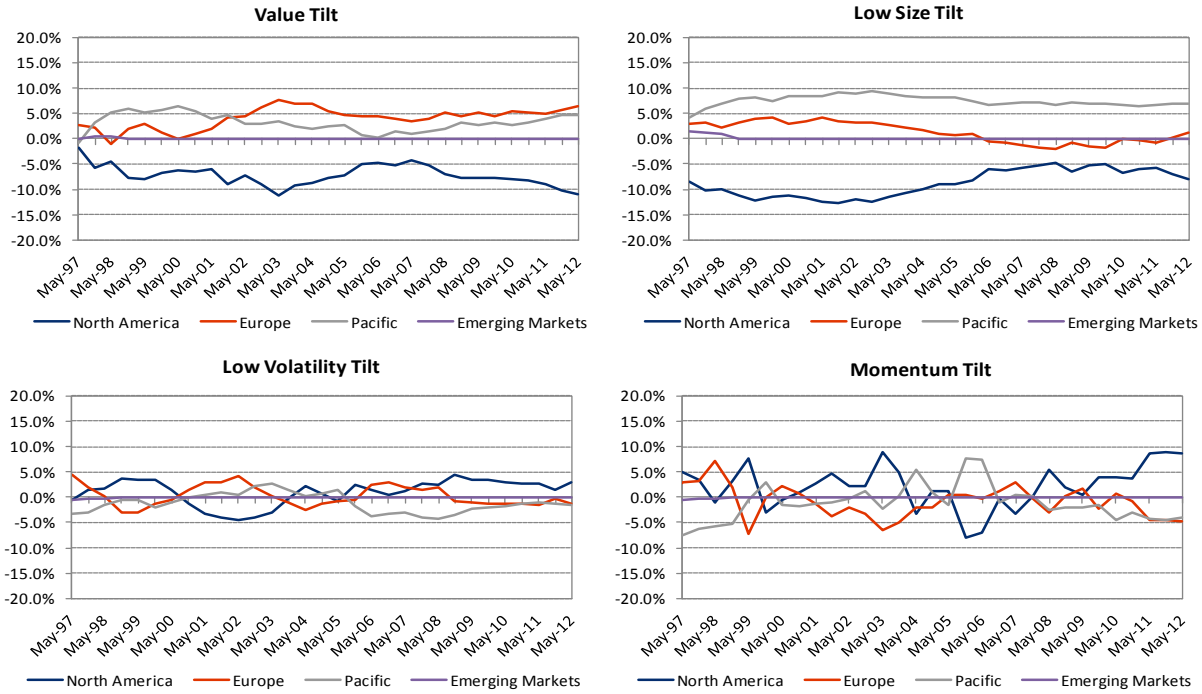
First, we look at sector active weights in Exhibit 13. (The contributions to risk for the sectors are shown in Appendix L. Risk is a function of both the magnitude of the active weight and the riskiness of the sector itself.) The World Value Tilt Index has had a relatively large overweight to Financials and underweight to Information Technology. Only the Financials overweight had a meaningful impact on the portfolio's forecast volatility as of June 2012 (see Exhibit 54). The World Low Size Tilt Index has historically had a moderate overweight to Consumer Discretionary, Industrials, and Materials. The World Low Volatility Tilt Index has had an overweight to Consumer Staples and underweight to Information Technology. Meanwhile, the Momentum Tilt Index has historically had relatively small active sector bets.

Exhibit 13: Sector Active Tilts (Benchmark = MSCI World Index, Average Active Weight, May 1997 to August 2012)



Active exposures to geographical regions are shown next in Exhibit 14. The World Value Tilt Index and World Low Size Tilt Index both exhibit persistent and large tilts to regions. Both risk premia indices for instance have historically had a significant underweight to North America. In contrast, the World Low Volatility Tilt Index and World Momentum Tilt Index have not exhibited any persistent regional tilts. In both these indices, active risk is less dependent on country risk.

Exhibit 14: Region Active Tilts (Benchmark = MSCI World Index, Active Weight, May 1997 to August 2012)



Next, we examine the risk premia indices in the context of the Barra factor model. The Barra factor model is similar in spirit to the Fama-French framework; the factors reflect the returns to stock characteristics such as those that are the focus of this report. The Barra factors are estimated in a unique way. The factors are cross-sectionally estimated with a multivariate regression using individual stock returns and exposures. Appendix C provides additional detail about the model. We can thus compute the exposure of any portfolio or index to the factors in the model where the exposures represent the portfolio's characteristic (i.e., Book-to-Price) expressed in terms of standard deviations from the universe's capitalization-weighted average.[14]

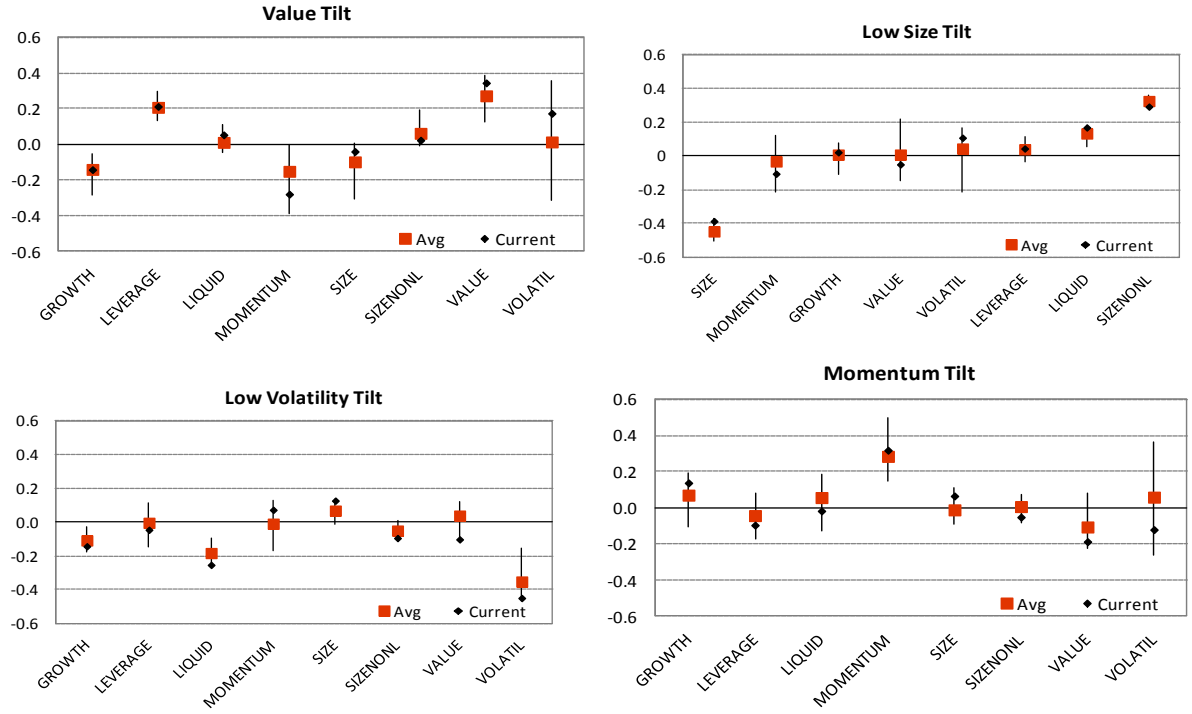
We use the Barra Global Equity Model (GEM2) specifically for this analysis. All exposures shown in Exhibit 15 are expressed relative to the MSCI World Index, i.e., are active exposures. Past research at Barra has shown that an active exposure above 0.2 or below -0.2 standard deviation units (or z scores) can be viewed as significant.

The Barra Global Equity Model includes equivalent factors for all four of our risk premia: Value, Size, Momentum, and Volatility. (Liquidity is a factor in the model as well.) These factors can be thought of as long-short pure theoretical factors similar to the well known Fama and French factors. The Barra model takes it one step further though in that these factors are also completely neutral to countries, industries, and to each other. Specifically in the model there are country and industry factors and these factors, along with style factors, are estimated concurrently in one regression so that the factor returns are orthogonal. Thus, we expect to see that our risk premia indices have a meaningful exposure (with the right sign) to the Barra factors but we do not expect the indices' exposures to the other style factors (and countries and industries) to be neutral. In other words, risk premia indices may also have incidental tilts to other factors.

[14] The universe for the Barra Global Equity Model (GEM2) is the list of constituents of the MSCI ACWI IMI which includes large, mid, and small caps.

As we expect, in Exhibit 15, all four risk premia tilt towards their equivalent Barra factors. As for other non-targeted factor exposures, the World Value Tilt Index stands out as having moderate negative tilts on Growth and Momentum and a positive tilt on Leverage. The World Low Volatility Tilt Index has exhibited significant negative exposure to Liquidity.

Exhibit 15: Barra Style Factor Tilts (Benchmark = MSCI World Index, Average Active Exposure, May 1997 to August 2012)



So far we have looked at the systematic sector, region, and style tilts in Exhibit 13-15 but the tilts themselves do not capture the impact on return and risk of these tilts. Some tilts may have relatively small return and risk impacts while others may be larger. A decomposition of historical returns can also provide interesting insight about the risk premia. To quantify the impact on returns, we perform a return decomposition using the Barra Global Equity Model. The decomposition is done on the period December 1998 to November 2012. Exhibit 16 decomposes the returns into the main categories. Note that all return categories exactly sum up to the risk premia index returns. The main categories are: style factors, country factors, industry factors, the World factor (similar to a market factor), and stock specific return (Asset Selection). The stock specific return is the return that is not explained by the systematic risk factors.

Exhibit 16: Broad Indices: Decomposition of Returns Using Barra Global Equity Model (GEM2) (December 1998 to November 2012, All Numbers in Annualized Percentage Return)

Source of Return	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum
1 Risk Free	2.29	2.29	2.29	2.29
2 Total Benchmark	3.22	3.22	3.22	3.22
3 Currency Selection	0.01	0.12	0.04	-0.23
5 Styles	1.65	0.74	0.93	-0.25
6 Industries	-0.59	-0.39	0.10	-0.02
7 Countries	-0.13	-0.16	0.01	-0.16
8 World Equity	0.00	0.00	0.00	0.00
9 Asset Selection	0.97	1.87	0.24	0.32
10 Active Equity [5+6+7+8+9]	1.91	2.05	1.28	-0.12
13 Total Active [3+4+10+11+12]	1.95	2.19	1.31	-0.32
14 Total Managed [2+13]	5.17	5.41	4.53	2.90

In the construction of the risk premia indices, we do not place any restrictions on exposure to industries and countries. We saw in Exhibits 13 and 14 that the indices can have systematic tilts towards certain industries and regions. Exhibit 16 further shows that these tilts can have an impact on returns. For instance, part of the returns from the World Value Tilt Index arises from systematic tilts towards countries and industries with relatively lower valuation. In this example the return contribution is actually negative, a drag of 13 bps. For all indices except the World Low Volatility Tilt Index, the allocations to countries and industries reduce active return during the period. In particular, industry allocations significantly dragged down the performance for both the World Value Tilt and Low Size Tilt Indices.

Exhibit 16 shows that the Styles and Asset Selection categories explain a large part of the active historical returns, while Currency Selection and Country Selection have been less important. Styles contributed to the largest portion of the active return for the World Value Tilt Index and the World Low Volatility Tilt indices. For the Low Size Tilt Index the contribution from Styles has been smaller, while Asset Selection has been more important. Exhibit 17 further decomposes the Style factors category into the individual factors. As seen in Exhibit 17, all indices show positive returns from their equivalent factors. The World Value Tilt Index for instance derives 138 basis points annually from the pure Barra Value factor. On the other hand, the Size factor, as defined in the GEM2 model, only explains a modest part of the strong historical return of the World Low Size Tilt Index.

We next observe whether any of the indices are significantly affected by exposure to other factors. There are indeed a few instances of this phenomenon. First, the World Low Size Tilt and World Low Volatility Tilt Indices derive a fair amount of return from the Barra Value factor. The Low Volatility, Value, and Low Size risk premia appear to have some interaction here which increases the active return for these indices.

Exhibit 17: Broad Indices: Decomposition of Style Returns Using Barra Global Equity Model (GEM2) (December 1998 to November 2012, All Numbers in Annualized Percentage Return)

Source of Return	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
Momentum	-0.24	-0.11	-0.37	0.57
Volatility	0.51	0.10	0.98	-0.54
Value	1.38	0.33	0.29	-0.27
Size	0.06	0.10	-0.02	0.01
Size Nonlinearity	0.13	0.40	-0.03	0.01
Growth	-0.04	0.01	-0.03	-0.01
Liquidity	0.04	-0.05	0.13	-0.09
Financial Leverage	-0.19	-0.04	-0.02	0.07
Total	1.65	0.74	0.93	-0.25

Valuation

Exhibit 18 compares valuation metrics across the simulated risk premia indices. Since the World Value Tilt Index is constructed using book value, cash earnings, earnings, and sales, we expect to see this index have the lowest statistics for the first four ratios shown in Exhibit 18, which is what we generally observe.[15] The Value Tilt Index captures companies with lower expected growth but at a cheaper price. The index also has the highest dividend yield ratio. Also in keeping with intuition, the World Momentum Tilt Index has relatively high valuation ratios, high growth rates, and low dividend yield. The World Low Size and Low Volatility Tilt Indices generally fall in between the Value and Momentum Tilt Indices. Interestingly, Return-on-equity (ROE) which can be viewed as an indicator for quality is highest for the Low Volatility Tilt Index; it is relatively low for the World Value Tilt Index and World Low Size Tilt Index as expected.

Exhibit 18: Valuation and Concentration Metrics (Monthly Average, November 1992 to August 2012)

		Score x mcap				*Score only*	
Statistics from 30/11/1992 to 31/08/2012	WORLD STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Price to Book	2.4	1.8	2.0	2.5	2.7	1.7	1.8
Price to Cash Earnings	10.5	8.1	9.8	10.3	11.3	9.5	9.0
Price to Earnings	19.5	18.7	20.9	18.1	20.1	23.8	19.3
Price to Sales	1.2	0.7	0.9	1.2	1.3	0.7	0.8
Div. Yield (%)	2.2	2.6	2.2	2.5	1.9	2.2	2.6
LT Fwd EPS G (%)	11.9%	10.5%	11.9%	10.9%	12.8%	11.6%	10.5%
Sustainable Growth rate (%)	7.1%	5.4%	5.5%	7.7%	8.2%	3.7%	4.8%
ROE (%)	12.2%	10.0%	9.9%	13.9%	13.4%	7.5%	9.6%

[15] Only Price to Earnings is not the lowest when the World Value Tilt Index is compared to the other three indices.

Investability

As discussed in Section III, investability is a key driver of transaction costs (including market impact). Transaction costs may be high, and could impose a significant performance drag, in particular for large portfolios. We focus on four key dimensions of investability. These are:

- **Tradability/Liquidity**: For a given fund size, quantifies how liquid the stocks are in the portfolio and how tradable the portfolio is.
- **Turnover/Cost of Replication:** Measures the turnover of the index at rebalancing which scales with costs. The higher the turnover, the higher the cost of trading.
- **Capacity:** For a given fund size, quantifies the percentage of a stock's free float or full market capitalization the fund would own.
- **Degree of Active Tilt:** Captures the degree to which a portfolio or index is "active" relative to the benchmark.

Exhibit 19 compares the simulated risk premia within these four categories. Measures such as average days to trade and annual turnover indicate that several risk premia indices have strong investability characteristics for portfolios of considerable size. The more scalable risk premia are Value, Low Size and Low Volatility. For a USD 100 billion portfolio, these risk premia indices' weighted average days to trade range between 4.7 to 5.5 days compared to 3 days for the World Index. Annual turnover since 1992 has ranged between 12.4% to 18.6% compared to 4.3% for the World Index. Momentum on the other hand appears to be less scalable. The weighted average days to trade is 11.1 days, double that of the other three risk premia. Annual turnover has averaged 41% since 1992, resulting in a performance drag of 41 bps annually assuming a 50 bps transaction cost.

The potential costs of implementing factor strategies remain an important issue. As a first indication of costs, we compute the performance drag from risk premia indices assuming a flat transaction cost of 50 basis points per trade. Under this assumption, the cost in basis points equals the one way turnover in percent of the index. The numbers for performance drag of 12.4 to 18.6 bps (Exhibit 19) for the World Value, Low Size, and Low Volatility Tilt Indices are not unreasonable. However, these numbers do not incorporate market impact costs. The size of the current equity portfolio in the Government Pension Fund Global is approximately USD 400 billion, and is expected to grow. Investability for portfolios with a size beyond USD 100 billion is discussed in section VIII of this report. There, we emphasize that for portfolios of USD 100 billion and greater, investability is a key constraint that should be given the same weight as return and risk in the design of risk premia strategies.

We highlight the significant differences between the "score times market cap" and "score-only" approaches. Comparing the World Low Size Tilt Index to the World Equal Weighted Index for instance, we see that days to trade metrics can be 2 to 4 times greater for the latter and stock ownership metrics 2 to 3 times larger. Comparing the World Low Volatility Tilt Index to the World Risk Weighted Index, we see that days to trade metrics can be 3 to 6 times greater for the latter and stock ownership metrics 3 to 6 times larger.

These results indicate the usefulness of a score times market capitalization weighting scheme for large investors. Starting with market capitalization ensures high investability, while the "tilt" towards a particular risk premia (or factor) score manages to capture the risk premia. As shown earlier, these risk premia indices retain significant exposures to the equivalent "pure" theoretical risk premia (Exhibit 15).

Exhibit 19: Investability Metrics for World Risk Premia Indices

		Score x mcap				Score only	
Statistics from 30/11/1992 to 31/08/2012	WORLD STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Tradability of the Strategy							
Weighted Average ATVR ###	77.5%	92.8%	93.4%	62.2%	70.3%	108.6%	87.3%
Days to Trade - Periodic Rebalancing # ## ####							
Weighted Average	3.1	4.7	5.5	5.0	11.1	13.0	17.6
95 percentile	1.3	7.1	7.5	5.6	17.0	23.3	26.4
Tail Average @ 95%	4.1	12.2	15.2	9.8	23.7	39.7	52.6
Maximum	14.1	40.0	61.2	52.7	72.5	138.2	297.9
Days to complete 95% trading	9.6	13.7	20.1	15.2	25.6	46.6	68.2
Days to Trade - Relative to benchmark # ## ####							
Weighted Average	na	11.0	14.2	23.0	11.2	29.2	44.7
95 percentile	na	18.9	31.9	17.2	14.6	83.9	104.5
Tail Average @ 95%	na	27.0	47.9	35.5	21.1	134.7	207.8
Maximum	na	69.4	110.0	99.3	93.8	360.0	946.9
Days to complete 95% trading	na	24.3	33.3	79.8	25.2	81.1	159.7
Replication Costs							
Avg. Annual Turnover (%)**	4.3%	18.6%	12.4%	12.5%	41.0%	23.3%	24.2%
Performance Drag in bps (at 50 bps)	4.3	18.6	12.4	12.5	41.0	23.3	24.2
Capacity of the Strategy							
Stock Ownership (% of Float Market Cap) # ###							
Average	0.5%	0.55%	0.89%	0.36%	0.38%	1.46%	1.30%
95 percentile	0.5%	1.33%	1.70%	0.85%	0.84%	4.33%	4.16%
Tail Average @ 95%	0.5%	1.79%	1.91%	1.08%	1.04%	5.55%	5.94%
Maximum	0.5%	4.82%	2.42%	1.69%	1.38%	8.96%	15.16%
Stock Ownership (% of Full Market Cap) # ###							
Average	0.4%	0.44%	0.69%	0.30%	0.32%	1.06%	0.94%
95 percentile	0.5%	1.07%	1.23%	0.75%	0.78%	2.79%	2.70%
Tail Average @ 95%	0.5%	1.42%	1.39%	0.98%	0.96%	3.42%	3.93%
Maximum	0.5%	3.29%	2.04%	1.58%	1.32%	5.19%	8.71%
Degree of Index Tilt & Concentration ###							
Active Share	na	24.0%	26.4%	25.8%	22.3%	47.3%	47.4%
Avg Weight Multiplier	1.0	1.4	1.4	1.2	1.2	4.8	5.3
Max Weight Multiplier	1	227	36	9	4	779	519
Max Strategy Weight	2.0%	1.5%	0.4%	3.0%	2.7%	0.1%	0.4%
Active Target Factor Exposure	na	0.28	(0.45)	(0.33)	0.28	(0.90)	(0.34)

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 100 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

V. Geographical Differences in Risk Premia Indices

Key Results

- When the risk premia indices are extended to the regional level, we find that generally excess return remains positive except for the Pacific Momentum Tilt Index. The Momentum Tilt Indices in the US and Europe are in fact the strongest performers in those regions. The weak Momentum Tilt Index in the Pacific drags down the overall World results.
- When region-neutral versions of the World Risk Premia Indices are constructed, the tracking error and annualized return are generally lower than the unconstrained World Risk Premia Index. However, the differences are minimal. The annualized returns decrease by 2 to 26 bps while the tracking errors decrease by 7 to 29 bps.

In this section, we look at the characteristics of simulated indices for geographical subgroups of the MSCI World Index. The countries in the MSCI World Index can be divided into three broad subregions: US, Europe, and Pacific. (Canada is also in the MSCI World Index but is excluded here). We also examine Emerging Markets which comprises 19 countries and is not part of the MSCI World Index we have so far analyzed. As seen in the previous section, the risk premia indices constructed using the constituents of the World Index can result in significant region over and under weights. This raises the question of whether confining the risk premia to specific regions diminishes or increases.

Regional Risk Premia Indices

In this section we consider the following regions:

- Emerging Markets
- USA
- Europe
- Pacific

For the investability metrics, our assumption is an allocation of USD 50 billion for USA and Europe, and USD 20 billion for Emerging Markets and Pacific regions.

Exhibit 20 examines the performance numbers for the various regional indices against the World Risk Premia Indices. (Note that the top panel in Exhibit 20 displays the results from the World indices in the previous section, which we include for comparison.) Exhibit 21 summarizes key investability metrics for the various regional indices. Additional investability metrics for all indices are in Appendix E.

Exhibit 20: Summary of Simulated Geographic Region Risk Premia Indices (November 1992 to August 2012)

		Score x Mcap				Score Only	
Statistics from 30/11/1992 to 31/08/2012	Market Cap Index	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
World							
Annualized Return (%)	7.2%	8.3%	7.9%	8.2%	8.1%	8.3%	9.6%
Annualized Active Return		1.0%	0.7%	0.9%	0.8%	1.1%	2.3%
Annualized Risk (%)	15.5%	16.1%	15.7%	13.2%	15.8%	16.3%	13.9%
Return/Risk	0.47	0.51	0.50	0.62	0.51	0.51	0.69
Sharpe Ratio	0.23	0.29	0.27	0.34	0.28	0.29	0.43
Tracking error (%)		3.2%	2.6%	3.4%	3.6%	5.1%	5.3%
Information Ratio		0.32	0.25	0.27	0.22	0.21	0.44
Emerging Markets (11/95-)							
Annualized Return (%)	7.2%	9.8%	8.0%	7.9%	8.3%	8.3%	9.3%
Annualized Active Return		2.5%	0.7%	0.7%	1.0%	1.0%	2.0%
Annualized Risk (%)	25.1%	26.4%	24.7%	22.5%	25.8%	25.0%	21.0%
Return/Risk	0.29	0.37	0.32	0.35	0.32	0.33	0.44
Sharpe Ratio	0.15	0.24	0.18	0.20	0.19	0.19	0.28
Tracking error (%)		4.2%	3.5%	3.6%	3.9%	7.3%	7.5%
Information Ratio		0.59	0.21	0.19	0.27	0.14	0.27
USA							
Annualized Return (%)	8.3%	8.7%	8.9%	8.4%	9.5%	9.5%	9.6%
Annualized Active Return		0.3%	0.6%	0.1%	1.1%	1.2%	1.3%
Annualized Risk (%)	15.3%	15.7%	15.7%	13.0%	15.9%	16.5%	13.8%
Return/Risk	0.55	0.55	0.57	0.65	0.60	0.57	0.70
Sharpe Ratio	0.31	0.32	0.34	0.37	0.37	0.36	0.44
Tracking error (%)		4.1%	2.9%	3.8%	3.9%	5.4%	6.3%
Information Ratio		0.08	0.20	0.02	0.29	0.22	0.20
Europe							
Annualized Return (%)	8.4%	8.8%	9.1%	9.1%	9.5%	9.1%	10.2%
Annualized Active Return		0.4%	0.7%	0.8%	1.2%	0.7%	1.9%
Annualized Risk (%)	18.1%	19.7%	18.9%	16.1%	18.0%	19.5%	17.4%
Return/Risk	0.46	0.45	0.48	0.57	0.53	0.47	0.59
Sharpe Ratio	0.26	0.26	0.29	0.34	0.33	0.28	0.38
Tracking error (%)		3.5%	2.6%	3.2%	3.7%	5.1%	4.7%
Information Ratio		0.13	0.27	0.24	0.32	0.14	0.39
Pacific							
Annualized Return (%)	3.0%	5.4%	3.9%	4.9%	2.3%	4.6%	6.6%
Annualized Active Return		2.4%	0.9%	2.0%	-0.7%	1.7%	3.6%
Annualized Risk (%)	18.8%	18.6%	18.5%	16.7%	19.1%	19.0%	16.3%
Return/Risk	0.16	0.29	0.21	0.30	0.12	0.24	0.41
Sharpe Ratio	-0.03	0.09	0.01	0.08	-0.07	0.05	0.18
Tracking error (%)		3.2%	3.2%	3.6%	4.5%	6.5%	6.7%
Information Ratio		0.75	0.28	0.54	-0.16	0.26	0.55

* Gross Total Returns in USD

Exhibit 21: Investability Metrics for Geographic Region Risk Premia Indices (June 30, 2012)

		Individual Risk Premia Indices				Score Only	
Statistics from 30/11/1992 to 31/08/2012	Market Cap Index	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
World							
Tradability of the Strategy							
Weighted Average Days to Trade***	3	4.7	5.5	5.0	11.1	13.0	17.6
Replication Costs							
Avg. Annual Turnover (%)**	4.3%	18.6%	12.4%	12.5%	41.0%	23.3%	24.2%
Performance Drag in bps (at 50 bps)	4.3	18.6	12.4	12.5	41.0	23.3	24.2
Emerging Markets							
Tradability of the Strategy							
Weighted Average Days to Trade***	3	27.7	6.7	11.9	12.1	31.8	58.0
Replication Costs							
Avg. Annual Turnover (%)**	10.8%	28.2%	19.2%	18.6%	45.8%	33.1%	33.4%
Performance Drag in bps (at 50 bps)	10.8	28.2	19.2	18.6	45.8	33.1	33.4
USA							
Tradability of the Strategy							
Weighted Average Days to Trade***	4	6.4	7.0	4.7	12.7	15.1	14.5
Replication Costs							
Avg. Annual Turnover (%)**	4.3%	18.5%	12.0%	11.8%	41.4%	21.9%	21.2%
Performance Drag in bps (at 50 bps)	4.3	18.5	12.0	11.8	41.4	21.9	21.2
Europe							
Tradability of the Strategy							
Weighted Average Days to Trade***	4	6.2	8.7	6.6	15.0	21.9	27.1
Replication Costs							
Avg. Annual Turnover (%)**	4.0%	17.2%	11.4%	12.1%	40.2%	22.4%	24.3%
Performance Drag in bps (at 50 bps)	4.0	17.2	11.4	12.1	40.2	22.4	24.3
Pacific							
Tradability of the Strategy							
Weighted Average Days to Trade***	3	3.8	4.2	6.7	10.6	9.1	16.3
Replication Costs							
Avg. Annual Turnover (%)**	4.6%	19.1%	11.5%	12.9%	44.9%	21.7%	23.8%
Performance Drag in bps (at 50 bps)	4.6	19.1	11.5	12.9	44.9	21.7	23.8

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

*** Weighted average of the days to trade for all stocks in the portfolio during rebalancing; average of the last four rebalancings ending Jun 2012. Assumes fund size of USD 50 billion for US and Europe, USD 20 billion for EM and Pacific; and a trade limit of 10% of daily volume

We highlight the following:

- ***Emerging Markets:*** The relative performances of the risk premia compared to the market capitalization-weighted index are very similar to those for the World. The notable exception is the EM Value Tilt Index which significantly outperforms the other risk premia indices; this index has generated 250 bps annual outperformance relative to the MSCI EM Index. In contrast the World Value Index generated 100 bps annual outperformance relative to the World. Annualized risk of the risk premia indices is similar to that of the capitalization-weighted index; here, in contrast to the World results, the Low Size Tilt Index actually has lower volatility than the capitalization-weighted index. Investability, however, is significantly lower for Emerging Markets overall, even for the capitalization-weighted index (see Appendix E). We thus caution that investability issues deserve special consideration for Emerging Markets.

- ***USA:*** In the USA, the USA Momentum Tilt Index is the highest returning risk premium index historically. This contrasts with both the World and Emerging Markets results, where the Value Tilt Indices lead performance. Also, the premium for the Low Volatility Tilt Index is considerably weaker in the USA than in the World and Emerging Market results. On the other hand, this index's Sharpe Ratio is quite high.
- ***Europe:*** In Europe, the results also vary from the other regions. Here, the Momentum Tilt Index has the highest return similar to the US but not the World and Emerging Markets Indices. On the basis of Sharpe Ratios, the Low Volatility Tilt Index is the most attractive, which is similar to the World results but not the US results.
- ***Pacific:*** The Pacific region results differ the most from the other regions. Here, like Emerging Markets, the Value Tilt Index has exhibited significant returns. Unlike the other regions, the Low Volatility Tilt Index delivers a much higher historical premium. Also, the premium for the Momentum Tilt Index completely disappears in stark contrast to the other regions.

When we disaggregate the overall performance metrics into various subperiods, there are significant cycles, e.g., periods of under- and over-performance, as was true of the World Risk Premia Indices. As shown in Exhibit 22, which disaggregates the returns into two approximately decade-long subperiods, the Small Cap premium reflected by the Low Size Tilt Index was weak in the 1990s but strong in the 2000s. Returns from Value and Momentum were higher than the market capitalization index in both subperiods but they were stronger in the 1990s, particularly in the case of the Value Tilt Index. The Low Volatility Tilt Index on the other hand earned relatively higher returns in the 2000s. Again, as discussed earlier in the context of the World Risk Premia Indices, investing in risk premia strategies requires strong governance structures (clear investment beliefs, strong board support) to withstand the periods of underperformance and benefit from the potential premia over a full cycle.

Exhibit 22: Subperiod Returns for Regional Risk Premia Indices

	Market Cap Index	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt
Whole Period					
World	7.2%	8.3%	7.9%	8.2%	8.1%
Emerging Markets	7.2%	9.8%	8.0%	7.9%	8.3%
USA	8.3%	8.7%	8.9%	8.4%	9.5%
Europe	8.4%	8.0%	9.1%	9.1%	9.1%
Pacific	3.0%	5.4%	3.9%	4.9%	2.3%
December 1992 to December 2002					
World	6.7%	8.9%	6.5%	7.9%	8.2%
Emerging Markets	-3.8%	-0.8%	-3.9%	-3.8%	-0.7%
USA	9.3%	10.0%	9.3%	9.4%	11.6%
Europe	8.5%	9.8%	8.7%	9.0%	10.4%
Pacific	-1.2%	1.8%	-0.8%	1.3%	-1.6%
January 2003 to August 2012					
World	7.8%	7.9%	9.4%	8.4%	8.0%
Emerging Markets	16.2%	18.2%	17.6%	17.4%	15.4%
USA	7.3%	7.2%	8.6%	7.4%	7.3%
Europe	8.2%	7.8%	9.4%	9.2%	8.7%
Pacific	7.6%	9.2%	9.0%	8.9%	6.4%

Next, we discuss whether periods of under- and over-performance across risk premia occur across regions at the same time. To illustrate the differences across regions, we plot the cumulative active returns to the risk premia indices across regions in Exhibit 23. There is low dispersion in long-term performance across Low Size Tilt Indices and high dispersion in performance across Value Tilt Indices. For the Momentum Tilt and Low Volatility Tilt Indices, the regional indices are moderately similar except for the Pacific Indices.

Exhibit 23: Summary of Simulated Geographic Region Risk Premia Indices (November 1992 to August 2012)

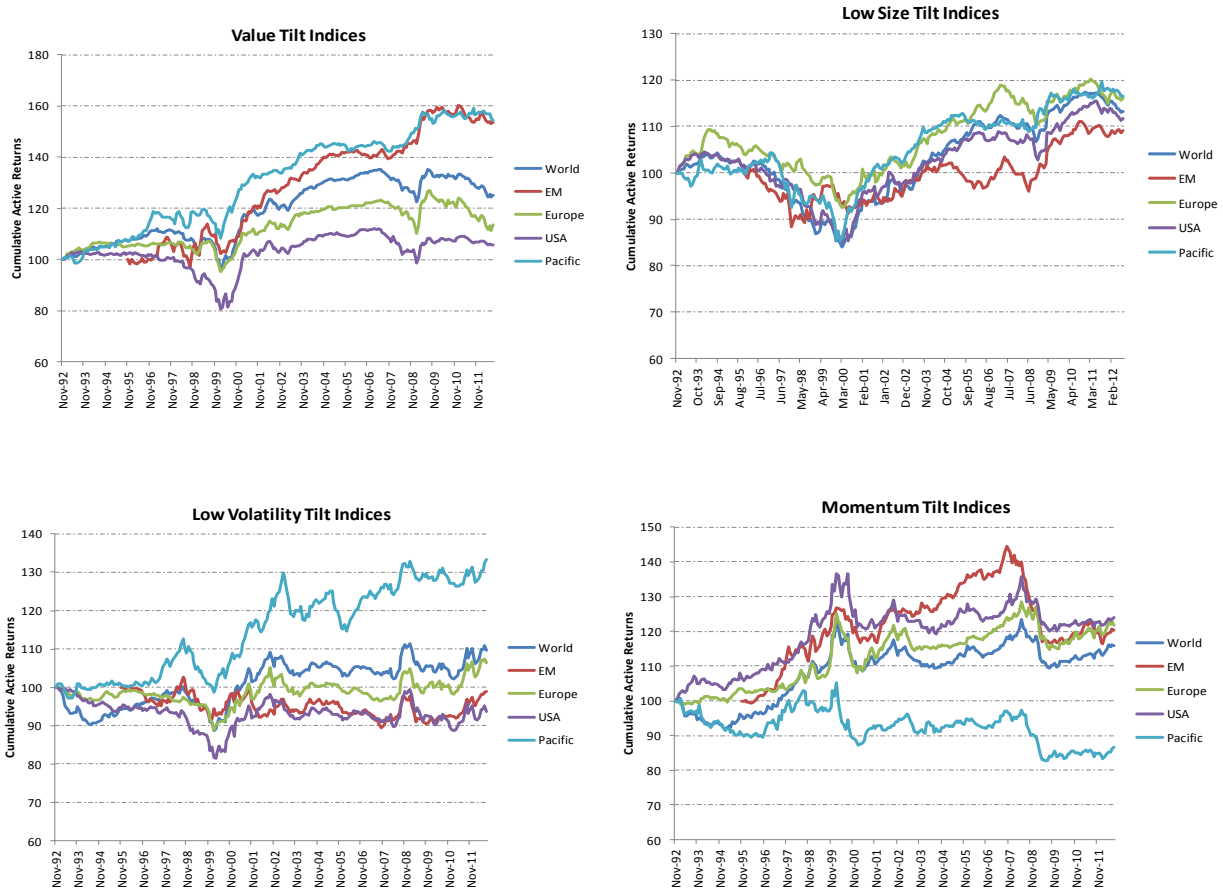


Exhibit 24 displays correlations using monthly active returns[16] for the various regional risk premia indices. These correlations measure month-to-month similarities between the indices as compared to the longer-term relationships in Exhibit 23. Again, the Value Tilt Indices have the lowest cross-region correlations. The average cross-region correlation is 0.32 versus that of 0.42, 0.63, and 0.61 for Low Size, Low Volatility, and Momentum respectively.

[16] Active returns are computed relative to the market cap weighted index. For example, the World Value Tilt Index returns are relative to the World Index, the USA Value Tilt Index returns are relative to the USA Index, and so forth.

Exhibit 24: Correlations across Risk Premia in Different Geographic Regions (Using Active Returns Relative to Market Capitalization-Weighted Index, December 1995 to August 2012)

	Value Tilt Indices						Low Size Tilt Indices						Low Volatility Tilt Indices						Momentum Tilt Indices					
		World	EM	Europe	USA	Pacific		World	EM	Europe	USA	Pacific		World	EM	Europe	USA	Pacific		World	EM	Europe	USA	Pacific
Value Tilt Indices																								
World		1.00																						
EM		0.44	1.00																					
Europe		0.00	-0.04	1.00																				
USA		0.89	0.32	0.06	1.00																			
Pacific		0.55	0.36	0.21	0.40	1.00																		
Low Size Tilt Indices																								
World		0.67	0.30	0.04	0.53	0.38		1.00																
EM		0.30	0.41	0.13	0.27	0.21		0.32	1.00															
Europe		0.54	0.29	-0.26	0.40	0.24		0.73	0.24	1.00														
USA		0.63	0.22	-0.13	0.68	0.23		0.77	0.20	0.56	1.00													
Pacific		0.38	0.24	0.23	0.27	0.66		0.50	0.40	0.30	0.17	1.00												
Low Volatility Tilt Indices																								
World		0.15	-0.06	0.89	0.22	0.27		0.04	0.15	-0.21	-0.06	0.27		1.00										
EM		-0.10	-0.35	0.54	0.00	-0.03		-0.05	0.06	-0.18	-0.09	0.10		0.59	1.00									
Europe		0.00	-0.04	1.00	0.06	0.21		0.04	0.13	-0.26	-0.13	0.23		0.89	0.54	1.00								
USA		0.17	-0.07	0.81	0.26	0.24		0.10	0.18	-0.17	-0.03	0.28		0.96	0.55	0.81	1.00							
Pacific		-0.04	-0.12	0.40	0.05	0.12		-0.25	0.04	-0.18	-0.14	0.08		0.58	0.48	0.40	0.48	1.00						
Momentum Tilt Indices																								
World		-0.66	-0.26	0.04	-0.65	-0.43		-0.33	-0.23	-0.27	-0.35	-0.37		-0.10	0.03	0.04	-0.16	-0.04		1.00				
EM		-0.37	-0.33	-0.02	-0.34	-0.33		-0.25	-0.30	-0.21	-0.17	-0.36		-0.05	-0.11	-0.02	-0.07	0.04		0.55	1.00			
Europe		-0.61	-0.25	0.17	-0.50	-0.35		-0.29	-0.13	-0.36	-0.30	-0.31		0.04	0.09	0.17	0.02	0.01		0.82	0.50	1.00		
USA		-0.61	-0.21	0.00	-0.68	-0.37		-0.26	-0.23	-0.23	-0.35	-0.30		-0.18	0.00	0.00	-0.23	-0.09		0.92	0.46	0.68	1.00	
Pacific		-0.46	-0.26	-0.15	-0.39	-0.58		-0.31	-0.20	-0.16	-0.17	-0.45		-0.17	-0.05	-0.15	-0.20	0.01		0.67	0.50	0.46	0.50	1.00

Region-Neutral Indices

Since the outperformance of risk premia is largely maintained when we shift to regional indices, it follows that global indices, specifically designed to be region-neutral (i.e., no overweights or underweights to regions) should also maintain their outperformance.[17] At the same time, we expect region-neutral versions of the risk premia indices to deliver lower returns relative to the unconstrained indices since tracking error to the market capitalization weighted indices will generally be lower if there are no active region tilts.

Exhibit 25 summarizes the performance of risk premia indices constructed such that the region active weights are zero at the time of each semiannual rebalancing. As expected, tracking error and annualized return are generally lower than the unconstrained World Risk Premia Index. However, the differences are minimal. The annualized returns decrease by 2 to 26 bps while the tracking errors decrease by 7 to 29 bps.

[17] The regional risk premia indices are effectively region-neutral since they are constructed "within" a specific region. One can think of a global retion-neutral risk premia index as one that combines these using market capitalization weights.

Exhibit 25: Summary of Simulated World Region-Neutral Risk Premia Indices (November 1992 to August 2012)

Statistics from 30/11/1992 to 31/08/2012	World Index	World Risk Premia Index	Region-Neutral World Risk Premia Index
Value Tilt			
Annualized Return (%)*	7.2%	8.3%	8.1%
Annualized Risk (%)	15.5%	16.1%	16.1%
Return/Risk	0.47	0.51	0.50
Sharpe Ratio	0.23	0.29	0.28
Tracking error (%)		3.2%	3.2%
Low Size Tilt			
Annualized Return (%)*	7.2%	7.9%	7.8%
Annualized Risk (%)	15.5%	15.7%	15.9%
Return/Risk	0.47	0.50	0.49
Sharpe Ratio	0.23	0.27	0.27
Tracking error (%)		2.6%	2.3%
Low Volatility Tilt			
Annualized Return (%)*	7.2%	8.2%	7.9%
Annualized Risk (%)	15.5%	13.2%	13.3%
Return/Risk	0.47	0.62	0.59
Sharpe Ratio	0.23	0.34	0.32
Tracking error (%)		3.4%	3.2%
Momentum Tilt			
Annualized Return (%)*	7.2%	8.1%	8.0%
Annualized Risk (%)	15.5%	15.8%	15.8%
Return/Risk	0.47	0.51	0.51
Sharpe Ratio	0.23	0.28	0.28
Tracking error (%)		3.6%	3.4%

* Gross Total Returns in USD

Furthermore, the investability characteristics are also similar for the region-neutral versions of the World Risk Premia Indices. Exhibit 26 compares key metrics such as weighted average days to trade and average annual turnover for these indices. In fact, the average annual turnover declines for all region-neutral risk premia indices relative to their unconstrained versions, as does average days to trade for the World Low Volatility and Momentum Tilt Indices.

Exhibit 26: Investability Metrics for Simulated World Region-Neutral Risk Premia Indices

	World Index	World Risk Premia Index	Region-Neutral World Risk Premia Index
Value Tilt			
Tradability of the Strategy			
Weighted Average Days to Trade***	3.1	4.7	5.1
Replication Costs			
Avg. Annual Turnover (%)**	4.3%	18.6%	18.2%
Performance Drag in bps (at 50 bps)	4.3	18.6	18.2
Low Size Tilt			
Tradability of the Strategy			
Weighted Average Days to Trade***	3.1	5.5	5.9
Replication Costs			
Avg. Annual Turnover (%)**	4.3%	12.4%	12.3%
Performance Drag in bps (at 50 bps)	2.2	12.4	12.3
Low Volatility Tilt			
Tradability of the Strategy			
Weighted Average Days to Trade***	3.1	5.0	4.9
Replication Costs			
Avg. Annual Turnover (%)**	4.3%	12.5%	12.1%
Performance Drag in bps (at 50 bps)	2.2	12.5	12.1
Momentum Tilt			
Tradability of the Strategy			
Weighted Average Days to Trade***	3.1	11.1	10.2
Replication Costs			
Avg. Annual Turnover (%)**	4.3%	41.0%	39.9%
Performance Drag in bps (at 50 bps)	2.2	41.0	39.9

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012
*** Weighted average of the days to trade for all stocks in the portfolio during rebalancingending Jun 2012. Assumes fund size of USD 100 billion; and a trade limit of 10% of daily volume

It should be noted that the Sharpe Ratios in Exhibit 25 are generally slightly lower or the same for the region-neutral indices. The World Low Volatility Tilt Index exhibits the largest decrease in Sharpe Ratio—from 0.34 to 0.32. Meanwhile, those for the World Momentum Tilt and Low Size Tilt Indices remain the same. These results are consistent with the intuition that the ability to arbitrage opportunities for value, momentum, low volatility, and small caps should in theory be larger given a broader opportunity set. The differences we find are nonetheless relatively small. Further research regarding this topic remains an interesting area of future study. Points of focus may include the implications of using alternative region definitions, signal definition, and rebalancing frequency.

VI. World Focused Risk Premia Indices

Key Results

- We explore the use of focused indices for capturing risk premia. Overall, the results do not suggest any advantages to employing focused indices. Historically, there is not a sizable difference in terms of return and risk but the focused indices are much less investable.
- For instance, with the Low Size Indices, active returns improve by 140 bps annually but annual turnover increases from 12.4% to 58.3% resulting in performance drag increasing from 12 bps to 58 bps assuming transaction costs of 50 bps. Similarly for the Momentum Indices, active returns improve by 120 bps annually but turnover increases from 41% to 112% resulting in performance drag increasing from 41 bps to 112 bps.
- For the Value and Low Volatility Indices, the active return in fact deteriorates when moving from broad to focused indices. The results of performance attribution suggest it is a result of the impact on sector active weights and incidental tilts to other factors.

To better understand the trade-off between investability and signal strength (Exhibit 3), we now simulate focused indices using the same methodology as outlined in Section III. For each of the four indices, we construct focused index versions using the same weighting approaches. The only difference between these focused and the broad indices is the choice of universe. Instead of including in the risk premium indices the whole universe of stocks (the same as the parent capitalization-weighted index), we use the top 300 stocks sorted by the desired characteristic.

In theory the signal should be stronger; that is, if the stock characteristic has as strong positive return, then a stronger signal should, all else equal, deliver higher returns. In practice, the focused index may have different (potentially larger) sector biases and/or exposures to other stock characteristics; these could offset the performance gain from the stronger signal. In addition, a signal's strength can vary across the distribution of stocks; some signals may be strong in the tails and some may be more evenly spread out. A signal that is strong in the middle of the distribution may not benefit through this approach.

Exhibits 27 and 28 show just the top-line performance numbers and the investability metrics for the focused indices. For comparison, we show them next to the equivalent broad index. In the case of Low Size and Low Volatility, we also show the score-only indices; and for Low Volatility, we show the MSCI World Minimum Volatility Index.[18]

In the case of Low Size and Momentum risk premia, the return to the risk premia increases (i.e., the signal strength increases) as expected when we move from broad to focused indices. The return to the Low Size Tilt Focused Index is 9.3% compared to 7.9% for the (Broad) Low Size Tilt Index. Compared to a return of 7.2% for the World Index, the focused index triples the active return achievable through the tilt to smaller cap stocks. However, this comes at a considerable cost to liquidity. The average number of days to trade increases from 5.5 days to 321 days and the turnover increases from 12.4% to 58.3%

[18] This index is an official MSCI index which is constructed using the Barra Global Equity Model (GEM2) with an optimizer that makes use of the full covariance matrix. Further details on this index can be found in "MSCI Global Minimum Volatility Indices Methodology" (January 2012).

A similar effect is seen with the Momentum risk premia as we move from broad to focused indices. Turnover for instance increases from 41% to 112%. Assuming a 50 bps per trade, the estimated cost of 112 bps is 71.3 bps higher than the estimated cost for the broad index and "eats up" over half of the premium (120 bps).

In the case of Value and Low Volatility, the return deteriorates when moving from broad to focused indices. This unintuitive result could either be a result of the distribution of the signal's strength across the universe or a result of incidental tilts. For both factors, the investability of the indices actually improves for certain metrics such as percentage stock ownership and weighted average Annual Traded Value Ratio (ATVR). Only the days to trade and the turnover increases but neither do so in a significant way.

Given the deterioration of investability for the risk premia whose signals strengthen, overall these results confirm the appropriateness of a broad approach to exploiting risk premia in large portfolios. The results do not suggest a clear benefit from employing focused indices relative to broad.

Exhibit 27: Comparison of Low Size and Low Volatility Focused Indices to Broad Indices[19]

	Low Size			Low Volatility			
Statistics from 30/11/1992 to 31/08/2012	Broad Low Size Tilt	Equal Weighted	Focused Low Size Tilt	Broad Low Volatility Tilt	Risk Weighted	Focused Low Volatility Tilt	Minimum Volatility
Annualized Return (%)*	7.9%	8.3%	9.3%	8.2%	9.6%	8.0%	5.5%
Annualized Risk (%)	15.7%	16.3%	18.7%	13.2%	13.9%	12.9%	11.4%
Return/Risk	0.50	0.51	0.50	0.62	0.69	0.62	0.48
Sharpe Ratio	0.27	0.29	0.30	0.34	0.43	0.34	0.22
Tradability of the Strategy							
Weighted Average ATVR ###	93.4%	108.6%	154.4%	62.2%	87.3%	52.1%	61.4%
Days to Trade - Periodic Rebalancing # ## ####							
Weighted Average	5.5	13.0	321.3	5.0	17.6	13.4	122.6
95 percentile	7.5	23.3	159.6	5.6	26.4	5.8	5.8
Tail Average @ 95%	15.2	39.7	403.3	9.8	52.6	17.5	17.5
Maximum	61.2	138.2	1992.6	52.7	297.9	85.3	85.3
Days to complete 95% trading	20.1	46.6	795.0	15.2	68.2	40.4	40.4
Days to Trade - Relative to benchmark # ## ####							
Weighted Average	14.2	29.2	387.5	23.0	44.7	51.3	196.1
95 percentile	31.9	83.9	934.0	17.2	104.5	68.2	68.2
Tail Average @ 95%	47.9	134.7	1334.4	35.5	207.8	99.3	99.3
Maximum	110.0	360.0	1825.7	99.3	946.9	144.7	144.7
Replication Costs							
Avg. Annual Turnover (%)**	12.4%	23.3%	58.3%	12.5%	24.2%	15.9%	42.6%
Performance Drag in bps (at 50 bps)	12.4	23.3	58.3	12.5	24.2	15.9	42.6
Capacity of the Strategy							
Stock Ownership (% of Float Market Cap) # ###							
Average	0.89%	1.46%	3.67%	0.36%	1.30%	0.14%	4.63%
95 percentile	1.70%	4.33%	21.47%	0.85%	4.16%	0.96%	0.96%
Tail Average @ 95%	1.91%	5.55%	24.12%	1.08%	5.94%	1.34%	1.34%
Maximum	2.42%	8.96%	30.56%	1.69%	15.16%	2.22%	2.22%
Stock Ownership (% of Full Market Cap) # ###							
Average	0.69%	1.06%	2.28%	0.30%	0.94%	0.13%	3.58%
95 percentile	1.23%	2.79%	15.32%	0.75%	2.70%	0.90%	0.90%
Tail Average @ 95%	1.39%	3.42%	17.50%	0.98%	3.93%	1.25%	1.25%
Maximum	2.04%	5.19%	25.76%	1.58%	8.71%	2.08%	2.08%
Degree of Index Tilt & Concentration ###							
Active Share	26.4%	47.3%	97.6%	25.8%	47.4%	43.2%	77.7%
Avg Weight Multiplier	1.42	4.76	63.51	1.24	5.28	1.80	1.80
Max Weight Multiplier	36	779	766	9	519	11	11
Max Strategy Weight	0.4%	0.1%	0.4%	3.0%	0.4%	4.0%	4.0%
Active Target Factor Exposure	(0.45)	(0.90)	(1.63)	(0.33)	(0.34)	(0.42)	(0.42)

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 100 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

[19] The higher turnover in Minimum Volatility is due to a one-off transition to the enhanced methodology and the GEM2L model in Nov 2009. The annual turnover for the live Index without the transition turnover is 20%"

Exhibit 28: Comparison of Value and Momentum Focused Indices to Broad Indices

	Value		Momentum	
Statistics from 30/11/1992 to 31/08/2012	Broad Value Tilt	Focused Value Tilt	Broad Momentum Tilt	Focused Momentum Tilt
Annualized Return (%)*	8.3%	8.1%	8.1%	9.3%
Annualized Risk (%)	16.1%	16.4%	15.8%	19.1%
Return/Risk	0.51	0.49	0.51	0.49
Sharpe Ratio	0.29	0.27	0.28	0.30
Tracking error (%)	3.2%	3.6%	3.6%	10.0%
Tradability of the Strategy				
Weighted Average ATVR ###	92.8%	86.1%	70.3%	68.4%
Days to Trade - Periodic Rebalancing # ## ####				
Weighted Average	4.7	11.9	11.1	56.5
95 percentile	7.1	5.5	17.0	68.6
Tail Average @ 95%	12.2	15.8	23.7	95.1
Maximum	40.0	73.7	72.5	252.8
Days to complete 95% trading	13.7	38.9	25.6	122.1
Days to Trade - Relative to benchmark # ## ####				
Weighted Average	11.0	22.0	11.2	48.8
95 percentile	18.9	42.4	14.6	64.5
Tail Average @ 95%	27.0	52.2	21.1	90.2
Maximum	69.4	64.1	93.8	283.6
Replication Costs				
Avg. Annual Turnover (%)**	18.6%	20.0%	41.0%	112.2%
Performance Drag in bps (at 50 bps)	18.6	20.0	41.0	112.2
Capacity of the Strategy				
Stock Ownership (% of Float Market Cap) # ###				
Average	0.55%	0.20%	0.38%	0.31%
95 percentile	1.33%	1.30%	0.84%	1.62%
Tail Average @ 95%	1.79%	2.02%	1.04%	2.22%
Maximum	4.82%	7.26%	1.38%	3.18%
Stock Ownership (% of Full Market Cap) # ###				
Average	0.44%	0.17%	0.32%	0.26%
95 percentile	1.07%	1.10%	0.78%	1.45%
Tail Average @ 95%	1.42%	1.69%	0.96%	2.00%
Maximum	3.29%	4.72%	1.32%	3.05%
Degree of Index Tilt & Concentration ###				
Active Share	24.0%	43.6%	22.3%	64.0%
Avg Weight Multiplier	1.39	2.13	1.23	4.84
Max Weight Multiplier	227	314	4	20
Max Strategy Weight	1.5%	2.2%	2.7%	5.9%
Active Target Factor Exposure	0.28	0.35	0.28	0.83

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 100 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

VII. Portfolios of Risk Premia

Key Results

- There are several benefits to combining multiple risk premia in a portfolio. These are diversification (both long-term and short-term, and in both normal and extreme periods), potential diversification of systematic sources of risk, and reduction of turnover due to natural crossing
- The combinations we analyze exhibit good performance, low tracking error, and high Sharpe Ratios and Information Ratios. For instance, all 8 combinations we analyze produce annualized active returns between 85 to 100 basis points, and all produce Sharpe Ratio improvements between 20% to 25%.
- Moreover, these combinations of risk premia are more investable because of the advantages of being able to cross trades across the indices at rebalancings. This leads to a reduction in annual turnover which results in transaction cost savings.

So far we have analyzed risk premia indices individually. In this section, we combine risk premia indices into portfolios comprising two or more risk premia. There are several reasons why portfolios of risk premia indices may make sense. First, risk premia are cyclical in nature and historically have exhibited long periods of underperformance. This may in fact be one of the reasons why the premia have not been arbitraged away. Second, building a portfolio of risk premia may bring diversification benefits not only over long cycles but also as viewed through monthly correlations and protection during crises. Third, combining certain risk premia can lead to a potential reduction in exposure to sources of systematic risk outside the targeted risk premia. These may include exposure to country risk and/or sector risk.

There is also an important implementation benefit related to combining risk premia in a portfolio. In a multiple-risk-premia portfolio, there may be the opportunity to cross trades for the individual risk premia in the portfolio. This "natural crossing" leads to lower turnover and by implication, lower transaction costs.

The benefits for combining risk premia we next discuss are:

- ***Diversification of Sources of Return/Alpha***
- ***Potential Reduction in Exposure to Sources of Systematic Risk Outside the Targeted Risk Premia***
- ***Natural Crossing Leading to Lower Turnover***

Diversification

We have seen already how risk premia indices undergo cycles including multi-year periods of underperformance which are often not coincident. As we saw in Section III, the MSCI World Low Size and Low Volatility Tilt Indices have historically experienced the most number of years of underperformance. (The World Low Size Tilt Index has historically seen the longest *consecutive* period of underperformance.) What this suggests is that investing in a single risk premia index may entail a significant amount of "timing risk." In other words, the point of entry into risk premia-based investing can have a sizable impact on performance.

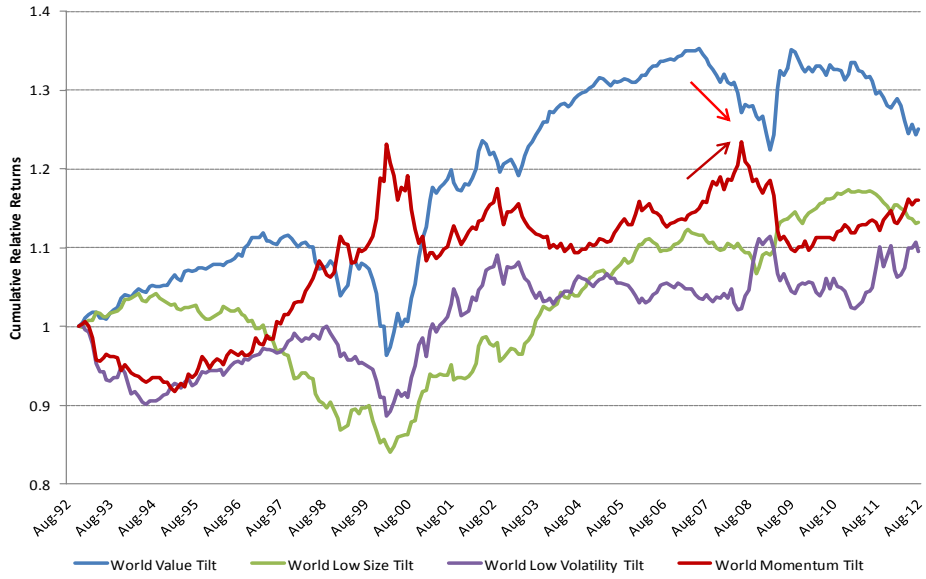
A clear implication is that investing in multiple risk premia at a single point of allocation (or entry into the investment) is likely to help ameliorate this problem of timing risk. Moreover, over time, the portfolio of risk premia will benefit from diversification across the indices. The potential for return diversification can also be seen in the correlations between monthly active returns shown in Exhibit 29. Notably, the active returns of the World Low Volatility and Momentum Tilt Indices have very low or negative correlation with other risk premia indices.

Exhibit 29: Correlation of Active Monthly Returns (December 1992 to August 2012, USD Gross Returns)

Correlations of Relative Returns	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
World Value Tilt	1.00			
World Low Size Tilt	0.66	1.00		
World Low Volatility Tilt	0.16	0.02	1.00	
World Momentum Tilt	-0.63	-0.33	-0.04	1.00

The benefits of diversification can be further seen in the illustration below. For instance, in the period April 2007 to August 2008 (see red arrows), the World Momentum Tilt Index moved in the opposite direction of the World Value Tilt Index. As discussed earlier in Section IV, Momentum and Value have generally tended to move in opposite directions since high momentum stocks tend to be less "value-like" and low momentum stocks tend to be more "value-like." In this particular period on the eve of the Financial Crisis, the magnitude of the factors' movements is particularly striking. Momentum stocks soared at the same time as value stocks plummeted during this period.

Exhibit 30: Risk Premia Indices May Exhibit Periods of Decoupling



Potential Reduction in Exposure to Sources of Systematic Risk

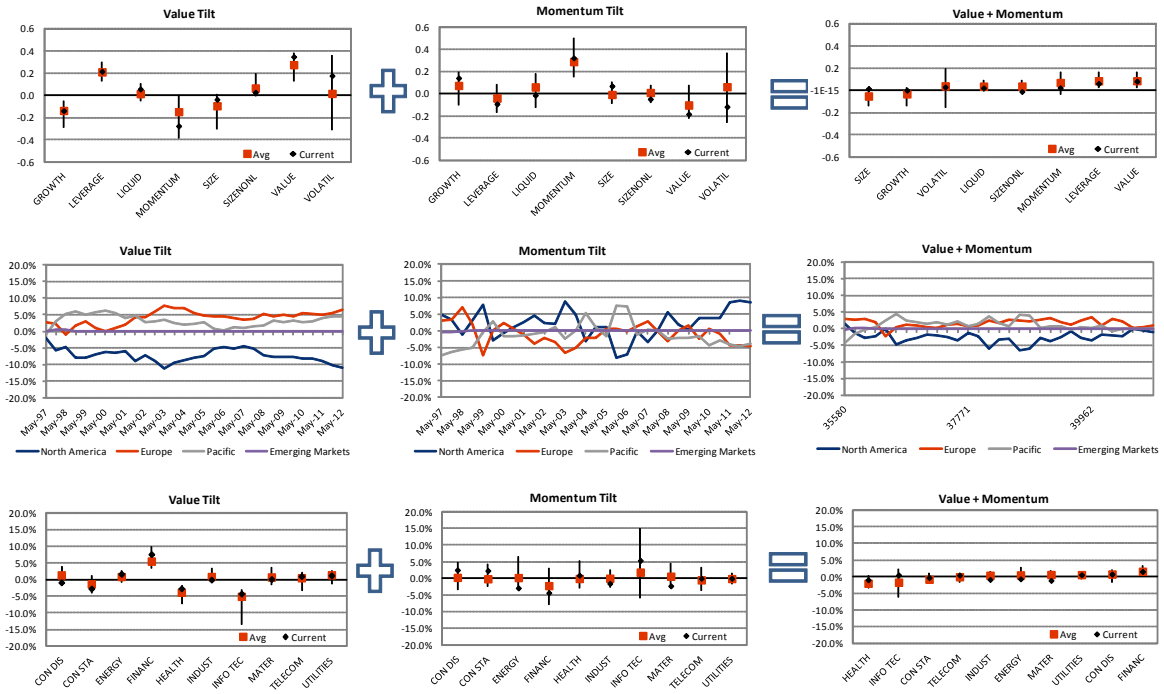
A second advantage that may accrue to portfolio of risk premia is the change in exposures to sources of other systematic risks outside the targeted risk premia. As we have seen, some risk premia indices can have substantial tilts to certain regions or sectors. By combining these risk premia with others, it is sometimes possible to reduce these tilts while still preserving the return and risk characteristics.

For instance, Exhibit 31A shows the impact on the sector and region active exposures by combining the World Momentum Tilt Index with the World Value Tilt Index. On its own, the World Value Tilt Index has considerable region tilts and a few important sector tilts. Merging the index with the Momentum Tilt Index neutralizes these tilts. The returns to the two risk premia are still preserved signaling that these tilts are not significant in driving the performance of the risk premia. The World Value Tilt Index outperformed the World Index by 116 bps annually from November 1992 to August 2012 while the World Momentum Tilt Index outperformed by 81 bps annually. The combined portfolio yielded 96 bps outperformance.

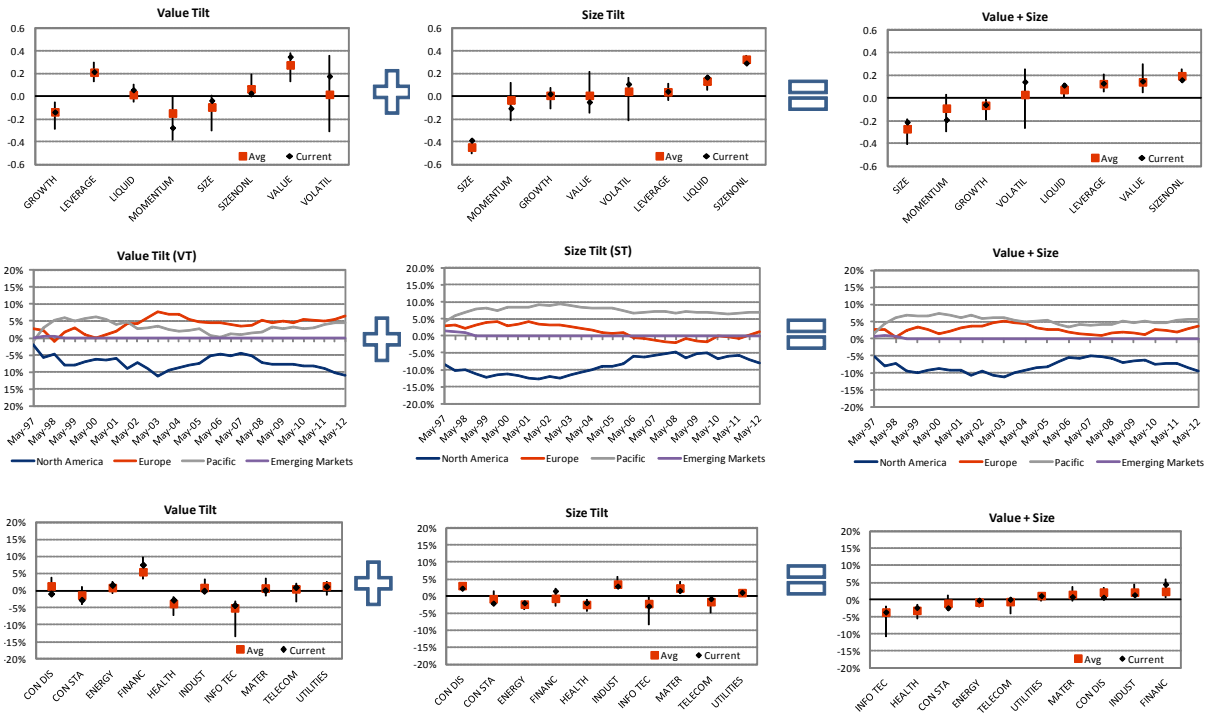
However, whether this phenomenon holds when combining two risk premia indices in a portfolio will depend on the specific risk premia indices chosen. Exhibit 31B illustrates the same charts this time for the combination of World Value Tilt and World Low Size Tilt Indices. Because both indices have historically been underweight North America, the regional exposures do not significantly change when the indices are combined. Both indices also historically underweight sectors like Health Care and Information Technology, having little effect on the combination portfolio's sector active weights.

Exhibit 31: Combining Risk Premia May Change the Exposure to Systematic Sources of Risk (Active Weights, Sector and Style Charts Show Average from May 1997 to August 2012)

A. Combination of World Value and Momentum Tilt Indices



A. Combination of World Value and Low Size Tilt Indices



Natural Internal Crossing Leading to Lower Turnover

Another benefit to combining multiple risk premia in a portfolio is related to implementation. As mentioned earlier, in a multiple-risk-premia portfolio, there may be the opportunity to cross trades for the individual risk premia in the portfolio. This "natural crossing" leads to lower turnover and by implication, lower transaction costs.

Take for example a stock whose price is falling over time. As the price falls, it may drop out of a momentum strategy but the lower price could push the stock into a value strategy. If a manager is running both the momentum and value strategies together, and making the simple assumption that the same amount of shares is required for both strategies, the manager would not have to sell the stock in this example. Zero turnover would be incurred and thus no transaction costs.

This logic can be extended to the risk premia indices. Combining certain risk premia indices might reduce turnover significantly due to this "natural crossing" at rebalancing. For instance, consider the case where an institutional investor allocates 50% of the portfolio to each of two strategy indices. The portfolio is rebalanced back to the target 50/50 allocation every six months. In the first implementation option, there are two "separate" managers, which requires reallocation of capital from one manager to the other to return to the target 50/50. Each manager would have to rebalance each strategy index separately without crossing trades. The second implementation option uses a single manager. In this "combined" portfolio, the manager can exploit crossing opportunities. In addition, in the combined option there would be no need for the asset owner to reallocate funds. As a result, the combined option offers potentially lower index turnover and lower transaction costs. We illustrate the benefits of natural crossing in Exhibit 32 using the simulated risk premia indices. Turnover is reduced by as much as 10.6 percentage points which results in lower transaction costs.

Exhibit 32: Reduction in Turnover Illustrates "Natural Crossing" Benefits (Simulated World Risk Premia Indices, November 1992 to August 2012)

	Turnover of Risk Premia Index #1	Turnover of Risk Premia Index #2	Turnover for "Separate" Manager Option	Turnover for "Combined" Manager Option	Reduction in Turnover
Low Volatility Tilt / Value Tilt	12.5%	18.6%	16.7%	12.7%	4.0%
Low Volatility Tilt / Momentum Tilt	12.5%	41.0%	28.0%	23.1%	4.9%
Value Tilt / Size Tilt	12.4%	18.6%	16.0%	15.0%	1.0%
Value Tilt / Momentum Tilt	41.0%	18.6%	31.3%	20.7%	10.6%

All portfolios are equally weighted. Turnover is a one-way annual average from November 1992 to August 2012

Results of Portfolios Formed by Combining Risk Premia Indices

We evaluate the following portfolios, all equally weighted:

- Value and Low Volatility
- Momentum and Low Volatility
- Value and Low Size
- Value and Momentum
- Value, Low Size, and Momentum
- Value, Low Volatility, and Momentum
- Value, Low Volatility, and Low Size
- Value, Low Size, Low Volatility, and Momentum

The key metrics we analyzed for the World Risk Premia Indices (Section IV) are consolidated in Exhibits 33 and 34. These exhibits strongly highlight the advantages of combining risk premia from both the risk and investability perspectives. While returns are effectively linear combinations of the individual risk premia, the risk metrics and investability metrics are not.

In Exhibit 33, combining two or more risk premia offers clear diversification benefits. Tracking errors fall substantially from the standalone risk premia indices. Four of the portfolios shown had tracking error of 1.4-1.6% while the other four were only moderately higher at 2.2-2.6%. These realized tracking errors are much lower than that of the individual risk premia indices which were 3.2% (Value), 2.6% (Low Size), 3.4% (Low Volatility), and 3.6% (Momentum) over the same period.

Turning to total annualized risk, we note that the combination portfolios also exhibit diversification benefits. The combined Low Volatility/Momentum Tilt Index's total risk is 14.4%, lower than the 14.6% obtained if we combine the individual annualized risks of 13.2% and 15.8% respectively.[20] As another example, if we combine the Low Volatility, Momentum, and Value Tilt Indices, the expected shortfall at 95% is -10.2% compared to the standalone shortfalls of -9.2%, -10.5%, and –11.4% respectively, which average to -10.4%.

In addition, the number of years of underperformance is generally the same or lower than the individual risk premia indices. In particular, the Low Volatility, Low Size, and Value Tilt combination and the combination of all four indices both exhibit substantially lower years of underperformance compared to any of the individual risk premia indices.

[20] Note that to be accurate, we square the annualized risk numbers and take the average of the two, then take the square root.

Exhibit 33: Return and Risk for Combined Risk Premia Portfolios (November 1992 to August 2012)

Statistics from 30/11/1992 to 31/08/2012	WORLD STANDARD	Low Volatility / Value	Low Volatility / Momentum	Value / Low Size	Value / Momentum	Value / Low Size / Momentum	Low Volatility / Momentum / Value	Low Volatility / Low Size / Value	Value / Low Size / Low Volatility / Momentum
Total Return Performance									
Annualized Return (%)*	7.2%	8.2%	8.1%	8.1%	8.2%	8.1%	8.2%	8.1%	8.1%
Annualized Risk (%)	15.5%	14.6%	14.4%	15.9%	15.7%	15.6%	14.8%	14.9%	15.0%
Return/Risk	0.47	0.57	0.57	0.51	0.52	0.52	0.55	0.55	0.54
Sharpe Ratio	0.23	0.32	0.31	0.28	0.29	0.29	0.31	0.30	0.30
Correlation		0.99	0.99	0.99	1.00	1.00	1.00	0.99	1.00
Historical Beta		0.93	0.92	1.01	1.01	1.01	0.95	0.96	0.97
Ann. Downside Deviation (%)	10.8%	10.0%	9.9%	10.9%	10.9%	10.8%	10.2%	10.3%	10.4%
Sortino ratio	0.67	0.82	0.82	0.74	0.76	0.75	0.80	0.79	0.79
95 percentile Var (%)	-8.3%	-7.1%	-6.8%	-8.3%	-7.9%	-7.9%	-7.7%	-7.6%	-7.8%
99 percentile Var (%)	-12.0%	-11.0%	-11.3%	-12.4%	-12.7%	-12.8%	-11.5%	-11.3%	-11.8%
Expected Shortfall @ 95%	-10.5%	-10.2%	-9.7%	-11.2%	-10.8%	-10.8%	-10.2%	-10.5%	-10.4%
Expected Shortfall @ 99%	-16.1%	-15.5%	-15.4%	-16.8%	-16.5%	-16.7%	-15.8%	-16.0%	-16.1%
Max Drawdown (%)	53.6%	53.3%	51.4%	55.9%	55.5%	55.2%	53.4%	53.7%	53.7%
Max Drawdown period (in months)	16	16	16	16	16	16	16	16	16
Skewness	-0.76	-0.78	-0.84	-0.74	-0.80	-0.81	-0.82	-0.80	-0.83
Kurtosis	4.49	4.99	4.61	5.13	4.67	4.84	4.75	5.06	4.86
Active Return Performance									
Active Return (bps)		100	89	85	96	87	96	90	90
Tracking error (%)		2.5%	2.4%	2.6%	1.5%	1.5%	1.6%	2.2%	1.4%
Information Ratio		0.40	0.37	0.32	0.64	0.58	0.62	0.41	0.62
Number of years of underperformance (out of 19)		7	5	7	5	7	6	6	6
Max Number of consecutive years of underperformance		2	2	3	2	3	2	3	2
Ann. Downside Deviation (%)		1.7%	1.8%	1.7%	0.9%	0.9%	1.0%	0.2%	0.9%
Sortino ratio		0.46	0.35	0.49	1.03	0.95	0.77	0.01	0.86
95 percentile Var (%)		-1.0%	-1.1%	-1.2%	-0.6%	-0.5%	-0.6%	-0.2%	-0.7%
99 percentile Var (%)		-1.9%	-2.6%	-1.9%	-1.0%	-0.8%	-1.3%	-0.2%	-1.0%
Expected Shortfall @ 95%		-1.6%	-1.9%	-1.7%	-0.8%	-0.8%	-1.1%	-0.2%	-0.9%
Expected Shortfall @ 99%		-3.1%	-3.0%	-2.5%	-1.5%	-1.4%	-1.7%	-0.2%	-1.4%
Max Drawdown (%)		11.8%	8.7%	14.6%	4.2%	3.0%	6.0%	3.2%	4.7%
Max Drawdown period (in months)		26	18	39	17	38	17	18	22
Skewness		0.22	-0.92	0.58	0.33	0.62	0.23	2.26	0.81
Kurtosis		7.59	6.43	7.32	5.78	6.79	7.80	25.46	9.08
Price to Book	2.4	2.1	2.6	1.9	2.1	2.1	2.3	2.1	2.2
Price to Cash Earnings	10.5	9.1	10.8	8.9	9.5	9.6	9.8	9.3	9.8
Price to Earnings	19.5	18.4	19.0	19.7	19.4	19.9	18.9	19.2	19.4
Price to Sales	1.2	0.9	1.3	0.8	0.9	0.9	1.0	0.9	1.0
Div. Yield (%)	2.2	2.5	2.2	2.4	2.2	2.2	2.3	2.4	2.3
LT Fwd EPS G (%)	11.9%	10.7%	11.8%	11.2%	11.7%	11.7%	11.4%	11.1%	11.5%
Sustainable Growth rate (%)	7.1%	6.3%	7.9%	5.4%	6.5%	6.1%	6.8%	6.0%	6.4%
ROE (%)	12.2%	11.6%	13.6%	10.0%	11.4%	10.8%	12.1%	11.0%	11.5%
Avg No of Stocks	1621	1,621	1,621	1,621	1,621	1,621	1,621	1,621	1,621
Effective No of Stocks	301	275	238	597	326	470	287	415	385
Market Cap coverage (%)	na	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Top 10 Sec wt (%)	11.8%	12.3%	14.3%	6.6%	11.0%	8.4%	12.2%	9.3%	10.0%
Gini Coefficient	0.67	0.68	0.71	0.50	0.66	0.56	0.68	0.57	0.60

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

Similarly in Exhibit 34, certain combinations of risk premia indices also produce more attractive investability metrics. The 95th percentile average days to trade (across stocks) for the World Low Volatility and Value Index is 8.2 days for a USD 100 billion portfolio. In comparison the individual indices' same metrics are 9.8 days and 12.2 days, respectively, which averaged would be 11.0 days.

Strikingly, the combination of all four risk premia (Value Tilt, Low Size Tilt, Momentum Tilt, and Low Volatility Tilt) best characterizes the benefits of the portfolio approach. Returns, risk, and investability (as seen by capacity and turnover numbers) are all attractive.

Exhibit 34: Investability Measures for Combined Risk Premia Portfolios (November 1992 to August 2012)

Statistics from 30/11/1992 to 31/08/2012	WORLD STANDARD	Low Volatility / Value	Low Volatility / Momentum	Value / Low Size	Value / Momentum	Value / Low Size / Momentum	Low Volatility / Momentum / Value	Low Volatility / Low Size / Value	Value / Low Size / Low Volatility / Momentum
Tradability of the Strategy									
Weighted Average ATVR ###	77.5%	77.5%	66.2%	93.1%	81.6%	85.5%	75.1%	82.8%	79.7%
Days to Trade - Periodic Rebalancing # ## ####									
Weighted Average	3	3.2	6.2	3.8	5.4	4.1	4.1	3.1	3.5
95 percentile	1	4.7	9.2	7.1	8.6	6.9	6.3	5.2	5.5
Tail Average @ 95%	4	8.2	13.2	12.0	12.3	10.7	9.2	9.3	8.9
Maximum	14	31.3	44.1	41.7	38.1	32.7	31.7	36.9	31.8
Days to complete 95% trading	10	9.5	14.8	12.1	13.3	11.2	10.7	9.8	10.1
Days to Trade - Relative to benchmark # ## ####									
Weighted Average		9.4	12.4	9.9	5.4	6.1	7.2	6.8	5.4
95 percentile		12.1	12.4	19.7	9.1	12.3	8.9	14.2	10.8
Tail Average @ 95%		19.1	22.3	29.8	12.8	18.8	14.0	21.1	15.7
Maximum		48.0	50.9	69.1	28.7	42.5	29.7	55.2	41.1
Replication Costs									
Avg. Annual Turnover (%)**	4.3%	12.7%	23.1%	15.0%	20.7%	15.5%	15.6%	12.0%	12.9%
Natural Crossing Turnover Reduction***		4.0%	4.9%	1.0%	10.6%	9.9%	10.0%	3.7%	9.7%
Performance Drag in bps (at 50 bps)	4.3	12.7	23.1	15.0	20.7	15.5	15.6	12.0	12.9
Capacity of the Strategy									
Stock Ownership (% of Float Market Cap) # ###									
Average	0.5%	0.45%	0.37%	0.72%	0.46%	0.60%	0.43%	0.60%	0.54%
95 percentile	0.5%	0.83%	0.73%	1.31%	0.77%	0.96%	0.66%	0.98%	0.81%
Tail Average @ 95%	0.5%	1.03%	0.84%	1.61%	1.00%	1.15%	0.79%	1.16%	0.93%
Maximum	0.5%	2.47%	1.14%	3.09%	2.45%	2.09%	1.68%	2.10%	1.60%
Stock Ownership (% of Full Market Cap) # ###									
Average	0.4%	0.37%	0.31%	0.56%	0.38%	0.48%	0.35%	0.47%	0.44%
95 percentile	0.5%	0.71%	0.68%	1.02%	0.67%	0.76%	0.62%	0.78%	0.67%
Tail Average @ 95%	0.5%	0.86%	0.79%	1.26%	0.82%	0.91%	0.70%	0.92%	0.76%
Maximum	0.5%	1.75%	1.14%	2.36%	1.77%	1.67%	1.26%	1.65%	1.31%
Degree of Index Tilt & Concentration ###									
Active Share		16.6%	19.8%	19.7%	11.7%	11.5%	11.6%	13.5%	9.4%
Avg Weight Multiplier	1	1.12	1.07	1.22	1.07	1.06	1.02	1.08	1.01
Max Weight Multiplier	1	113	5	118	113	79	76	79	59
Max Strategy Weight	2.0%	2.2%	2.5%	1.0%	1.9%	1.4%	2.1%	1.6%	1.7%

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

*** Turnover reduction from natural crossing is calculated as the difference between the turnover if the risk premia strategies are run separately and the actual turnover shown in the row above. Exhibit 32 provides an illustration.

Assuming a fund size of USD 100 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

Combination Portfolios for Region-Neutral Risk Premia Indices

Lastly, we also show the metrics for select portfolios formed from the region-neutral World Risk Premia Indices first discussed in Section V. The region-neutral premia indices were constructed such that the region active weights are zero at the time of each semiannual rebalancing. As seen in Exhibit 35, the same benefits illustrated with the unconstrained indices are also applicable to the region-neutral versions of the indices. Comparing Exhibit 35 to Exhibits 33 and 34, the return, risk, Sharpe Ratio, and Information Ratio differences are minimal. Moreover the investability implications remain the same.

Exhibit 35: Summary of Select Portfolios Formed from Simulated World Region-Neutral Risk Premia Indices (November 1992 to August 2012)

Statistics from 30/11/1992 to 31/08/2012	World Index	Value Region-Neutral / Low Size Region-Neutral	Value Region-Neutral / Low Volatility Region-Neutral / Low Size Region-Neutral	Value Region-Neutral / Low Volatility Region-Neutral / Low Size Region-Neutral / Momentum Region-Neutral
Total Return Performance				
Annualized Return (%)*	7.2%	8.0%	8.0%	8.0%
Annualized Risk (%)	15.5%	15.9%	15.0%	15.0%
Return/Risk	0.47	0.50	0.53	0.53
Sharpe Ratio	0.23	0.27	0.29	0.29
Active Return Performance				
Active Return (bps)		72	73	76
Tracking error (%)		2.5%	2.0%	1.3%
Information Ratio		0.29	0.35	0.61
Tradability of the Strategy				
Weighted Average ATVR ###	77.5%	86.7%	79.0%	77.6%
Days to Trade - Periodic Rebalancing # ## ####				
Weighted Average	3	4.1	3.3	3.4
95 percentile	1	6.6	5.1	5.4
Tail Average @ 95%	4	11.9	9.3	9.0
Maximum	14	45.7	38.9	32.6
Days to complete 95% trading	10	13.4	10.4	10.1
Days to Trade - Relative to benchmark # ## ####				
Weighted Average		9.3	6.7	5.2
95 percentile		19.9	13.5	10.1
Tail Average @ 95%		27.2	19.5	14.8
Maximum		82.5	66.2	48.2
Replication Costs				
Avg. Annual Turnover (%)**	4.3%	14.8%	11.8%	12.5%
Performance Drag in bps (at 50 bps)	4.3	14.8	11.8	12.5
Capacity of the Strategy				
Stock Ownership (% of Float Market Cap) # ###				
Average	0.5%	0.66%	0.57%	0.53%
95 percentile	0.5%	1.18%	0.88%	0.76%
Tail Average @ 95%	0.5%	1.43%	1.03%	0.85%
Maximum	0.5%	2.57%	1.77%	1.37%
Stock Ownership (% of Full Market Cap) # ###				
Average	0.4%	0.53%	0.46%	0.43%
95 percentile	0.5%	0.96%	0.76%	0.66%
Tail Average @ 95%	0.5%	1.20%	0.89%	0.74%
Maximum	0.5%	2.00%	1.37%	1.06%
Degree of Index Tilt & Concentration ###				
Active Share		17.9%	12.4%	9.2%
Avg Weight Multiplier	1	1.22	1.08	1.01
Max Weight Multiplier	1	140	93	70
Max Strategy Weight	2.0%	1.1%	1.7%	1.8%

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 100 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

In summary, there can be quite a few benefits to combining risk premia in allocations including diversification (both long-term and short-term, and in both normal and extreme periods), potential diversification of systematic sources of risk, and reduction of turnover due to natural crossing.

VIII. Investability of Risk Premia: A Discussion

Throughout the report we have assumed a portfolio size of USD 100 billion. How does investability scale as the size of the portfolio increases beyond this threshold? Many of the metrics we employ here scale linearly with the size of the fund. These metrics include days to trade and stock ownership percentages. Other metrics including the annual turnover and performance drag are already measured in percentages.

As shown in Exhibit 36, the average days to trade across stocks ranges from 4.7 to 11.1 days for a USD 100 billion portfolio across the four main World Risk Premia indices. At USD 400 billion, the average days to trade ranges between 19 and 44 days. Thus it is important to note that as we assume higher levels of investment, these simple strategies will become less investable. Moreover, we find that the larger the active weight of a stock in the risk premia index, the lower its investability (see Appendix F). In other words there is a negative correlation between stock active weights (that in part reflects signal strength) and investability. Finally, investability dimensions such as market impact are known to scale non-linearly (e.g., market impact increases faster than the size of the trade). These become of even greater concern as the fund size grows.

Exhibit 36: Investability Metrics for Simulated Portfolios of Varying Size (USD $100 Billion and Higher, November 1992 to August 2012)

Statistics from 30/11/1992 to 31/08/2012	WORLD STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Tradability of the Strategy							
Weighted Average ATVR ###	77.5%	92.8%	93.4%	62.2%	70.3%	108.6%	87.3%
Replication Costs							
Avg. Annual Turnover (%)**	4.3%	18.6%	12.4%	12.5%	41.0%	23.3%	24.2%
Performance Drag in bps (at 50 bps)	4.3	18.6	12.4	12.5	41.0	23.3	24.2
Days to Trade - Periodic Rebalancing ## ####							
Weighted Average ($100 b)	3	4.7	5.5	5.0	11.1	13.0	17.6
Weighted Average ($200 b)	6	9	11	10	22	26	35
Weighted Average ($400 b)	12	19	22	20	44	52	70
Days to complete 95% trading ($100 b)	10	13.7	20.1	15.2	25.6	46.6	68.2
Days to complete 95% trading ($200 b)	19	27	40	30	51	93	136
Days to complete 95% trading ($400 b)	39	55	81	61	102	187	273
Capacity of the Strategy							
Stock Ownership (% of Float Market Cap) ###							
Average ($100 b)	0.5%	0.55%	0.89%	0.36%	0.38%	1.46%	1.30%
Average ($200 b)	0.9%	1.1%	1.8%	0.7%	0.8%	2.9%	2.6%
Average ($400 b)	1.8%	2.2%	3.6%	1.4%	1.5%	5.9%	5.2%
95 percentile ($100 b)	0.5%	1.33%	1.70%	0.85%	0.84%	4.33%	4.16%
95 percentile ($200 b)	0.9%	2.7%	3.4%	1.7%	1.7%	8.7%	8.3%
95 percentile ($400 b)	1.9%	5.3%	6.8%	3.4%	3.4%	17.3%	16.6%

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

As the size of the investment grows, there are techniques that may be used to improve investability features. As previously discussed, our starting point in this report was a set of straightforward indices which combine market capitalization-based weights with a tilt on a desired risk premia. We do not employ any additional constraints, either on the starting universe or the stocks to be included in the risk premia index. Moreover, we assume the whole portfolio is rebalanced on a single day coincident with the MSCI GIMI semiannual rebalancing for market capitalization weighted indices.

There are in fact several avenues large investors can explore to improve investability in factor strategies. In the context of indices, we can think of them as advanced index techniques which have the potential to further improve investability characteristics. These advanced index techniques include those which aim to spread the trades over time or filter out the less liquid names. Examples of the former include different approaches to rebalancing, which for traditional indices and for the purposes of this study, is done on a single day. Examples of the latter include constraints built into the index or additional screens to the stock universe. Exhibit 37 displays various advanced techniques, grouped by the decision criteria.

Exhibit 37: A Sample of Advanced Index Techniques

Dimension	Solution
Opportunity Set	• Restrict the opportunity set to stocks with low market impact
Signal Specification	• Modify signal definition with a penalty for tradability / illiquidity
Portfolio Constraints	• Add stock level constraints using tradability measures such as capping the maximum weight of any given stock • Allow shorting of securities • Apply Turnover Constraints and/or Buffers
Optimization	• Incorporate an explicit penalty for trading in the utility function
Rebalancing	• Spread rebalancing over a longer period – feasible for signals with low autocorrelation • Divide portfolio into a set of independent portfolios (e.g., 4 portfolios with overlapping names rebalanced at different times) • Rebalance as needed, if portfolio drifts a certain amount of distance from target or if signal change is sufficiently large • Rebalance half way between proforma index and current index (introduces path dependency) • Rebalance part of the way with an explicit turnover budget

To illustrate the potential benefits of one of these techniques, we construct a modified World Momentum Tilt Index where the momentum signal is modified by a penalty for illiquidity. The raw momentum z-score is adjusted as follows:

$$z_{new} = z_{Mom} - z_{Illiquidity}$$

The z-score for illiquidity is based on the Amihud (2002) measure:

$$Illiquidity = Average\left(\frac{|r_t|}{Volume_t}\right)$$

Exhibit 38 summarizes the characteristics of the modified World Momentum Tilt Index over the period November 2007 to August 2012. The index earns slightly better returns than the original World Momentum Tilt Index while showing significant improvement on measures of investability like days to trade and turnover.

Exhibit 38: Modifying the Signal for Illiquidity (Simulation Period: November 2007 to August 2012)

	World Momentum Tilt	Modified World Momentum Tilt
Annualized Return (%)	-2.20%	-2%
Annualized Risk (%)	21.10%	20.80%
Tracking Error	3.40%	2.90%
Active Share	22.30%	19.20%
Active Target Factor Exposure (Standard Dev.)	0.28	0.22
Average Stock Ownership (% of Float Market Cap)	0.38%	0.32%
Weighted Average Amihud	6.11	4.91
Days to Trade (Relative to benchmark)	11.2	9.4
Days to Trade (Periodic Rebalancing)	11.1	8.2
Avg. Annual Turnover (%)	41.10%	34.10%

The above example serves as one illustration of what can be achieved with advanced index techniques. In practice, the actual techniques need to be tailored to the institution in question. Implementation considerations such as the infrastructure for portfolio management and trading would play an important role.

This exploration into risk premia indices for large-scale portfolios is meant as a starting point for tackling an important issue for funds like the Government Pension Fund Global. In practice, there are few examples of funds of the size of the Government Pension Fund Global which have actually implemented risk premia or factor-based strategies. Therefore, evidence from actual experience is limited. It is clear however that for equity portfolios of USD 100 billion and greater, investability is a key constraint and should be given the highest importance when constructing risk premia or factor strategies.

IX. References

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X. Appendix

Appendix A: Simulated Index Methodology

This appendix provides details on the construction of the simulated indices used in this study. The universe and rebalancing cycles are the same across all indices as discussed in Section IV. Only the treatment of outliers and the weighting schemes differ. The term "Parent Index" refers to the market capitalization-weighted index whose universe the risk premia index is based on.

Value Tilt Index

For a given rebalancing effective date, the security level fundamental accounting data available as of close of the previous end of month is used. The following four variables are used:

- **Book Value weight:** The security level book value weight is computed as the ratio of the free float adjusted book value to the cumulative sum of the positive free float adjusted book value of all constituent securities in the MSCI Parent Index. The security level book value used in the above calculation is the latest reported book value. In case the book value is negative, the book value weight is set to 0. In case the book value is missing for a security, then the book value weight is set to the pro forma market capitalization weight.
- **Sales Value weight:** The average value of sales for each security is obtained from the previous three reported fiscal year end sales values. The security level sales value weight is computed as the ratio of the free float adjusted average sales value to the cumulative sum of the positive free float adjusted average sales values of all the constituent securities in the MSCI Parent Index. In case the average sales value is negative, the sales value weight is set to 0.
- **Earnings Value weight:** The average value of earnings for each security is obtained from the previous three reported fiscal yearend earnings values. The security level earnings value weight is computed as the ratio of the free float adjusted average earnings value to the cumulative sum of the positive free float adjusted average earnings values of all the constituent securities in the MSCI Parent Index. In case the average earnings value is negative, the earnings value weight is set to 0.
- **Cash Earnings Value weight:** The average value of cash earnings for each security is obtained from the previous three reported fiscal year end cash earnings values. The security level cash earnings value weight is computed as the ratio of the free float adjusted average cash earnings value to the cumulative sum of the positive free float adjusted average cash earnings values of all the constituent securities in the MSCI Parent Index. In case the average cash earnings value is negative, the cash earnings value weight is set to 0.

The final security level value weight is derived as an average of the four single variable value weights.

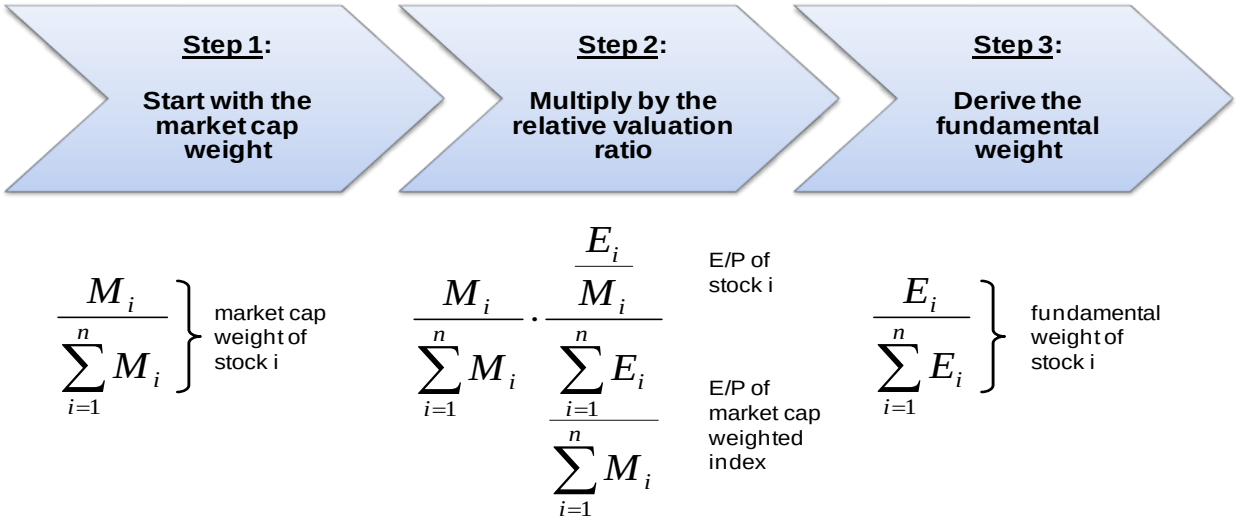
$$weight_i = \frac{1}{4} \times \left(\frac{BV_i}{\sum BV_i} + \frac{SV_i}{\sum SV_i} + \frac{EV_i}{\sum EV_i} + \frac{CEV_i}{\sum CEV_i} \right) \quad (1.1)$$

In the event of all fundamental variables being unavailable for a security, the security level final value weight is set to the pro forma market capitalization weight. In the event that some but not all

fundamental variables are missing, the treatment of these is discussed in Appendix II of the "MSCI Value Weighted Indices Methodology" (August 2012).[21]

It should be noted that so-called popular "fundamental indices" are the same as the value tilt indices we evaluate here. As discussed by Asness (2006), the weights of a fundamental index can be derived by multiplying the weights of a capitalization-weighted index by the relative valuation ratio of each stock.

Exhibit 39: Fundamental Indices and Value Tilt Indices are Equivalent



Source: Clifford Asness, "The Value of Fundamental Indexing", Institutional Investor, October 2006, 94-99

Size Tilt Index

The simulated Size Tilt Indices are constructed using all constituents of the Parent Index. There are no additional screens or constraints. All stocks are weighted as follows:

$$v_i = \sqrt{mcap_i} \qquad (1.2)$$

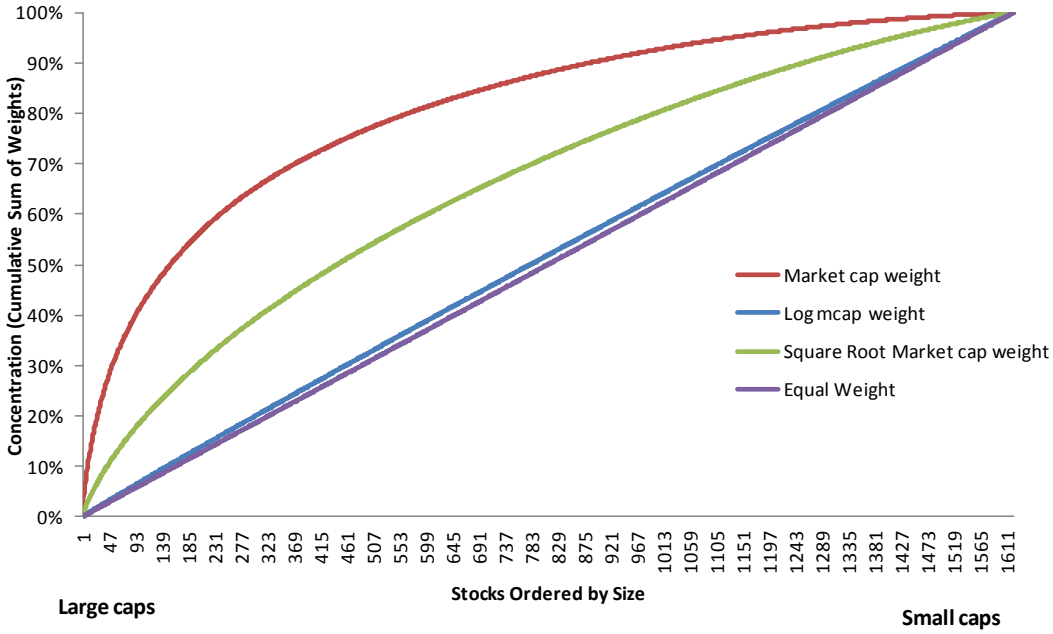
$$weight_i = \frac{v_i}{\sum_{i=1}^{N} v_i} \qquad (1.3)$$

Note that market capitalization is free-float adjusted.

The weighting scheme based on square root market capitalization-weighting is less concentrated than one based on market capitalization-weighting but more concentrated than one based on equal weighting. Exhibit 40 shows the concentrations of the weighting schemes.

[21] http://www.msci.com/eqb/methodology/meth_docs/MSCI_Value_Weighted_Index_Methodology_Book_Aug2012.pdf

Exhibit 40: Comparison of Concentration Schemes for Different Capitalization Weighting Schemes (Constituents of the MSCI World Index, November 16, 2012)



We note that "diversity-weighted" indices pioneered by Fernholz, Garvy and Hannon (1998) are another type of index weighting scheme that result in portfolios that are less concentrated than market capitalization-weighting and puts more emphasis on small caps. Fernholz, Garvy, and Hannon (1998) measure the level of market concentration by "diversity." By raising a stock's market capitalization weight to a power between zero and one (suggested by the authors to be 0.76), the diversity-weighted index represents delivers intermediate concentration between a capitalization-weighted and equal-weighted portfolio. The square root of market capitalization-weighted index is a special instance of a diversity-weighted index.

Low Volatility Tilt Index

The weights for the Low Volatility Tilt Indices are computed as follows:

$$k_i = \frac{1}{\sigma_i^2} \qquad (1.4)$$

The security level variance used in the above calculation (denominator), is the squared term of security level standard deviation computed using weekly returns over three years prior to the rebalancing date. In case the price data are not available for a three year period, the respective country-sector average of volatility is used for that security. In the event of country-sector average being unavailable, country average volatility is used. This aims to avoid estimating risk over different volatility regimes. Security standard deviation is capped at 80% on upside and 12% on downside. Only non-zero weekly returns are considered for computation of variance to deal with stale prices due to suspensions/ market disruptions etc.

The weight of each stock is then:

$$weight_i = \frac{\left(k_i \times mcap\_weight_i\right)}{\sum_{i=1}^{N}\left(k_i \times mcap\_weight_i\right)} \quad (1.5)$$

where *mcap_weight* is the free float adjusted market capitalization weight of the stock.

Momentum Tilt Index

First, z-scores are constructed as follows:

$$z_i = \frac{\left(x_i - \bar{x}\right)}{\sigma_x} \quad (1.6)$$

where *x* is the 1-year price momentum computed from daily local returns. The scores are truncated at +/-3 standard deviations. Stocks are standardized using the universe of the parent index.

Next, the standardized scores are translated into positive scores as follows:

$$score_i = 1 + z_i \qquad where \qquad z_i > 0 \quad (1.7)$$

$$score_i = \frac{1}{1 - z_i} \qquad where \qquad z_i < 0 \quad (1.8)$$

The weight is then calculated as:

$$weight_i = \frac{\left(score_i \times mcap\_weight_i\right)}{\sum_{i=1}^{N}\left(score_i \times mcap\_weight_i\right)} \quad (1.9)$$

where *mcap_weight* is the free float adjusted market capitalization weight of the stock.

Equal Weighted Index

The MSCI Equal Weighted Indices are constructed from the applicable MSCI country and composites indices and have the same constituents as the underlying Parent Indices. At construction and at each rebalancing, each issuer in the equal weighted index is given an equal weight (i.e. 1/N, where N is the number of issuers in the Parent Index). Between two rebalancings, the weightings of constituents will change due to price performance. If there are multiple securities of the same issuer in the index, the issuer will be equal weighted and the securities will be free float-adjusted market capitalization weighted.

At each rebalancing, a constraint factor is calculated for each constituent in the MSCI Equal Weighted Index. The constraint factor is defined as the weight in the MSCI Equal Weighted Index at the time of the rebalancing divided by the weight in the Parent Index. The constraint factor remains constant between

index reviews except in case of corporate events as described below. Please see the paper "MSCI Equal Weighted Indices Methodology" (May 2011)[22] for further detail.

Risk Weighted Index

The security level risk weight is computed as the ratio of the inverse of the security variance to the sum of the inverse of security variance of all constituent securities in the MSCI Parent Index.

$$weight_i = \frac{1/\sigma_i^2}{\sum_{i=1}^{N} 1/\sigma_i^2} \quad (1.15)$$

The security level variance used in the above calculation, is the squared term of security level standard deviation computed using weekly returns over three years prior to the rebalancing date. In case the price data are not available for a three year period, the respective country-sector average of volatility is used for that security. In the event of country-sector average being unavailable, country average volatility is used. This aims to avoid estimating risk over different volatility regimes. Security standard deviation is capped at 80% on upside and 12% on downside. Only non-zero weekly returns are considered for computation of variance to deal with stale prices due to suspensions/ market disruptions etc. Please see the paper "MSCI Risk Weighted Indices Methodology" (August 2012)[23] for further detail.

[22] http://www.msci.com/eqb/methodology/meth_docs/MSCI_Equal_Weighted_Indices_Methodology_May11.pdf

[23] http://www.msci.com/eqb/methodology/meth_docs/MSCI_Risk_Weighted_Index_Methodology_Aug2012.pdf

Appendix B: Mappings to MSCI Indices

In the study, for purposes of consistency, all broad indices are labeled "Tilt" Indices. In some cases, these indices are the same as those commercially offered by MSCI and whose names may be slightly different. All indices and their equivalents are shown below.

Exhibit 41: Mapping to MSCI Indices

Risk Premia	Index Name in Ministry of Finance Study	Equivalent MSCI Official Index
High Value	Value Tilt	MSCI Value Weighted Indices
Low Size	Low Size Tilt	N/A
High Momentum	Momentum Tilt	MSCI Momentum Weighted Indices (preliminary and still under Consultation)
Low Volatility	Low Volatility Tilt	N/A
Low Liquidity	Liquidity Tilt	N/A
Low Size	Equal Weighted	MSCI Equal Weighted Indices
Low Volatility	Risk Weighted	MSCI Risk Weighted Indices

Appendix C: The Barra Global Equity Model (GEM2)

The Barra multi-factor model framework yields valuable insight into the underlying sources of portfolio return by separating systematic effects from the purely stock-specific component that can be diversified away. In the model, excess returns are driven by a relatively small number, K_E, of global equity factors, plus an idiosyncratic component unique to the particular stock,

$$r_n = \sum_{k=1}^{K_E} X_{nk} f_k + u_n . \qquad (2.1)$$

Here, X_{nk} $(k \le K_E)$ is the exposure of stock n to equity factor k, f_k is the factor return, and u_n is the specific return of the stock. The specific returns u_n are assumed to be uncorrelated with the factor returns. The factor exposures are known at the start of each period, and the factor returns are estimated via cross-sectional regression.

The coverage universe is the set of all securities for which the model provides risk forecasts. The estimation universe, by contrast, is the subset of stocks that is used to estimate the model. Judicious selection of the estimation universe is a critical component to building a sound risk model. *Representation, liquidity* and *stability* are the three primary goals that must be attained when selecting a risk model estimation universe. The GEM2 estimation universe utilizes the MSCI *All Country World Investable Market Index* (ACWI IMI), part of the MSCI Global Investable Market Indices family which represents the latest in MSCI index-construction methodology. MSCI ACWI IMI aims to reflect the full breadth of global investment opportunities by targeting 99 percent of the float-adjusted market capitalization in 48 developed and emerging markets. The index-construction methodology applies innovative rules designed to achieve index stability, while reflecting the evolving equity markets in a timely fashion. Moreover, liquidity screening rules are applied to ensure that only investable stocks with reliable pricing are included for index membership.

The equity factor set in GEM2 includes a World factor (w), countries (c), industries (i), and styles (s). Every stock is assigned an exposure of 1 to the World factor. Hence, the local excess returns in Equation 2.5 can be rewritten as

$$r_n = f_w + \sum_c X_{nc} f_c + \sum_i X_{ni} f_i + \sum_s X_{ns} f_s + u_n . \qquad (2.2)$$

Mathematically, the World factor represents the intercept term in the cross-sectional regression. Economically, it describes the aggregate up-and-down movement of the global equity market. Typically, the World factor is the dominant source of total risk for a diversified long-only portfolio.

Country factors play a critical role in global equity risk modeling. One reason is that they are powerful indicator variables for explaining the cross section of global equity returns. A second, related, reason is that the country allocation decision is central to many global investment strategies, and portfolio managers often must carefully monitor their exposures to these factors.

Exhibit 42 shows a list of the 55 countries covered by GEM2, together with their corresponding currencies. The country exposures X_{nc} in GEM2 are set equal to 1 if stock n is in country c, and set equal to 0 otherwise. We assign country exposures based on country membership within the MSCI ACWI IMI, MSCI China A Index and MSCI GCC Countries Index. Note that depository receipts and cross-listed assets are assigned factor exposures for the underlying or primary asset, as defined by the MSCI Equity Indices.

Exhibit 43: GEM2 Country Factors and Currencies

Country Code	Country Name	Currency Name	Average Weight	Jan-08 Weight
ARG	Argentina	Argentine Peso	0.09	0.08
AUS	Australia	Australian Dollar	1.58	2.27
AUT	Austria	Euro	0.16	0.34
BHR	Bahrain	Bahraini Dinar	0.01	0.02
BEL	Belgium	Euro	0.62	0.63
BRA	Brazil	Brazilian Real	0.64	1.69
CAN	Canada	Canadian Dollar	2.53	3.14
CHL	Chile	Chilean Peso	0.17	0.24
CHN	China Domestic	Chinese Yuan	1.86	7.97
CHX	China International	Hong Kong Dollar	0.66	2.74
COL	Colombia	Colombian Peso	0.03	0.06
CZE	Czech Republic	Czech Koruna	0.06	0.14
DNK	Denmark	Danish Krone	0.38	0.42
EGY	Egypt	Egyptian Pound	0.05	0.15
FIN	Finland	Euro	0.58	0.64
FRA	France	Euro	4.08	4.80
DEU	Germany	Euro	3.23	3.41
GRC	Greece	Euro	0.27	0.41
HKG	Hong Kong	Hong Kong Dollar	1.05	1.47
HUN	Hungary	Hungarian Forint	0.06	0.08
IND	India	Indian Rupee	0.53	2.22
IDN	Indonesia	Indonesian Rupiah	0.13	0.31
IRE	Ireland	Euro	0.25	0.25
ISR	Israel	Israeli Shekel	0.19	0.29
ITA	Italy	Euro	2.00	1.91
JPN	Japan	Japanese Yen	11.24	8.23

Exhibit43: GEM2 Country Factors and Currencies (continued)

Country Code	Country Name	Currency Name	Average Weight	Jan-08 Weight
JOR	Jordan	Jordanian Dinar	0.03	0.04
KOR	Korea	Korean Won	1.00	1.89
KWT	Kuwait	Kuwaiti Dinar	0.13	0.31
MYS	Malaysia	Malaysian Ringgit	0.42	0.48
MEX	Mexico	Mexican Peso	0.42	0.54
MAR	Morocco	Moroccan Dirham	0.03	0.08
NLD	Netherland	Euro	1.44	1.00
NZL	New Zealand	New Zealand Dollar	0.09	0.06
NOR	Norway	Norwegian Krone	0.33	0.65
OMN	Oman	Omani Rial	0.01	0.03
PAK	Pakistan	Pakistan Rupee	0.03	0.06
PER	Peru	Peruvian Sol	0.04	0.10
PHL	Philippines	Philippine Peso	0.06	0.13
POL	Poland	Polish Zloty	0.10	0.30
PRT	Portugal	Euro	0.19	0.22
QAT	Qatar	Qatari Rial	0.05	0.16
RUS	Russia	Russian Ruble	0.48	1.60
SAU	Saudi Arabia	Saudi Rial	0.31	0.82
SGP	Singapore	Singapore Dollar	0.47	0.66
ZAF	South Africa	South African Rand	0.62	0.79
ESP	Spain	Euro	1.38	1.76
SWE	Sweden	Swedish Krone	1.03	0.96
CHE	Switzerland	Swiss Franc	2.48	2.21
TWN	Taiwan	Taiwan Dollar	1.22	1.23
THA	Thailand	Thailand Bhat	0.18	0.33
TUR	Turkey	New Turkish Lira	0.17	0.41
GBR	UK	U.K. Pound	8.44	6.98
ARE	UAE	Emirati Dirham	0.06	0.28
USA	US	US Dollar	46.37	31.99

Note: Weights are computed within the GEM2 estimation universe using total market capitalization. Average is taken over the period from January 1997 to January 2008.

Industries are also important variables in explaining the sources of global equity return co-movement. One of the major strengths of GEM2 is to employ the Global Industry Classification Standard (GICS®) for the industry factor structure. The GICS scheme is hierarchical, with 10 top-level sectors, which are then divided into 24 industry groups, 68 industries, and 154 sub-industries. GICS applies a consistent global methodology to classify stocks based on careful evaluation of the firm's business model and economic operating environment. The GICS structure is reviewed annually by MSCI Barra and Standard & Poor's to ensure it remains timely and accurate.

In GEM2, selection of the industry factor structure begins at the second level of the GICS hierarchy, with each of the 24 industry groups automatically qualifying as a factor. This provides a reasonable level of granularity, without introducing an excessive number of factors. We then analyze each industry group, carefully examining the industries and sub-industries contained therein to determine if a more granular factor structure is warranted. The result of this process is the set of 34 GEM2 industry factors, presented in Exhibit 44.

Exhibit 44: GEM2 Industry Factors

GICS Sector	GEM2 Code	GEM2 Industry Factor Name	Average Weight	Jan-08 Weight
Energy	1	Energy Equipment & Services	0.75	1.29
	2	Oil, Gas & Consumable Fuels	4.88	9.32
	3	Oil & Gas Exploration & Production	1.00	1.72
Materials	4	Chemicals	2.36	2.84
	5	Construction, Containers, Paper	1.38	1.24
	6	Aluminum, Diversified Metals	1.05	2.41
	7	Gold, Precious Metals	0.37	0.58
	8	Steel	0.79	1.83
Industrials	9	Capital Goods	7.33	8.60
	10	Commercial & Professional Services	1.43	0.77
	11	Transportation Non-Airline	1.82	2.32
	12	Airlines	0.37	0.45
Consumer	13	Automobiles & Components	2.52	2.29
Discretionary	14	Consumer Durables & Apparel	2.33	1.93
	15	Consumer Services	1.35	1.39
	16	Media	3.24	2.11
	17	Retailing	3.42	2.08
Consumer	18	Food & Staples Retailing	1.82	1.76
Staples	19	Food, Beverage & Tobacco	4.56	4.37
	20	Household & Personal Products	1.43	1.20
Health Care	21	Health Care Equipment & Services	2.13	1.93
	22	Biotechnology	0.78	0.68
	23	Pharmaceuticals, Life Sciences	6.17	3.82
Financials	24	Banks	10.52	10.83
	25	Diversified Financials	5.63	5.06
	26	Insurance	4.61	4.14
	27	Real Estate	2.08	3.07
Information	28	Internet Software & Services	0.62	0.74
Technology	29	IT Services, Software	3.24	2.56
	30	Communications Equipment	2.46	1.41
	31	Computers, Electronics	3.69	2.81
	32	Semiconductors	2.47	1.52
Telecom	33	Telecommunication Services	7.11	5.84
Utilities	34	Utilities	4.31	5.08

Notes: Weights are computed within the GEM2 estimation universe using total market capitalization. Average is taken over the period from January 1997 to January 2008.

Investment style represents another major source of systematic risk. Style factors, also known as *risk indices*, are designed to capture these sources of risk. They are constructed from financially intuitive stock attributes called *descriptors,* which serve as effective predictors of equity return covariance. Since the descriptors within a particular style factor are meant to capture the same underlying driver of returns, these descriptors tend to be significantly collinear. For instance, price-to-book ratio, dividend yield, and earnings yield are all attributes used to identify value stocks, and they tend to exhibit significant cross-sectional correlation. Although these descriptors have significant explanatory power on their own, naively including them as separate factors in the model may lead to serious multi-collinearity problems. Combining these descriptors into a single style factor overcomes this difficulty, and also leads to a more parsimonious factor structure.

Unlike country and industry factors, which are assigned exposures of either 0 or 1, style factor exposures are continuously distributed. To facilitate comparison across style factors, they are standardized to have a mean of 0 and a standard deviation of 1. In other words, if d_{nl}^{Raw} is the raw value of stock n for descriptor l, then the standardized descriptor value is given by

$$d_{nl} = \frac{d_{nl}^{Raw} - \mu_l}{\sigma_l}, \tag{2.14}$$

where μ_l is the cap-weighted mean of the descriptor (within the estimation universe), and σ_l is the equal-weighted standard deviation. We adopt the convention of standardizing using the cap-weighted mean so that a well-diversified cap-weighted global portfolio, such as MSCI ACWI IMI, has approximately zero exposure to all style factors. For the standard deviation, however, we use the equal-weighted mean to prevent large-cap stocks from having an undue influence on the overall scale of the exposures.

Some of the style factors are standardized on a *global-relative* basis, others on a *country-relative* basis. In the former case, the mean and standard deviation in Equation 3.2 are computed using the entire global cross section. In the latter case, the factors have mean 0 and standard deviation 1 within each country. When deciding which standardization convention to adopt, we consider both the intuitive meaning of the factor and its explanatory power.

Formally, descriptors are combined into risk indices as follows

$$X_{nk} = \sum_{l \in k} w_l \, d_{nl}, \tag{2.15}$$

where w_l is the descriptor weight, and the sum takes place over all descriptors within a particular risk index. Descriptor weights are determined using an optimization algorithm to maximize the explanatory power of the model.

A summary of all style factors and their descriptors and weightings are shown in Exhibit 45.

Exhibit 45: GEM2 Style Factors

GEM2L Style Factor	Purpose	Descriptor Components (Weight)
Volatility	Captures relative volatility	• Historical sigma (0.050) • Historical beta (0.500) • Cumulative range (0.150) • Daily standard deviation (0.300)
Momentum	Captures sustained relative performance	• 12-month relative strength (0.250) • 6-month relative strength (0.375) • Historical alpha (0.375)
Size	Differentiates between large and small cap companies	• Logarithm of market capitalization (1.000)
Value	Captures the extent to which a stock is priced inexpensively in the market	• Forecast earnings to price (0.450) • Earnings to price (0.100) • Book to price (0.200) • Dividend yield (0.100) • Cash earnings to price (0.150)
Growth	Captures stock's growth prospects	• 5-year earnings growth (0.150) • 5-year sales growth (0.150) • Analyst predicted 5-year earnings growth (0.700)
Size Non-Linearity	Captures deviations from linearity in the relationship between returns and logarithm of market	• Cube of logarithm of market capitalization (1.000)
Liquidity	Measures the relative trading activity of a firm's shares in the market	• Monthly share turnover (0.200) • Quarterly share turnover (0.350) • Annual share turnover (0.450)
Financial Leverage	Measures a firm's financial leverage	• Book leverage (0.400) • Market leverage (0.500) • Debt to assets (0.100)

The equity factor returns f_k in GEM2 are estimated by regressing the local excess returns r_n against the factor exposures X_{nk},

$$r_n = \sum_{k=1}^{K_E} X_{nk} f_k + u_n . \qquad (2.3)$$

GEM2 uses weighted least squares, assuming that the variance of specific returns is inversely proportional to the square root of total market capitalization.

As described earlier, the GEM2 equity factors include the World factor, countries, industries, and styles. Every stock in GEM2 has unit exposure to the World factor, and indicator variable exposures of 0 or 1 to countries and industries. As a result, the sum of all country factors equals the World factor, and similarly for industries, i.e.,

$$\sum_c X_{nc} = 1, \quad \text{and} \quad \sum_i X_{ni} = 1, \qquad (2.4)$$

for all stocks n. In other words, the sum of all country columns in the factor exposure matrix gives a column with 1 in every entry, which corresponds to the World factor. The same holds for industry factors. The GEM2 factor structure, therefore, exhibits exact two-fold collinearity. Constraints must be applied to obtain a unique solution.

In GEM2 we adopt an intuitive set of constraints that require the cap-weighted country and industry factor returns to sum to zero,

$$\sum_c w_c f_c = 0, \quad \text{and} \quad \sum_i w_i f_i = 0, \tag{2.5}$$

where w_c is the weight of the estimation universe in country c, and w_i is the corresponding weight in industry i. These constraints remove the exact collinearities from the factor exposure matrix, without reducing the explanatory power of the model.

Intuitively, the return of the World factor is essentially the cap-weighted return of the estimation universe. As a first approximation, the pure country factors can be regarded as going long 100 percent the particular country, and going short 100 percent the World portfolio. For instance, going long 100 percent Japan and short 100 percent the World results in a portfolio with roughly 91 percent weight in Japan, and -91 percent in all other countries. The pure country factors, however, have zero exposure to industry factors. This is accomplished by taking appropriate long/short combinations in other countries. For instance, the Japanese market is over-represented in the segment corresponding to the Automobile factor. To partially hedge this exposure, the pure Japan factor takes a net short position of -1.08 percent in the US Automobile segment. A similar short position would be found in the German Automobile segment.

The pure Automobile factor can be thought, as a first approximation, to be formed by going 100 percent long the Automobile industry and 100 percent short the World portfolio. A more refined view of the factor takes into account that the net weight in each country is zero. The pure Automobile factor naturally takes a large long position in Japanese automobiles, but hedges the Japan exposure by taking short positions in other Japanese segments.

The pure Volatility factor is perhaps the easiest to understand, as it takes offsetting long and short positions within all segments corresponding to GEM2 factors (e.g., Japan, US, and Automobiles). Note that the weights are not equal to zero for segments that do not correspond to GEM2 factors, such as Japanese automobiles.

For a further discussion of the Barra GEM2 Model, we refer readers to “The Barra Global Equity Model (GEM2): Methodology Notes” (2008) by Menchero, Morozov, and Shepard.

Appendix D: Definitions of Metrics in Report

Return and Risk Metrics

Annualized Return:

$$r = \left(\frac{P_{end}}{P_{start}}\right) \wedge \left(\frac{365}{T}\right) - 1$$

where P_{end} = price at end date, P_{start} = price at start date, and T = number of calendar days between the end date and start date

Annualized Risk:

$$\sigma = stdev\left(r_1, r_2, ..r_t\right) * \sqrt{12}$$

where $\left(r_1, r_2, ..r_t\right)$ = gross monthly returns

Return/Risk:

$$ret\_to\_risk = r/\sigma$$

Tracking Error:

$$TE = stdev\left(ra_1, ra_2, ..ra_t\right) * \sqrt{12}$$

Where $ra_1, ra_2, ..ra_t$ = monthly active return (i.e., risk premia index return minus benchmark index return)

Correlation: ρ = Correlation between monthly return series of strategy index and monthly return series of benchmark

Historical Beta:

$$\beta = \rho * \frac{\sigma_{riskpremia}}{\sigma_{benchmark}}$$

Information Ratio:

$$IR = \frac{r_{riskpremia} - r_{benchmark}}{TE}$$

where r = annualized return

Annualized Downside Deviation:

$$\sigma_{downside} = stdev(r_1 < 0, r_2 < 0, ..r_t < 0) * \sqrt{12}$$

where $(r_1 < 0, r_2 < 0, ..r_t < 0)$ = gross monthly returns where less than zero

Sortino Ratio:

$$r/\sigma_{downside}$$

Where r = annualized return

95 percentile VaR (%): Found by ranking monthly return series in ascending order and select the 5th percentile value from the top. If 5th percentile does not correspond to a value, we linearly interpolate to estimate.

99 percentile Var (%): Found by ranking monthly return series in ascending order and select the 1st percentile value from the top. If 1st percentile does not correspond to a value, we linearly interpolate to estimate.

Expected Shortfall @ 95%: Average of all monthly return observations less than the 95 percentile Var

Expected Shortfall @ 99%: Average of all monthly return observations less than the 99 percentile Var

Max Drawdown (%): Maximum drawdown is the cumulative loss between global maxima (peak) to global minima (trough) over the entire period, i.e. 1 - global minima/global maxima.

Max Drawdown period (in months): Number of months between global maxima and global minima.

Investability Metrics

The investability measures are listed below with their exact calculation:

Active Share:

$$ActiveShare = \frac{1}{2}\sum_{i=1}^{N}\left|w_{fund,i} - w_{index,i}\right|$$

Where

$w_{fund,i}$ = weight in the active fund (or risk premia index)

$w_{index,i}$ = weight in the capitalization-weighted index

Weight Multiplier:

$$WM = w_{index} \times IF$$

Where

w_{index} = weight in the capitalization-weighted index

IF = $= \frac{w_{fund}}{w_{index}}$

w_{fund} = weight in the active fund (or risk premia index)

w_{index} = weight in the capitalization-weighted index

Active Target factor Exposure (Exposure of Strategy Index to the target factor - Exposure of benchmark to that factor)

$$ATFE = Exp_{fund,target} - Exp_{index,target}$$

Where

$Exp_{fund,target}$ = Exposure of Strategy Index to target factor

$Exp_{index,target}$ = Exposure of benchmark to target factor

Herfindahl Index (Average of (sum of square of security weight for portfolio snapshot) at every rebalancing)

$$HH = \sum_{i=1}^{N} w_i^2$$

Where

w_i = weight in the active fund (or risk premia index)

Effective Number of Stocks

$$EN = \frac{1}{HH}$$

Where HH = Herfindahl Index

Market Cap Coverage (Average (Market Cap of strategy index/market cap of parent index))

$$MCapCovg = \frac{\sum_{j=1}^{N} Mcap_{fund,i}}{\sum_{i=1}^{N} Mcap_{index,i}}$$

Where

$Mcap_{fund,i}$ = FIF Market cap of securities in the active fund (or risk premia index)

$Mcap_{index,i}$ = FIF Market Cap of securities in the capitalization-weighted index

Top 10 Sec wt (%) (Average (sum of top 10 securities at each rebalancing))

$$Top10 = (\sum_{i=1}^{10} w_i)$$

Where w_i = weight in the active fund (or risk premia index)

Percentage ownership:

$$PO_i = \frac{w_i \times AUM}{marketcap_i}$$

Days to Trade:

$$days\_to\_trade_i = \frac{weight_i \times AUM}{ATV_i \times Limit}$$

$$days\_to\_trade_i = \frac{number\_shares_i}{average\_traded\_shares_i \times Limit}$$

Performance drag:

$$drag = 2 \times portfolio\_turnover \times y$$

Weighted Average ATVR

$$W\_ATVR = \sum_{i=1}^{N} w_i * ATVR$$

w_i = weight in the active fund (or risk premia index)

Appendix E: Investability for Geographical Regions

Exhibit 46: Investability Metrics for Emerging Markets

	Score x Mcap					Score Only	
Statistics from 30/11/1995 to 31/08/2012	EM STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Tradability of the Strategy							
Weighted Average ATVR ###	125.0%	138.6%	138.8%	97.0%	106.0%	150.3%	111.7%
Days to Trade - Periodic Rebalancing # ## ####							
Weighted Average	2.8	27.7	6.7	11.9	12.1	14.2	42.0
95 percentile	4.0	9.3	12.2	11.9	22.8	30.7	43.0
Tail Average @ 95%	6.4	21.4	18.2	24.0	37.6	46.8	87.4
Maximum	19.9	249.2	70.7	152.4	150.8	172.1	377.4
Days to complete 95% trading	7.7	36.2	21.5	42.2	32.3	46.0	235.1
Days to Trade - Relative to benchmark # ## ####							
Weighted Average	na	12.1	13.5	21.6	12.9	31.8	58.0
95 percentile	na	24.3	50.3	29.5	23.7	117.7	153.9
Tail Average @ 95%	na	40.7	83.8	61.5	35.8	222.4	294.0
Maximum	na	127.7	150.6	211.5	76.4	501.7	1029.7
Days to complete 95% trading	na	28.8	38.6	75.8	39.7	111.8	226.9
Replication Costs							
Avg. Annual Turnover (%)**	10.8%	28.2%	19.2%	18.6%	45.8%	33.1%	33.4%
Performance Drag in bps (at 50 bps)	10.8	28.2	19.2	18.6	45.8	33.1	33.4
Capacity of the Strategy							
Stock Ownership (% of Float Market Cap) # ###							
Average	0.6%	0.66%	1.10%	0.53%	0.56%	1.64%	1.42%
95 percentile	0.6%	1.59%	1.89%	1.28%	1.29%	4.10%	4.15%
Tail Average @ 95%	0.7%	1.99%	2.10%	1.75%	1.54%	5.15%	5.67%
Maximum	0.7%	3.04%	2.60%	3.44%	2.00%	7.94%	15.24%
Stock Ownership (% of Full Market Cap) # ###							
Average	0.3%	0.38%	0.58%	0.29%	0.31%	0.84%	0.71%
95 percentile	0.6%	1.07%	1.27%	0.75%	0.84%	2.39%	2.19%
Tail Average @ 95%	0.6%	1.48%	1.47%	1.07%	1.09%	2.99%	3.02%
Maximum	0.7%	2.70%	1.96%	2.45%	1.65%	4.52%	7.62%
Degree of Index Tilt & Concentration ###							
Active Share		22.4%	24.8%	21.9%	24.4%	44.5%	44.9%
Avg Weight Multiplier	1	1.70	1.06	0.96	0.97	4.29	5.62
Max Weight Multiplier	1	206	74	18	4	3,229	2,196
Max Strategy Weight	3.9%	4.1%	0.9%	3.9%	4.9%	0.1%	1.1%

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 20 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

Exhibit 47: Investability Metrics for USA

		Score x Mcap				Score Only	
Statistics from 30/11/1992 to 31/08/2012	USA Standard	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Tradability of the Strategy							
Weighted Average ATVR ###	57.7%	57.4%	67.2%	46.7%	60.5%	77.3%	62.8%
Days to Trade - Periodic Rebalancing # ## ####							
Weighted Average	4	6.4	7.0	4.7	12.7	15.1	14.5
95 percentile	1	7.9	7.0	5.3	19.9	19.9	22.3
Tail Average @ 95%	5	14.6	18.6	8.6	25.7	41.3	40.4
Maximum	14	43.2	64.6	26.4	45.3	145.4	163.9
Days to complete 95% trading	10	17.0	24.0	12.9	26.1	52.2	45.5
Days to Trade - Relative to benchmark # ## ####							
Weighted Average	na	13.8	14.4	25.9	11.9	27.4	42.2
95 percentile	na	22.3	28.1	23.2	15.2	69.1	95.9
Tail Average @ 95%	na	32.0	35.2	43.3	19.1	85.3	153.4
Maximum	na	48.4	61.1	85.0	35.2	160.0	326.3
Days to complete 95% trading	na	37.2	27.7	85.0	21.8	68.4	153.3
Replication Costs							
Avg. Annual Turnover (%)**	4.3%	18.5%	12.0%	11.8%	41.4%	21.9%	21.2%
Performance Drag in bps (at 50 bps)	4.3	18.5	12.0	11.8	41.4	21.9	21.2
Capacity of the Strategy							
Stock Ownership (% of Float Market Cap) # ###							
Average	0.4%	0.47%	0.76%	0.31%	0.35%	1.14%	0.94%
95 percentile	0.4%	1.15%	1.32%	0.79%	0.81%	2.89%	2.77%
Tail Average @ 95%	0.4%	1.47%	1.43%	1.05%	1.00%	3.47%	3.70%
Maximum	0.4%	2.80%	1.69%	1.38%	1.28%	4.97%	7.25%
Stock Ownership (% of Full Market Cap) # ###							
Average	0.4%	0.44%	0.70%	0.30%	0.33%	1.04%	0.87%
95 percentile	0.4%	1.09%	1.21%	0.75%	0.73%	2.55%	2.56%
Tail Average @ 95%	0.4%	1.35%	1.33%	1.00%	0.93%	3.09%	3.32%
Maximum	0.4%	2.30%	1.64%	1.38%	1.21%	4.45%	5.15%
Degree of Index Tilt & Concentration ###							
Active Share		21.9%	26.3%	27.5%	22.5%	46.1%	44.3%
Avg Weight Multiplier	1	1.67	1.41	1.28	1.30	3.40	3.51
Max Weight Multiplier	1	293	35	5	4	753	329
Max Strategy Weight	3.7%	3.5%	1.1%	5.8%	4.9%	0.2%	0.9%

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 50 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

Exhibit 48: Investability Metrics for Europe

		Score x Mcap				Score Only	
Statistics from 30/11/1992 to 31/08/2012	Europe STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Tradability of the Strategy							
Weighted Average ATVR ###	101.2%	129.7%	117.6%	79.7%	85.2%	130.0%	105.5%
Days to Trade - Periodic Rebalancing # ## ####							
Weighted Average	4.1	6.2	8.7	6.6	15.0	21.9	27.1
95 percentile	2.9	10.7	14.9	7.3	25.0	40.0	40.6
Tail Average @ 95%	6.7	19.6	25.9	13.0	36.6	67.4	74.7
Maximum	12.6	51.8	58.3	38.2	98.4	151.9	204.2
Days to complete 95% trading	10.2	17.1	29.6	16.8	35.4	79.8	98.6
Days to Trade - Relative to benchmark # ## ####							
Weighted Average	na	16.2	22.5	25.2	16.2	46.4	56.2
95 percentile	na	29.1	55.9	24.2	24.4	144.9	139.7
Tail Average @ 95%	na	40.2	80.2	40.4	42.2	205.1	264.4
Maximum	na	106.3	147.0	81.6	215.7	421.6	672.6
Days to complete 95% trading			54.9	80.8	40.3	142.4	159.1
Replication Costs							
Avg. Annual Turnover (%)**	4.0%	17.2%	11.4%	12.1%	40.2%	21.6%	23.2%
Performance Drag in bps (at 50 bps)	4.0	17.2	11.4	12.1	40.2	21.6	23.2
Capacity of the Strategy							
Stock Ownership (% of Float Market Cap) # ###							
Average	0.9%	0.32%	1.74%	0.68%	0.79%	2.85%	2.45%
95 percentile	0.9%	1.31%	3.29%	1.45%	1.71%	8.51%	7.06%
Tail Average @ 95%	0.9%	1.33%	3.62%	1.81%	2.07%	10.24%	9.57%
Maximum	0.9%	1.36%	4.02%	2.55%	2.69%	13.02%	15.02%
Stock Ownership (% of Full Market Cap) # ###							
Average	0.7%	0.28%	1.21%	0.52%	0.61%	1.84%	1.61%
95 percentile	0.9%	1.30%	2.30%	1.26%	1.46%	4.98%	4.30%
Tail Average @ 95%	0.9%	1.31%	2.67%	1.68%	1.78%	6.09%	5.75%
Maximum	0.9%	1.36%	3.83%	2.39%	2.30%	8.28%	9.90%
Degree of Index Tilt & Concentration ###							
Active Share		25.6%	25.9%	23.4%	20.9%	48.0%	45.6%
Avg Weight Multiplier	1	1.18	1.35	1.13	1.18	4.89	5.36
Max Weight Multiplier	1	38	27	7	5	1,438	450
Max Strategy Weight	3.2%	3.1%	1.0%	5.5%	4.0%	0.2%	0.9%

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 50 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

Exhibit 49: Investability Metrics for Pacific

		Score x Mcap				Score Only	
Statistics from 30/11/1992 to 31/08/2012	PACIFIC STANDARD	Value Tilt	Low Size Tilt	Low Volatility Tilt	Momentum Tilt	Equal Weighted	Risk Weighted
Tradability of the Strategy							
Weighted Average ATVR ###	114.9%	118.2%	126.7%	97.8%	110.5%	138.0%	107.5%
Days to Trade - Periodic Rebalancing # ## ####							
Weighted Average	2.9	3.8	4.2	6.7	10.6	9.1	16.3
95 percentile	1.2	6.6	6.8	8.1	19.5	18.2	24.3
Tail Average @ 95%	3.1	11.3	11.2	15.6	31.1	27.9	48.2
Maximum	7.6	31.4	31.8	60.3	62.9	58.2	153.3
Days to complete 95% trading	6.5	10.5	13.3	20.2	26.9	27.8	56.0
Days to Trade - Relative to benchmark # ## ####							
Weighted Average	na	8.9	10.4	16.1	9.6	22.1	40.4
95 percentile	na	16.3	31.1	23.8	21.3	72.2	103.6
Tail Average @ 95%	na	28.8	45.0	42.2	30.5	108.0	188.9
Maximum	na	81.1	86.9	112.7	59.2	224.3	602.7
Days to complete 95% trading	na	20.5	27.1	40.3	27.3	71.1	135.8
Replication Costs							
Avg. Annual Turnover (%)**	4.6%	19.1%	11.5%	12.9%	44.9%	21.7%	23.8%
Performance Drag in bps (at 50 bps)	4.6	19.1	11.5	12.9	44.9	21.7	23.8
Capacity of the Strategy							
Stock Ownership (% of Float Market Cap) # ###							
Average	0.5%	0.65%	1.05%	0.58%	0.63%	1.52%	1.39%
95 percentile	0.6%	1.30%	1.75%	1.29%	1.47%	3.64%	3.58%
Tail Average @ 95%	0.6%	1.67%	1.95%	1.61%	1.74%	4.54%	5.31%
Maximum	0.7%	2.97%	2.29%	2.62%	2.12%	6.23%	10.09%
Stock Ownership (% of Full Market Cap) # ###							
Average	0.6%	0.49%	0.74%	0.43%	0.46%	1.03%	0.95%
95 percentile	0.6%	1.11%	1.29%	1.04%	1.03%	2.43%	2.59%
Tail Average @ 95%	0.7%	1.41%	1.41%	1.33%	1.32%	2.75%	3.47%
Maximum	0.7%	2.67%	1.63%	1.96%	2.11%	3.61%	5.10%
Degree of Index Tilt & Concentration ###							
Active Share		18.3%	23.0%	21.9%	21.4%	42.5%	44.3%
Avg Weight Multiplier	1	1.13	1.19	1.24	1.13	3.03	3.33
Max Weight Multiplier	1	22	22	7	4	292	106
Max Strategy Weight	4.3%	4.2%	1.1%	4.5%	4.8%	0.2%	1.1%

* Gross Total Returns in USD based on data from 30/11/1992 to 31/08/2012

** Average annual one-way index turnover from 30/11/1992 to 31/08/2012

Assuming a fund size of USD 20 billion

Assuming trade limit of 10% of daily trading volume

As of 01 Jun 2012 rebalancing

Average of last four rebalancings ending Jun 2012

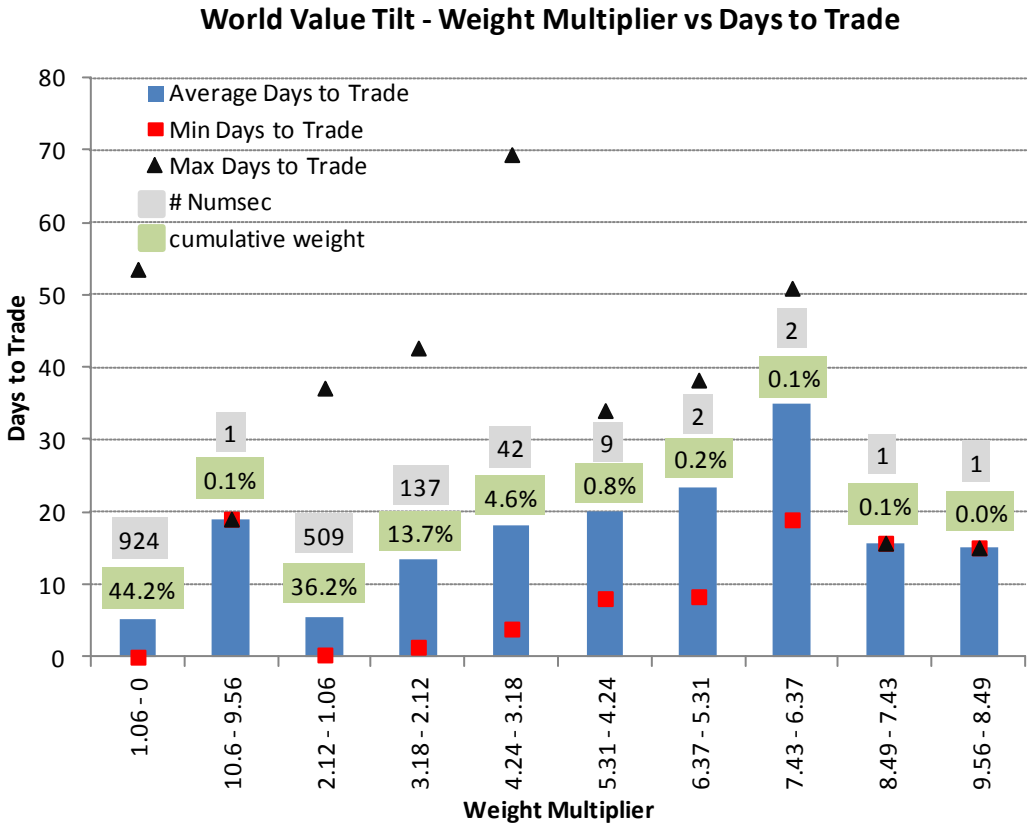
Appendix F: Relationship Between the Weights and Investability

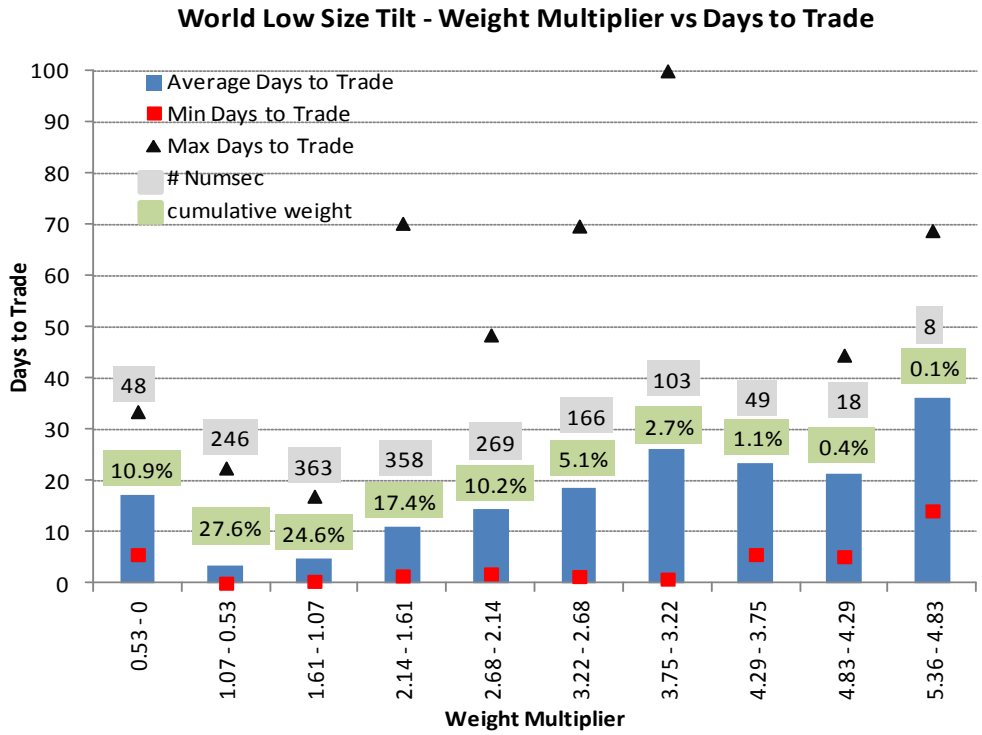
In this section, we show the relationship between each stock's weight and the investability as reflected by a stock's days to trade in a given portfolio. All analyses are as of the June 30, 2012 rebalancing.

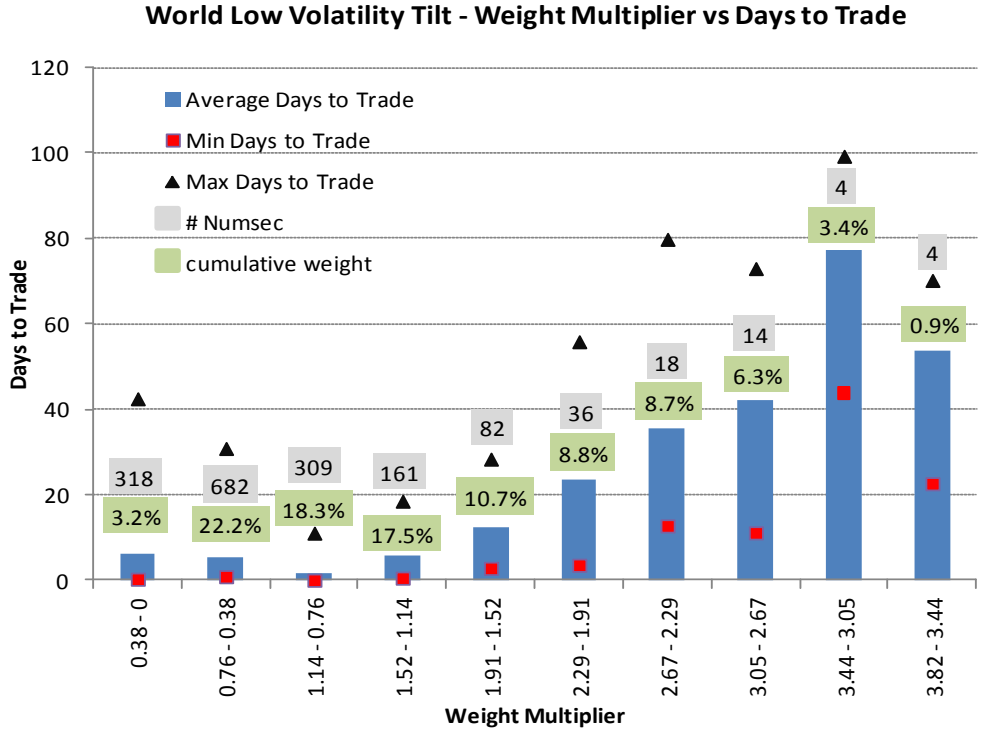
Exhibit 50 groups stocks by weight multiplier (which is the weight in the risk premia index) and plots them from left to right for each risk premia index. The average days to trade is shown in the blue bar for the stocks in each group.

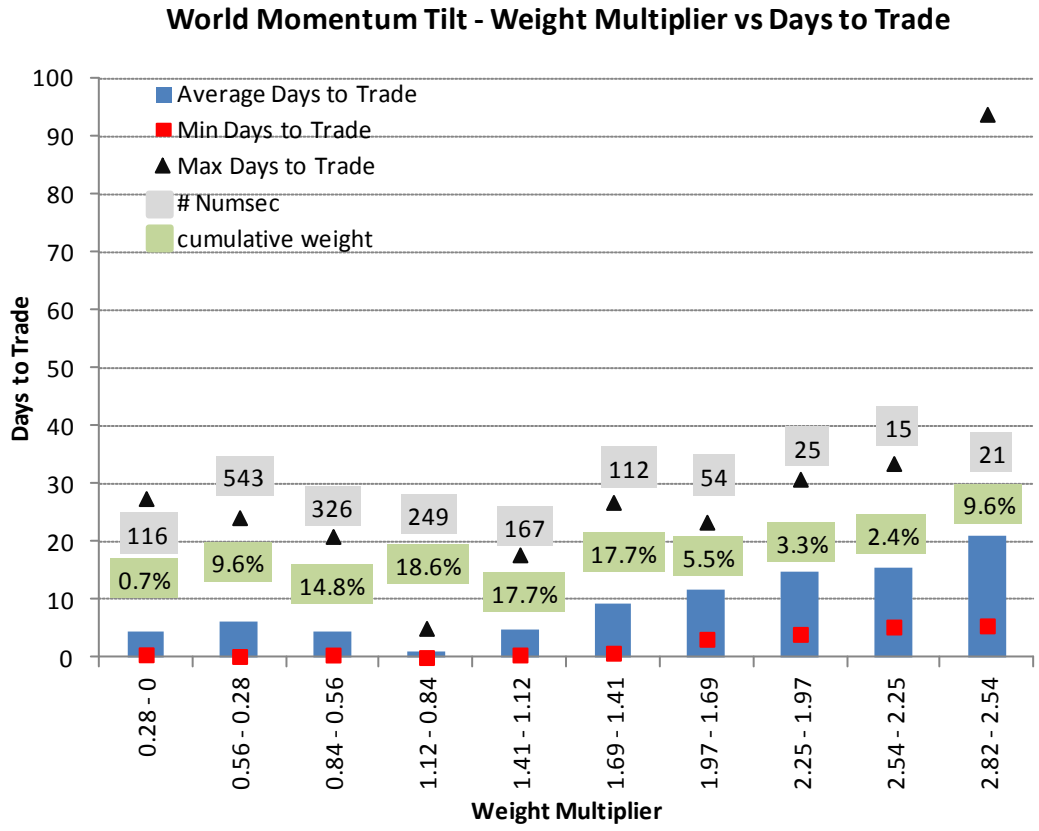
For all simulated indices, as expected, investability generally decreases (days to trade increases) as the weight multiplier increases.

Exhibit 50: The Relationship Between the Weights and Investability





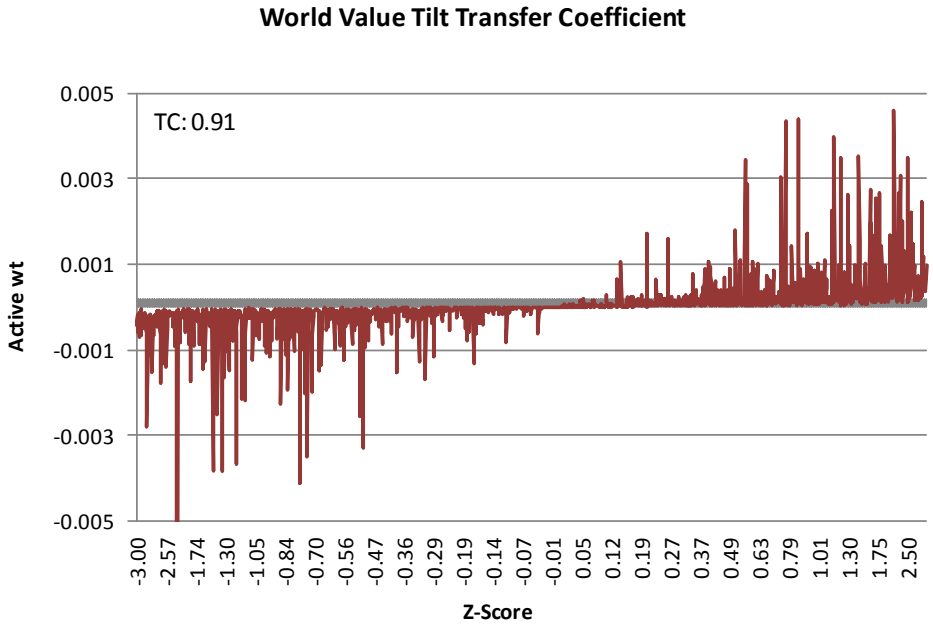


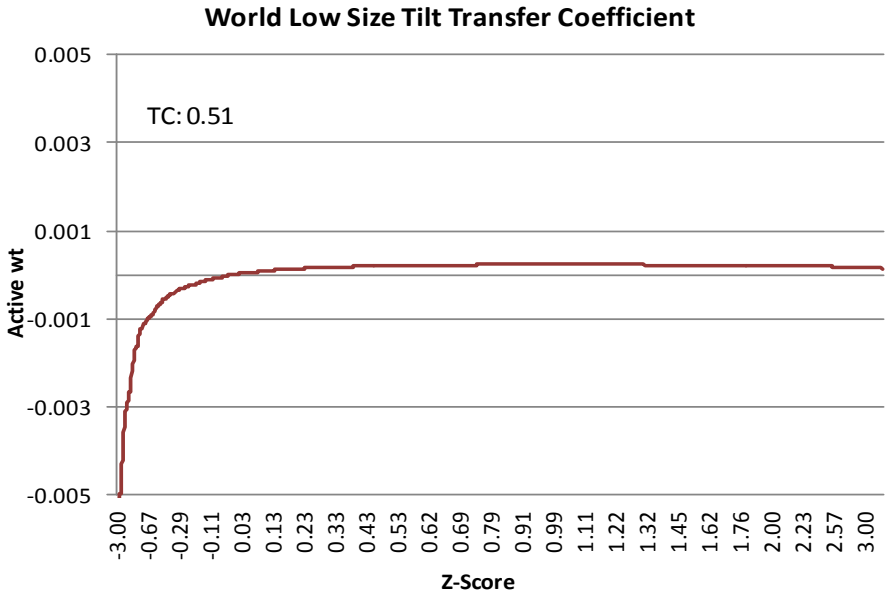


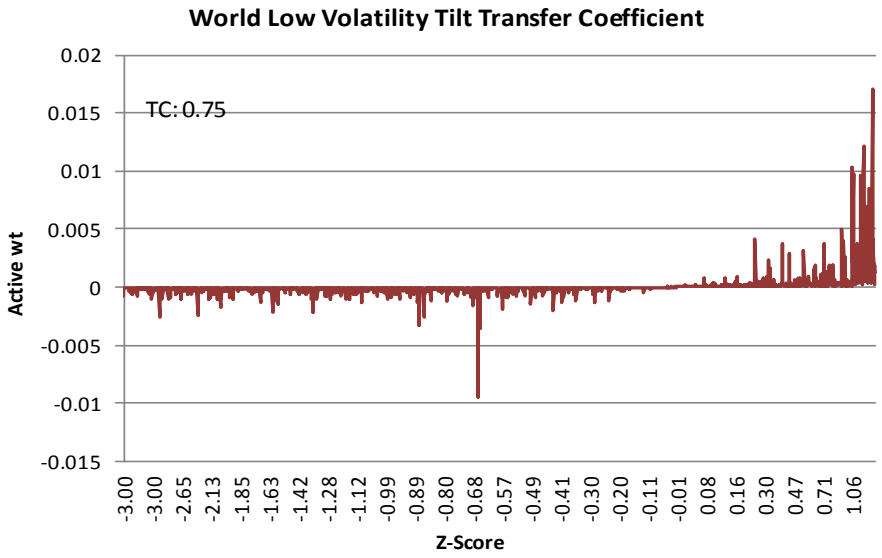
Appendix G: Efficiency Analysis

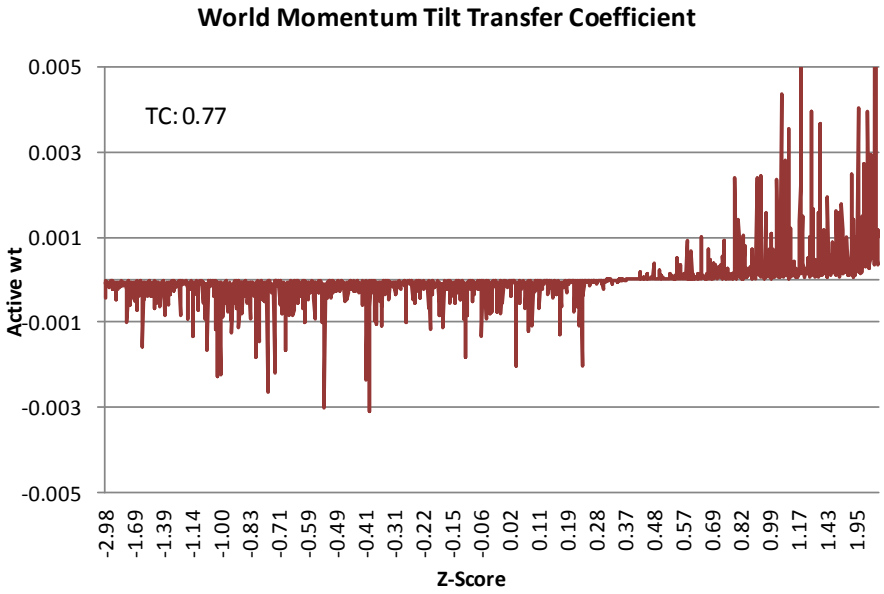
In this section, we discuss efficiency which is the correlation between the signal as reflected by the score or raw variable and the weights. The higher this correlation, the more efficiently the index captures the signal. All analyses are as of the June 30, 2012 rebalancing. Transfer coefficients are computed as the Pearson Rank Correlation. The transfer coefficient is highest for the Value Tilt Index and reasonably high for both the Momentum and Low Volatility Tilt Indices.

Exhibit 51: The Relationship Between the Signal and Weights (June 30, 2012)









Appendix H: Decomposing the Returns Using the Barra Factor Model

One way to understand the drivers of returns is to decompose the returns of a portfolio to factors in a factor model. Using the Barra Global Equity Model (GEM2) described in Appendix C, we can exactly attribute the returns to the factors. What is not attributable to factors is referred to stock specific return (or what is labeled "Asset Selection" in the following charts).

Factor returns are the returns to the pure long-short factors estimated as part of the model construction. The returns to any portfolio or index can be written as a linear combination of factor component returns and stock specific returns. The factor combination returns are found by multiplying the exposure of the portfolio to the factor times the factor return. The exposure of the portfolio is just the weighted average of the stocks' exposures.

For instance, if there are two stocks in the portfolio A and B and two factor returns K and J, we decompose the portfolio's returns (in a single point in time, i.e., 1 day or 1 month) as follows:

$$ret_{port} = X_{port,K} r_K + X_{port,J} r_J + w_A sr_A + w_B sr_B \quad (3.1)$$

Where

$$X_{port,K} = w_A X_{A,K} + w_B X_{B,K}$$

$$X_{port,J} = w_A X_{A,J} + w_B X_{B,J}$$

w_A and w_B are the weights of the stocks A and B in the portfolio

$X_{A,J}$ is stock A's exposure to factor J

r_K and r_J are factor returns for that period

sr_A and sr_B are the specific returns to stocks A and B for that period

When there are 153 factors in the model as we have in the GEM2 model, we can write Equation (3.1) in matrix form:

$$ret_{port} = (w'X)F + w'u \quad (3.2)$$

Where

w = weight vector (*n* stocks x 1)

X = exposure matrix (*n* stocks by *k* factors)

F = factor return vector (*k* factors x 1)

u = specific return vector (*n* stocks x 1)

In Exhibit 52 we decompose the returns into the main categories. Note that all return categories exactly sum up to the risk premia index returns. The main categories are: style factors, country factors, industry factors, the World factor (similar to a market factor), and stock specific return (Asset Selection). All analysis is done in active space. The GEM2 model starts in 1997 which shortens our analysis period. We focus on the period December 1998 and on which is the earliest allowable date given that the Low Liquidity Tilt Indices begin in November 1998.

Exhibit 52: Broad Indices: Decomposition of Returns Using Barra Global Equity Model (GEM2) (December 1998 to November 2012, All Numbers in Annualized Percentage Return)

Source of Return	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
1 Risk Free	2.29	2.29	2.29	2.29
2 Total Benchmark	3.22	3.22	3.22	3.22
3 Currency Selection	0.01	0.12	0.04	-0.23
5 Styles	1.65	0.74	0.93	-0.25
6 Industries	-0.59	-0.39	0.10	-0.02
7 Countries	-0.13	-0.16	0.01	-0.16
8 World Equity	0.00	0.00	0.00	0.00
9 Asset Selection	0.97	1.87	0.24	0.32
10 Active Equity [5+6+7+8+9]	1.91	2.05	1.28	-0.12
13 Total Active [3+4+10+11+12]	1.95	2.19	1.31	-0.32
14 Total Managed [2+13]	5.17	5.41	4.53	2.90

In Exhibit 52, as we would expect, styles contribute the largest portion of return for all the indices except the World Momentum Tilt and the two Low Size indices. The Low Size Indices have a fair amount of return arising from Asset Selection. This result can at least be partially due to the fact that the regression scheme for estimating factor returns puts heavier weight on larger caps. The World Momentum Tilt Index is unusual in that Asset Selection contributes the most return. Note that because we use a truncated period from the analysis in the body of the report, the active return to the Momentum Tilt Index is slightly negative which makes these results more difficult to interpret.

Because the styles in Exhibit 52 include all 8 GEM2 style factors, we next decompose this return further. As seen in Exhibit 53, all indices derive positive returns from their equivalent factors, as we would hope to see. The World Value Tilt Index for instance derives 138 basis points annually from the pure Value factor. Looking next to see if any of the indices are significantly affected by exposure to other factors, a few instances appear. First, the World Size Tilt, World Equal Weighted, and World Low Volatility Tilt Indices derive a fair amount of return from the Value factor. Low Volatility, Value, and Low Size risk premia appear to have some interaction here which help naturally boost returns for these indices.

Exhibit 53: Broad Indices: Decomposition of Style Returns Using Barra Global Equity Model (GEM2) (December 1998 to November 2012, All Numbers in Annualized Percentage Return)

Source of Return	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
Momentum	-0.24	-0.11	-0.37	0.57
Volatility	0.51	0.10	0.98	-0.54
Value	1.38	0.33	0.29	-0.27
Size	0.06	0.10	-0.02	0.01
Size Nonlinearity	0.13	0.40	-0.03	0.01
Growth	-0.04	0.01	-0.03	-0.01
Liquidity	0.04	-0.05	0.13	-0.09
Financial Leverage	-0.19	-0.04	-0.02	0.07
Total	1.65	0.74	0.93	-0.25

One of the puzzles discussed in Section VI is the lower returns to World Focused Risk Tilt and World Focused Value Tilt Indices. Next we show the same tables above for the World Focused Indices. Comparing the results in Exhibits 54 and 55 to those previously, we first glean that the contribution from the Barra Value factor return is actually greater for the World Focused Value Tilt Index. It is in fact offset by incidental tilts to other factors; for instance, Industry Tilts, a negative Momentum exposure and a positive Financial Leverage exposure bring down the performance.

Similarly for the World Risk Tilt Index, we observe that the active returns for this subperiod are in fact higher for the focused index than the broad index, which was not the case using the longer period from November 1992-on. Nevertheless, the return from (a negative exposure to) the Volatility factor accounts for only part of the return from Style factors. A Value bias and Low Size bias also contribute. This suggests in periods when this focused index underperforms the broad index, it may be related to incidental tilts.

Exhibit54: Focused Indices: Decomposition of Returns Using Barra Global Equity Model (GEM2) (December 1998 to November 2012, All Numbers in Annualized Percentage Return)

Source of Return	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
1 Risk Free	2.29	2.29	2.29	2.29
2 Total Benchmark	3.22	3.22	3.22	3.22
3 Currency Selection	-0.12	1.58	0.72	-0.43
5 Styles	1.45	2.97	2.69	-0.65
6 Industries	-0.63	-0.49	-0.45	0.22
7 Countries	-0.08	-0.86	-0.31	-0.40
8 World Equity	0.00	0.00	0.00	0.00
9 Asset Selection	0.24	3.17	2.29	0.32
10 Active Equity [5+6+7+8+9]	0.98	4.79	4.23	-0.51
13 Total Active [3+4+10+11+12]	0.90	6.31	4.95	-0.87
14 Total Managed [2+13]	4.12	9.53	8.17	2.36

Exhibit 55: Focused Indices: Decomposition of Style Returns Using Barra Global Equity Model (GEM2) (December 1998 to November 2012, All Numbers in Annualized Percentage Return)

Source of Return	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
Momentum	-0.33	-0.31	-0.23	2.32
Volatility	0.55	0.54	1.06	-2.00
Value	1.58	1.31	0.96	-0.99
Size	0.01	0.41	0.24	0.14
Size Nonlinearity	-0.17	1.04	0.69	0.04
Growth	-0.07	0.00	-0.01	0.03
Liquidity	0.11	0.01	0.02	-0.38
Financial Leverage	-0.25	-0.04	-0.04	0.20
Total	1.45	2.97	2.69	-0.65

Appendix I: Decomposing Returns by Fundamentals

In this section we decompose the gross returns to the risk premia indices (in USD) into several components:

- Inflation
- Dividend Growth
- Forward Price-to-earnings Growth
- Real EPS Growth

For inflation we use changes in the US Consumer Price Index (seasonally adjusted, All Urban Consumers) released by the US Bureau of Labor Statistics. Note that the indices we evaluate are global; however the currency is USD.

All fundamental data is maintained and calculated by MSCI. Regarding earnings, MSCI defines earnings as the net income from the continuing operations available to all equity shareholders (i.e., all shareholders holding securities that exhibit equity-like characteristics), excluding extraordinary items or non-recurring items, minority interest and preferred dividends (in cases where preferred shares do not exhibit equity like characteristics).

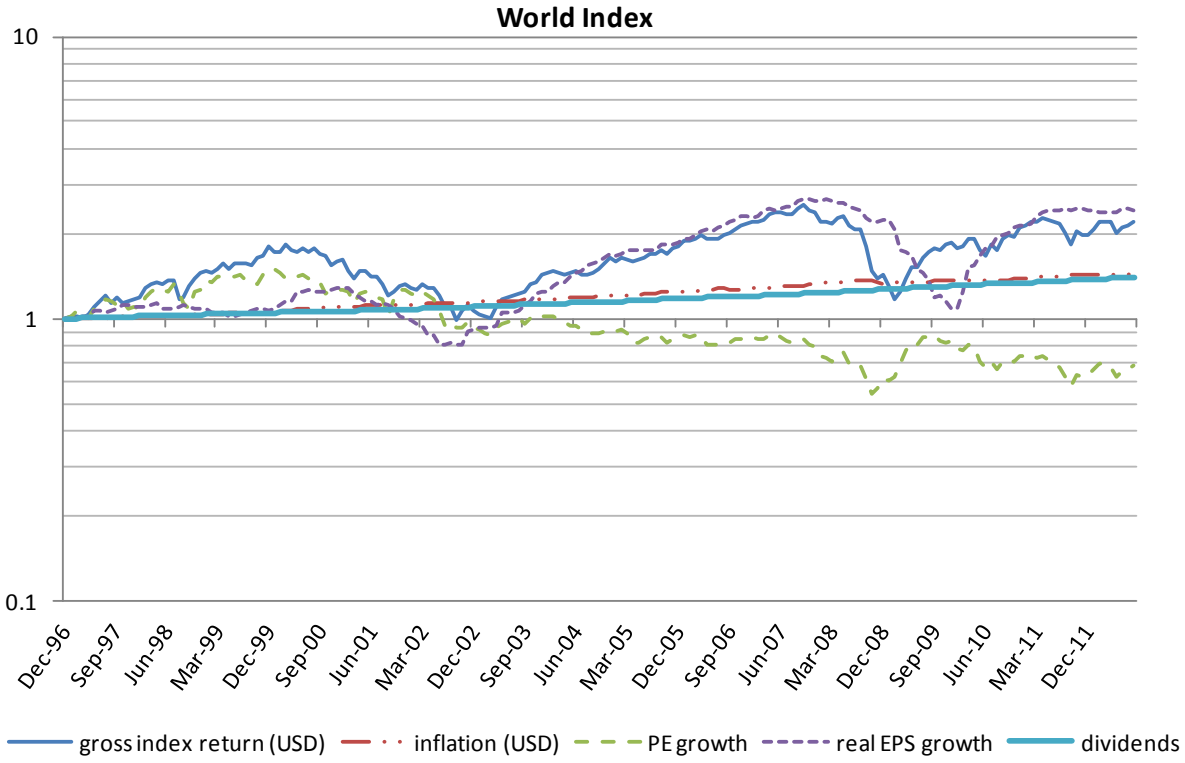
In cases where MSCI determines that a company has unusual gains or losses that do not reflect the earnings potential of the company going forward, the item will be treated as non-recurring and will be excluded from earnings on an after-tax basis. Profit / loss on sale of discontinued operations, restructuring charges, bankruptcy charges, changes in accounting policy etc. could be some instances where the profits / losses are adjusted by MSCI to reflect normalized earnings.

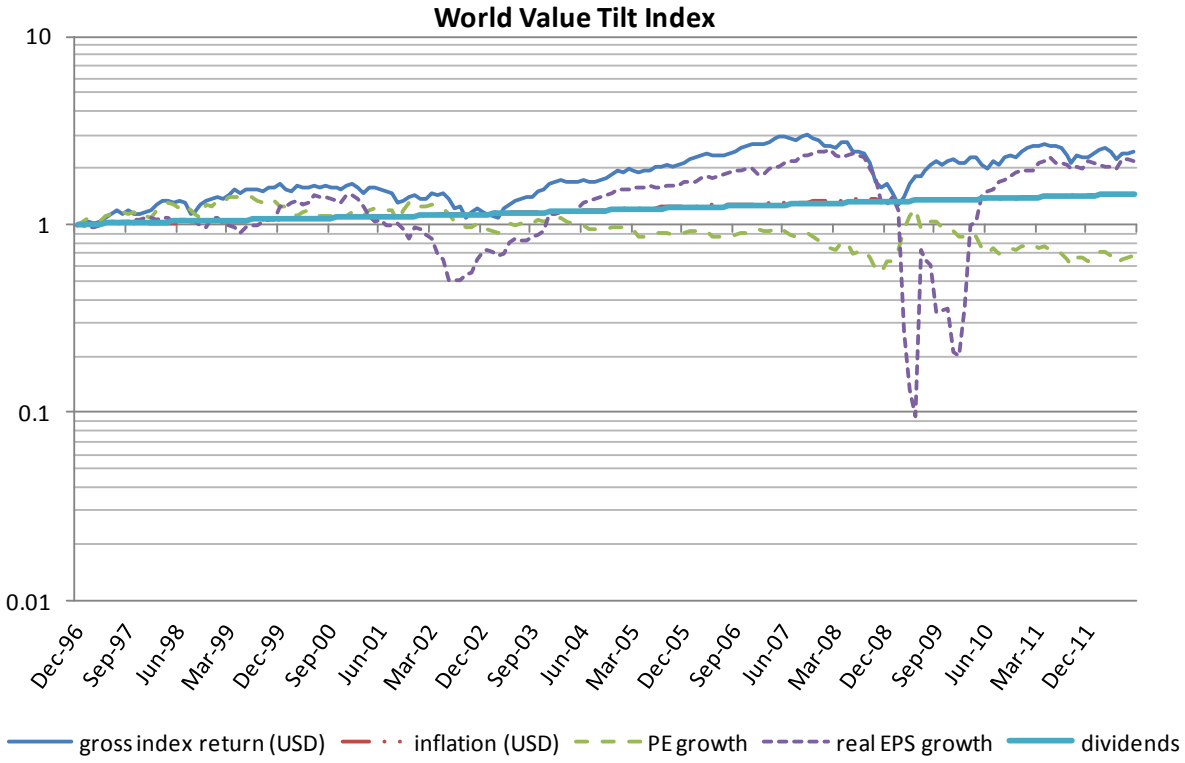
For all countries, the EPS is calculated using net earnings and number of shares, except in the US, Canada, the UK, and Ireland where MSCI follows basic (undiluted) EPS from continuing operations available to common shareholders as reported by companies.

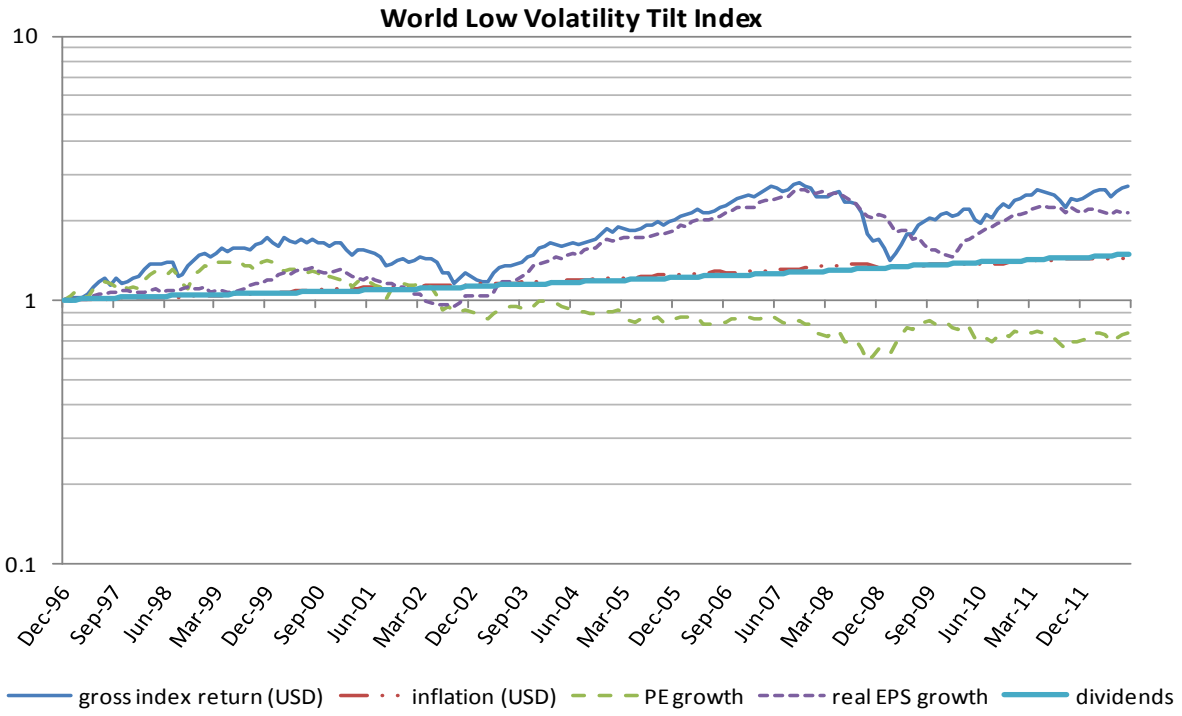
Additional details about the fundamental variables (dividends, Forward P/E, and Earnings Per Share) can be found in the paper “MSCI Fundamental Data Methodology” (May 2011).

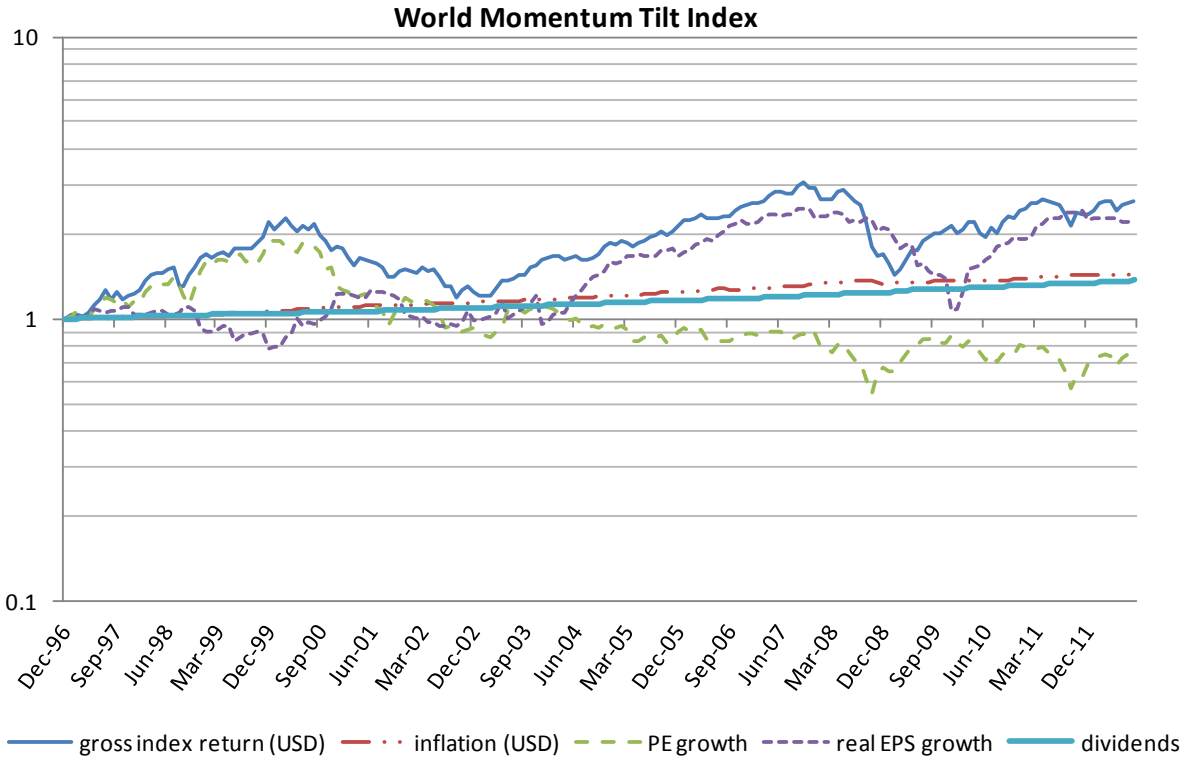
The following exhibits decompose returns into the above components.

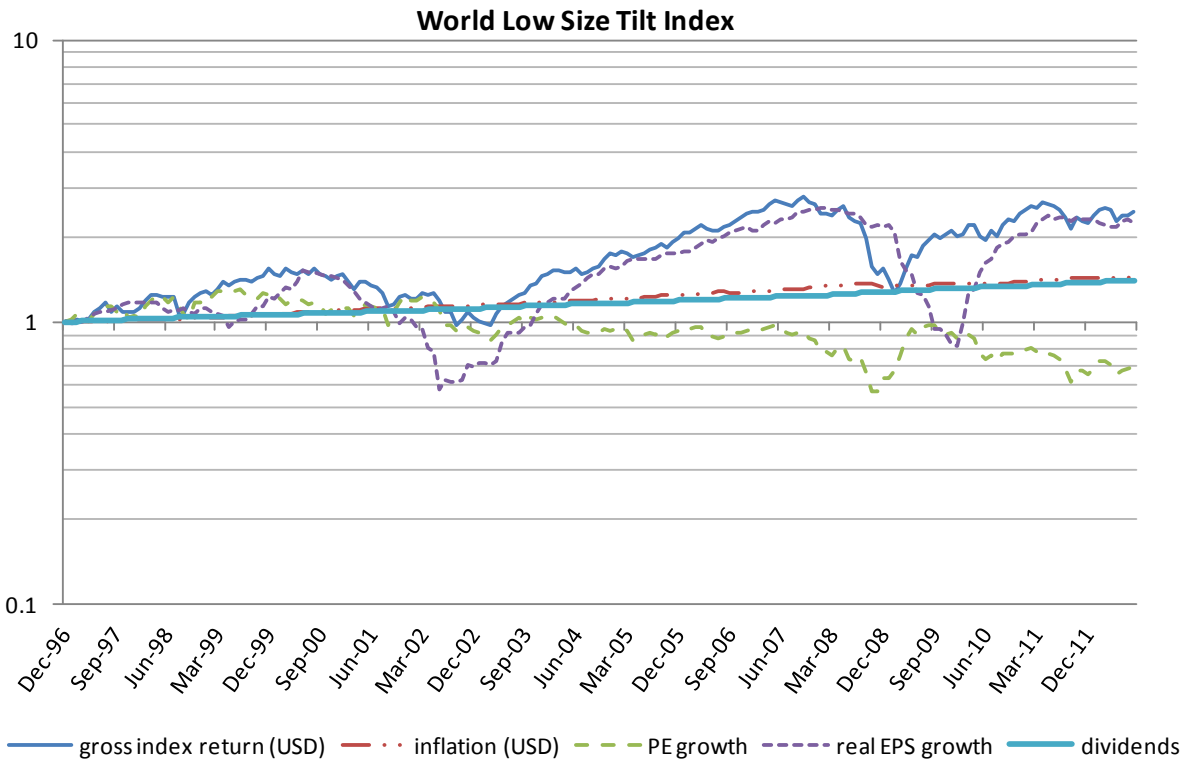
Exhibit56: Decomposition of USD Gross Index Levels for Simulated Risk Premia











Appendix J: Evaluating Low Liquidity Tilt Indices

Background on the Liquidity Premium

There is an ongoing active literature on whether liquidity as a stock characteristic is priced. In theory, less liquid stocks should command a premium to offset the additional risks and costs for these stocks. A sizable set of empirical studies have found that low liquidity stocks do earn a premium. The seminal work by Amihud & Mendleson (1986) found that low liquidity stocks outperformed the high liquidity ones for US equities using bid-ask spreads as a measure of liquidity. Later, Datar et al. (1998) demonstrated the persistence of the higher expected return when the turnover is low, after controlling for other factors. Amihud (2002) concluded that low liquidity positively affects the stock excess return. Both studies use US equities.

More recently, Ang, Goetzman & Schaefer (2009), Ibbotson et al. (2012), and Ilmanen (2011) all find empirical support for the existence of the illiquidity premium. There is a general understanding that measuring liquidity is challenging. According to Ibbotson et al. (2012) for instance: "A single 'perfect' measure of liquidity is unlikely to exist, since Brown, Crocker and Foerster (2009) found that liquidity measures may encode momentum and information effects in large-cap stocks."

Bid-ask spreads, absolute returns scaled by daily trade value, transaction costs, and turnover have all been used as measures of liquidity. Brennan and Subrahmanyam (1996) used transaction costs as a measure of liquidity. They regress the price impact of a unit trade size from microstructure trading data. Amihud (2002) use average price impact relative to daily trading volume of each security. Pástor and Stambaugh (2003) conceptualize liquidity from a more macro perspective, to show that stock returns vary with their sensitivity to market wide liquidity. It is important to note that in spite of the various operationalizations of the idea, these studies all conclude that there exists a liquidity factor. There is evidence of this for international markets as well (Lesmond, 2005; Bekaert, Harvey and Lunblad, 2007; and Stahel, 2005).

There remains a vigorous debate over whether the premium exists, how significant it is, and whether the liquidity effect is merely masking a size or value effect.

Measuring Liquidity

The methodology for building the Low Liquidity Indices follows the same general framework outlined in Section III and uses turnover as the measure of liquidity. Haugen and Baker (1996), Datar, Naik and Radcliffe (1998), Ibbotson, Chen, Kim, and Hu (2012) document the liquidity premium using turnover.

The Liquidity Tilt Index uses multiple turnover descriptors. First, for each descriptor, a z-score is calculated as follows:

$$z_i = \frac{\left(x_i - \bar{x}\right)}{\sigma_x} \qquad (4.1)$$

where x is the raw descriptor. Note that the market capitalization-weighted mean is used here (which is different from the simple mean used in the Momentum z-score). There are 3 descriptors: Monthly Share Turnover (MST), Quarterly Share Turnover (QST), and Annual Share Turnover (AST). Each of these is standardized with respect to the market capitalization-weighted mean by country. The z-scores for each descriptor are combined as follows. For clarity, let's call this an exposure as opposed to a z-score (the same terminology as used in the Barra model which the definition is borrowed from):

$$X_i = 0.2 \times MST + 0.35 \times QST + 0.45 \times AST \qquad (4.2)$$

The scores are truncated at +/-3 standard deviations.

We multiply scores by -1 so that the scores denote "illiquidity" as opposed to "liquidity."

Next, the standardized scores are translated into positive scores as follows:

$$score_i = 1 + z_i \qquad where \qquad z_i > 0 \tag{4.3}$$

$$score_i = \frac{1}{1 - z_i} \qquad where \qquad z_i < 0 \tag{4.4}$$

The weight is then calculated as:

$$weight_i = \frac{\left(score_i \times mcap\_weight_i\right)}{\sum_{i=1}^{N}\left(score_i \times mcap\_weight_i\right)} \tag{4.5}$$

where mcap_weight is the free float adjusted market capitalization weight of the stock.

All Low Liquidity Indices begin in November 1998.

It may be worthwhile to better understand what using a measure based on share turnover for liquidity implies. Share turnover is meant to capture liquidity while accounting for the size of the company. By dividing trading volume by the number of shares outstanding, the measure accounts for size. Thus, even large companies can have very low liquidity. For instance, as of June 2012, the company with the largest weight in the Low Liquidity Index was Exxon, a large cap. This is seen in Exhibit 57 which lists the top 10 constituents as of June 1, 2012.

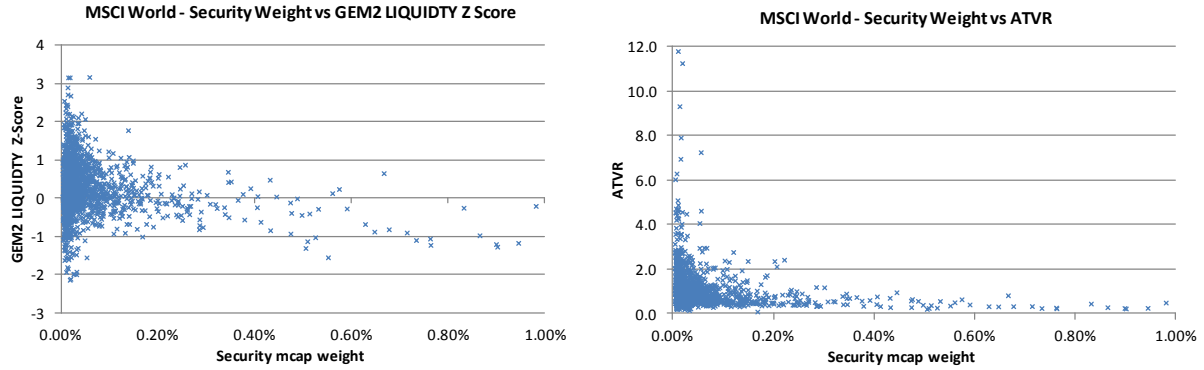
Exhibit 57: Top 10 Constituents by Positive Active Weight in the World Low Liquidity Tilt Index as of June 30, 2012

Security Name	Country	Sector	ATVR	Weight in World Low Liquidity	Active weight
EXXON MOBIL CORP	US	ENERGY	27.5%	3.2%	1.5%
AT&T	US	TELECOM SERVICES	22.9%	1.9%	1.0%
IBM CORP	US	INFO TECHNOLOGY	25.8%	1.9%	0.9%
GENERAL ELECTRIC CO	US	INDUSTRIALS	25.1%	1.8%	0.9%
PROCTER & GAMBLE CO	US	CON. STAPLES	23.6%	1.5%	0.8%
WAL-MART STORES	US	CON. STAPLES	36.0%	1.3%	0.7%
CHEVRON CORP	US	ENERGY	28.6%	1.5%	0.7%
PFIZER	US	HEALTH CARE	24.8%	1.4%	0.7%
JOHNSON & JOHNSON	US	HEALTH CARE	27.0%	1.4%	0.7%
ROYAL DUTCH SHELL A	GB	ENERGY	34.8%	1.1%	0.5%

ATVR is Annual Traded Value Ratio and is FIF-adjusted. For a description of this variable, please refer to the "MSCI Global Investable Market Indices Methodology"

Another helpful illustration is shown in Exhibit 58 where we plot the GEM2 Liquidity factor z-score (or exposure) alongside Annual Traded Value Ratio (ATVR). MSCI employs ATVR to screen out extreme daily trading volumes, taking into account the free float-adjusted market capitalization size of securities.[24] The lower the ATVR, the less liquid the security. For both metrics below, the largest stocks typically have low ATVR and negative Liquidity scores.

Exhibit 58: Profile of Share Turnover and Annual Traded Value Ratio by Market Capitalization Weight (June 1, 2012)



There are other alternative measures for liquidity that are not scaled by market cap or shares outstanding. For instance, Amihud (2002) proposed a measure which yields a strong relationship between illiquid stocks and size (small caps).

Performance of the Low Liquidity Tilt Indices

Exhibits 59 and 60 compare the World Low Liquidity Tilt Index against the other indices. Note that the Low Liquidity Tilt Index is the only one that does not exhibit significant active returns.

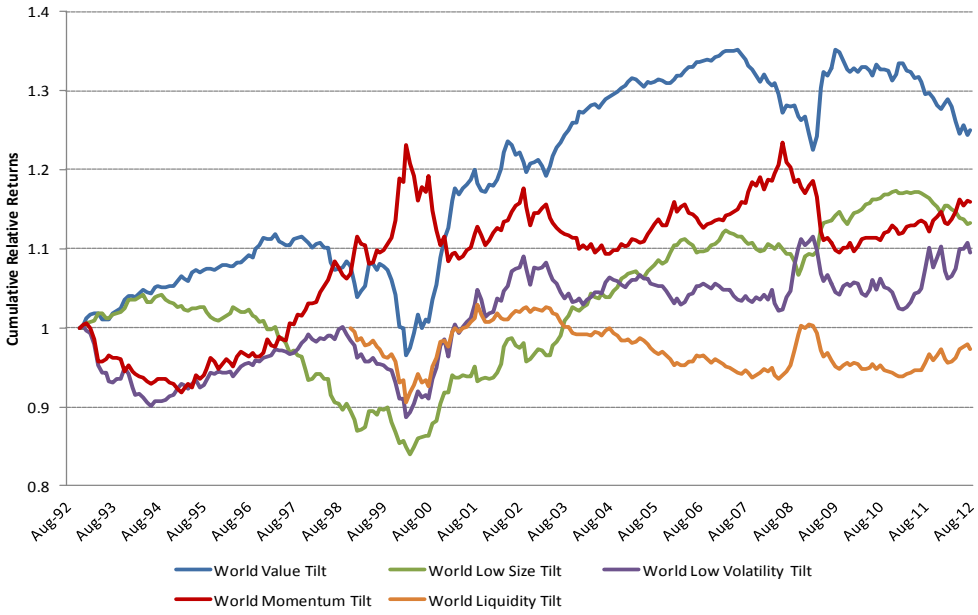
Exhibit 59: Annualized Returns to Simulated Risk Premia Indices (December 1978 to August 2012)

		Score x mcap					*Score only*	
	World	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt	World Low Liquidity Tilt	World Equal Weighted	World Risk Weighted
Total Returns								
Dec 1998 to August 2012	3.4%	4.4%	5.2%	4.7%	4.1%	3.5%	6.6%	7.8%
Dec 2002 to August 2012	7.8%	7.9%	9.4%	8.4%	8.0%	7.5%	10.7%	11.2%
Active Returns (basis points)								
Dece 1998 to August 2012		104	175	131	65	0	318	443
Dec 2002 to August 2012		11	160	66	18	0	295	345

All figures are annualized USD Gross returns using longest available time period.

[24] ATVR is computed as follows. First, monthly median traded values are computed as the median daily traded value multiplied by the number of days in the month that the security traded. The daily traded value of a security is equal to the number of shares traded during the day multiplied by the closing price of that security. Second, the monthly median traded value of a security is divided by its free float-adjusted security market capitalization at the end of the month, giving the monthly median traded value ratio. Finally, the 12-month ATVR is obtained by taking the average of the monthly median traded value ratios of the previous 12 months – or the number of months for which this data is available (previous 6 months, 3 months or 1 month) – and annualizing it by multiplying it by 12.

Exhibit 60: Cumulative Active Returns for Simulated Risk Premia Indices (November 1992 to August 2012)



Regional Low Liquidity Tilt Indices are shown in Exhibit 61. We note that there is a small premium in both Europe and the Pacific but none in the US or Emerging Markets.

Exhibit 61: Regional Risk Premia Indices for Low Liquidity (November 1992 to August 2012)

	MSCI EM Index	EM Low Liquidity Index	MSCI USA Index	USA Low Liquidity Index	MSCI Europe Index	Europe Low Liquidity Index	MSCI Pacific Index	Pacific Low Liquidity Index
Annualized Return	11.5%	11.5%	3.4%	3.2%	3.4%	3.8%	3.8%	4.0%
Annualized Risk	24.3%	23.4%	16.1%	14.2%	19.8%	18.5%	17.8%	16.5%
Return/Risk	47.2%	49.2%	20.9%	22.6%	17.0%	20.5%	21.0%	24.3%

All figures are annualized USD Gross returns from 11/1998-8/2012.

Discussion of Results

The low returns for the World Low Liquidity Index are inconsistent with prior studies which have shown the existence of a liquidity premium, even those that use turnover as a measure of liquidity. The most likely reason is the choice of universe and weighting scheme[25]. In past studies, larger universes which include small caps and sometimes micro caps are typically used. Ibbotson et al. (2012) for instance use the top 3,500 stocks by US market cap. Quartile portfolios are formed based on turnover and within the portfolios, stocks are typically equally weighted.[26] The inclusion of small caps and equal weighting contrasts with our approach here which confines the analysis to large and mid caps and uses a weighting

[25] Rebalancing frequency, definition of turnover (or other measure of liquidity), exact construction of portfolio, time period may also cause differences… but we don't think so.

[26] In Ibbotson et al. (2012), liquidity is measured by the annual share turnover (the sum of the twelve monthly volumes divided by each month's shares outstanding). Value as measured by the trailing earnings/price ratio (with lagged earnings because of reporting delays) as of year-end. Momentum is measured by the annual return during the selection year (i.e., 12-month momentum.) he stocks are sorted into quartiles for each variable, so that each of the selection-year portfolios receives a quartile number of the stocks for each of turnover, size, value, and momentum. In each of the performance years (1972—2011), the portfolios selected are equally weighted at the beginning of each year and passively held. The low liquidity quartile portfolio clearly outperforms both the small cap portfolio and the high momentum portfolio. Additional regressions using FF results in Less Liquid stocks retaining significant alpha after the other FF factors have been accoutned for.

scheme that scales with market cap. The differences seem to imply that the illiquidity effect may be restricted to smaller cap stocks.

Overall, the definition of the liquidity is critical to whether a premium is identified. This topic deserves further consideration beyond the scope of this study.

Appendix K: Systematic versus Specific Risk

Exhibit 62 show the sources of forecast active risk based on the Barra Global Equity Model (GEM2) as of June 1, 2012. All risk numbers are annualized. Several results are striking. The World Low Volatility Tilt and Value Tilt Indices have a much greater amount of risk arising from exposure to the Barra style factors (which include the factors these risk premia indices are meant to tilt on). In the case of the Value Tilt Index, positive exposure to the Barra Value factor and negative exposure to the Barra Momentum factor drive the higher risk. In the case of the Low Volatility Tilt Index, the negative exposure to the Volatility factor (a low beta bet in other words) causes this large active risk.

Comparing the risk arising from country tilts is also interesting. In particular, the World Low Volatility Tilt Index takes relatively less active bets along country dimensions and the risk is correspondingly low. This index also exhibits lower sector risk because the sectors where it takes the largest active bets happen to low volatility sectors such as Consumer Staples.

Exhibit 62: Active Forecast Risk Decomposition (June 1, 2012)

Active Systematic Risk vs Specific Risk in Percentage (GEM2L, June 1, 2012)

	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
Systematic Risk				
Styles	2.4%	1.2%	3.6%	1.9%
Industries	0.5%	0.3%	0.9%	0.6%
Country	1.1%	1.1%	0.3%	0.9%
Currency	0.8%	0.6%	0.3%	0.7%
World Equity	0.0%	0.0%	0.0%	0.0%
Specific Risk	0.6%	0.6%	0.5%	1.0%

Active Contributions to Systematic Risk vs Specific Risk in Percentage (GEM2L, June 1, 2012)

	World Value Tilt	World Low Size Tilt	World Low Volatility Tilt	World Momentum Tilt
Systematic Risk	96.3%	89.7%	98.4%	85.1%
Styles	68.3%	45.5%	69.2%	51.1%
Industries	3.2%	2.8%	4.6%	4.7%
Country	14.9%	33.9%	0.6%	11.1%
Currency	8.0%	11.0%	0.4%	7.6%
World Equity	0.0%	0.0%	0.0%	0.0%
Covariance * 2	2.0%	-3.5%	23.6%	10.6%
Specific Risk	3.8%	10.3%	1.6%	14.9%

Appendix L: Active Contribution to Risk for Sectors, Regions, and Style Factors Using the Barra Global Equity Model (GEM2L)

Exhibits 63 to 65 show the contributions to active risk for the four World broad indices. The benchmark in all cases is the MSCI World Index. The risk estimate is as of June 1, 2012 using the Barra Global Equity Long-Term Model (GEM2L). Contributions to active risk (when the currency, country, industry, style, and specific contributions are summed) plus the covariance term between factors exactly sum to 100%. The covariance terms between factors are not shown below. For all charts below, shown on the y-axis is the contribution to active risk in percent; for instance, risk from exposure to the Financials sector contributes 1% (out of 100%) to the World Value Tilt Index Factor. Note that the sum of all the sectors plus a covariance term (not shown) equals the risk shown in the bottom panel of Exhibit 55 ("Industries").

Exhibit 63: Sectors: Contribution to Active Risk Using the Barra GEM2L Model (June 1, 2012)

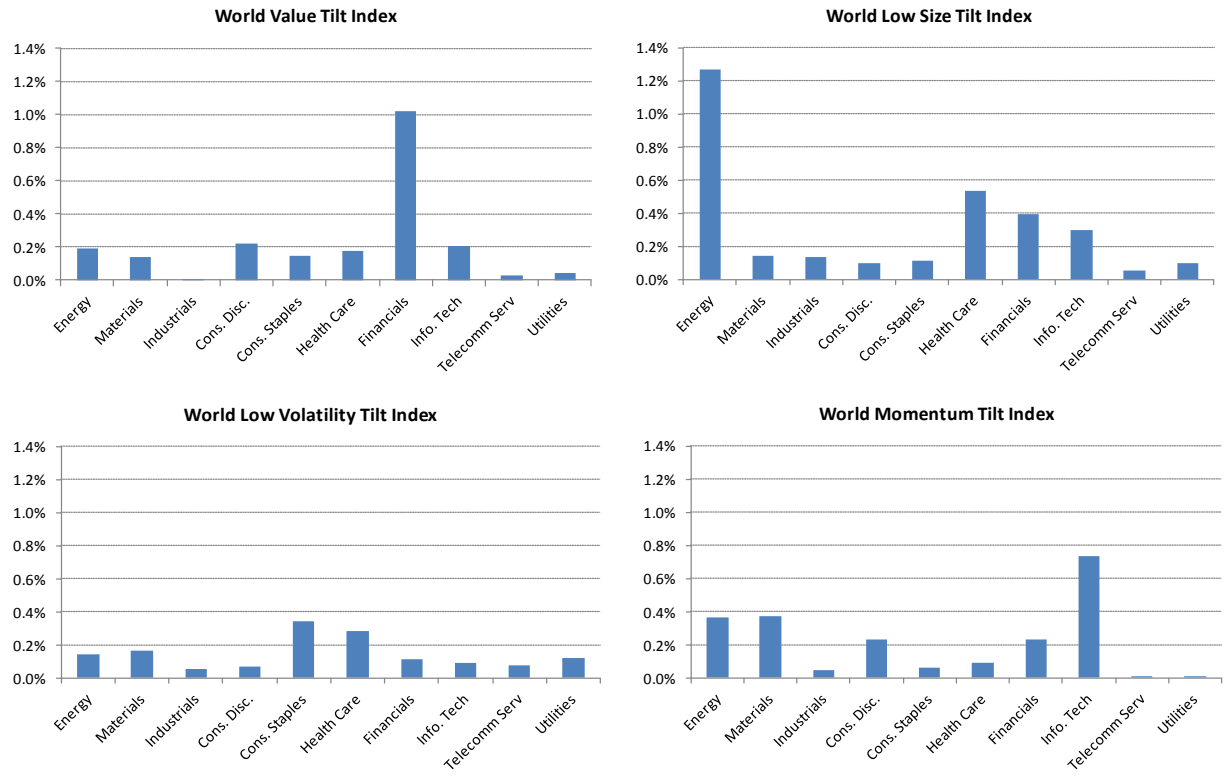


Exhibit 64: Regions: Contribution to Active Risk Using the Barra GEM2L Model (June 1, 2012)

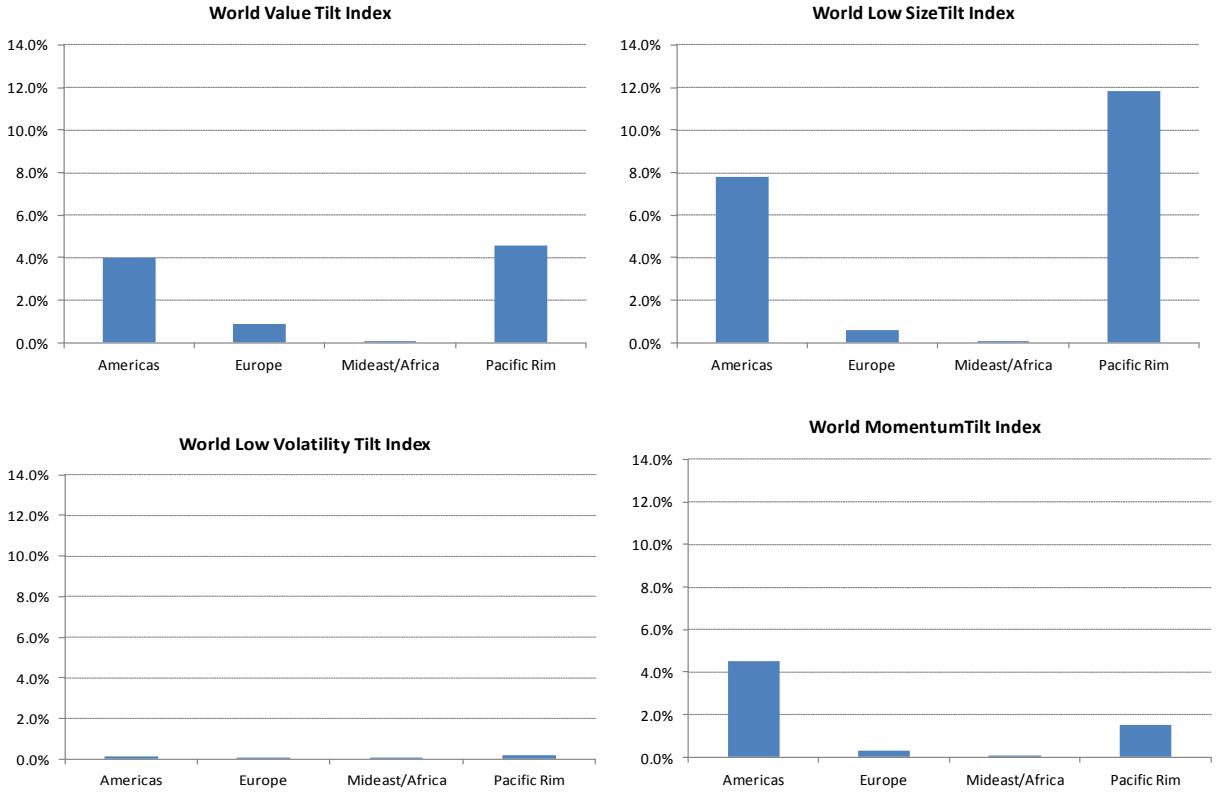
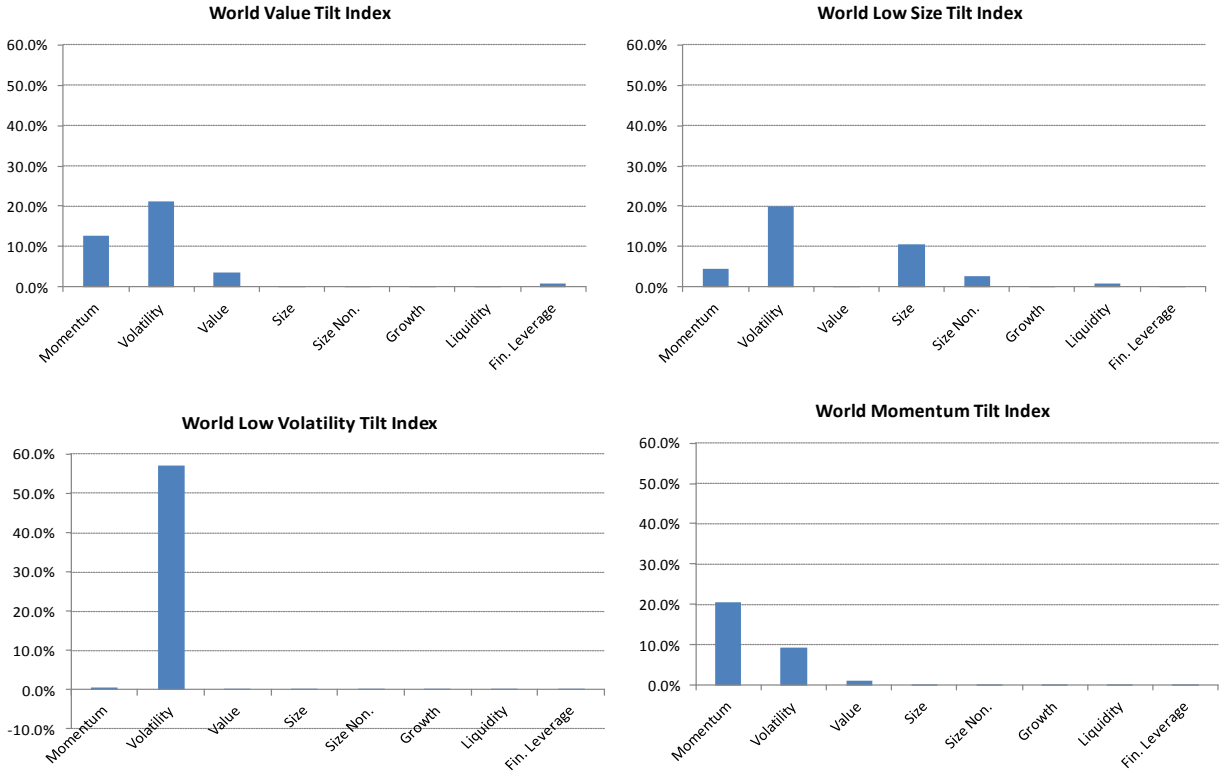
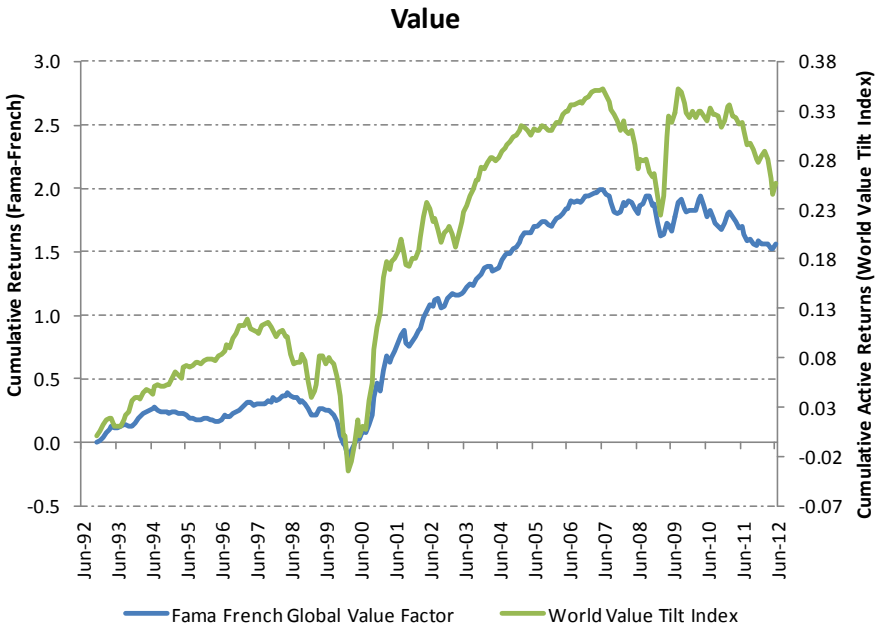


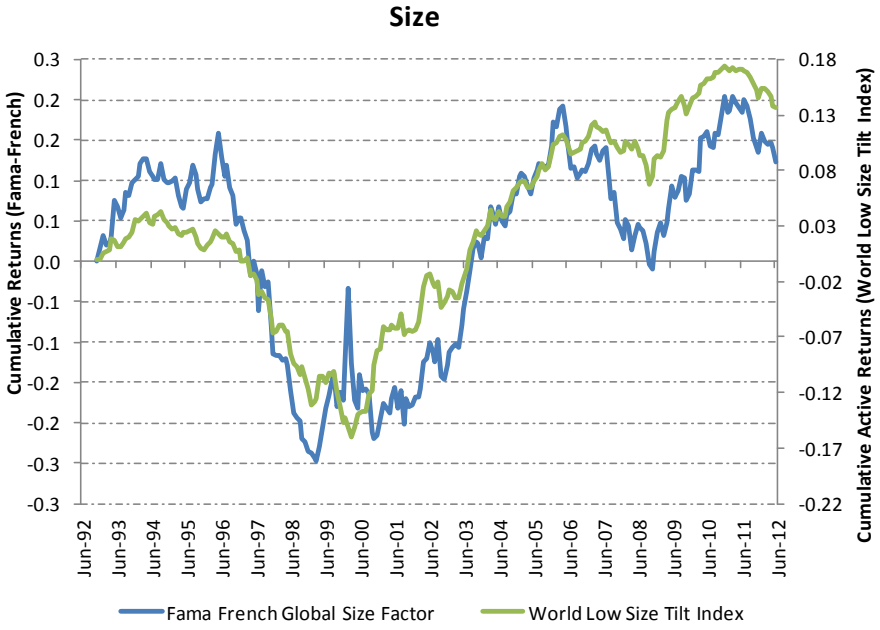
Exhibit 65: Style Factors: Contribution to Active Risk Using the Barra GEM2L Model (June 1, 2012)

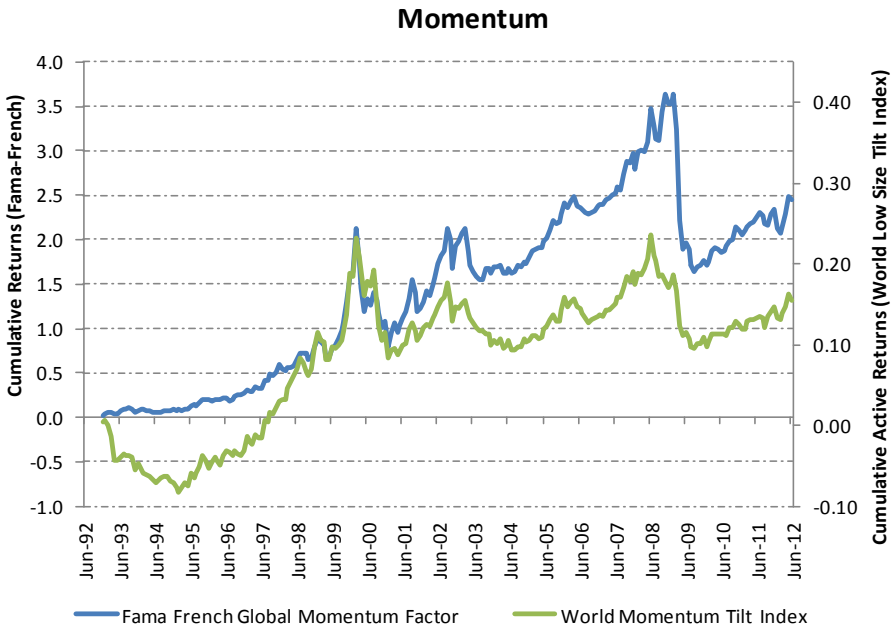


Appendix M: Comparison of Fama-French Factors to World Broad Risk Premia Indices

Exhibit 66: Comparison of Fama-French Global Factors to World Risk Premia Tilt Indices







Appendix N: Additional Metrics for Active Return Drawdown

We show additional metrics for the active return drawdown in Exhibit 67 below. All statistics are computed over months where the MSCI World Index return is negative. For example, the average active return shown below is the average of active returns over all months where the World Index return is negative.

Exhibit 67: Drawdown Characteristics for World Risk Premia Indices (Monthly Returns, November 1992 to August 2012)

	World Value Tilt	World Low Size Tilt	World Low Risk Tilt	World Momentum Tilt
Average active return	0.06%	0.08%	0.77%	-0.02%
Min active return	-1.90%	-1.99%	-0.84%	-3.83%
Max active return	3.13%	2.30%	3.37%	2.44%

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[1] *As of June 30, 2011, based on eVestment, Lipper and Bloomberg data.*