Milliman Research Report

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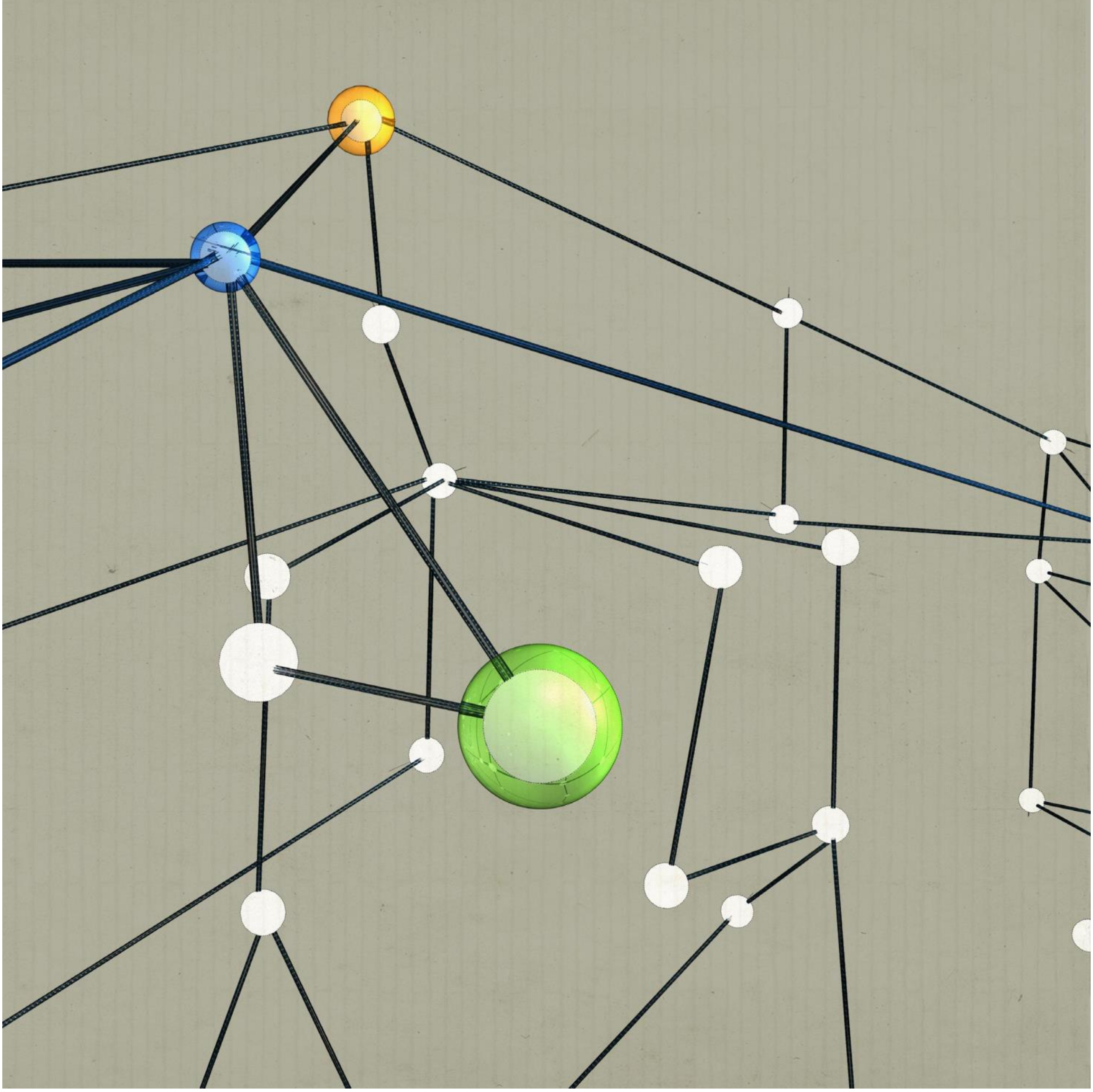
JANUARY 2015

Risk Factor Portfolio Management



1 RISK FACTORS

1.1 What are risk factors?

The concept of a ‘risk factor’ stems from the belief that the returns on an asset can be broken down or split up into distinct sub-components that each contribute to the overall return and risk characteristics of the asset. Extending this into portfolio management, Podkaminer (2013) likened risk factors to atoms and assets to molecules. For example, the return earned on a corporate bond can be broken down according to the risks to which the bond holder is exposed, including duration, inflation and credit risks.

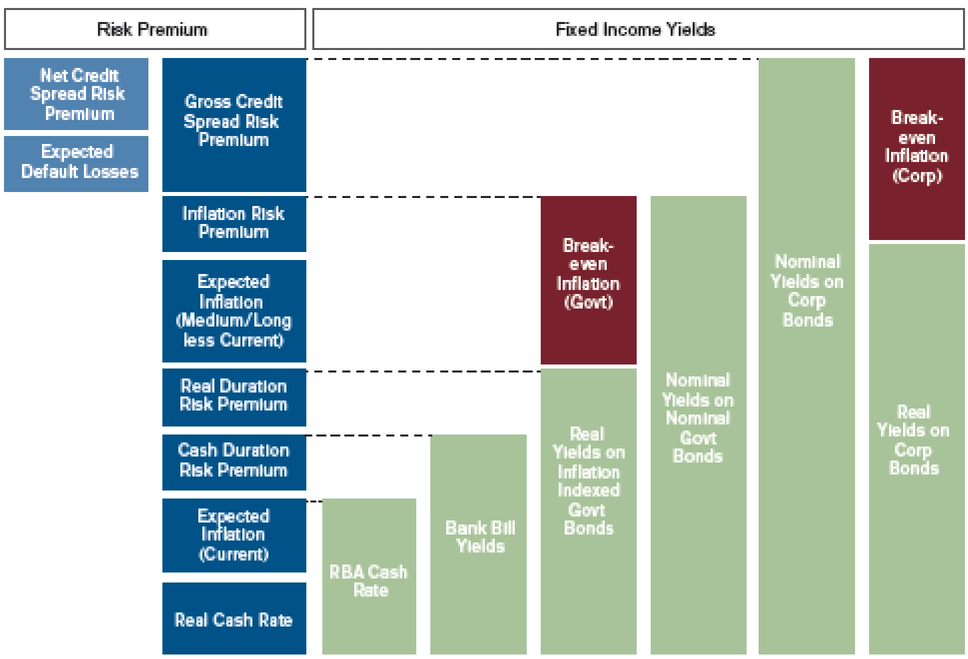
Over recent years, risk factor investment frameworks have started to reach into mainstream academic and practitioner literature. However, there remains no universally accepted definition that describes them; confusingly and unhelpfully, they are also variously referred to as ‘risk premias’, ‘betas’, ‘smart betas’ and even ‘scientific betas’.

In this paper we define a risk factor as a causal driver of asset returns which has risk, return and relationship characteristics with other risk factors. All risk factors have a degree of uncertainty or risk associated with them, and a corresponding risk premium which may be positive or negative. Some authors have chosen to focus on a less granular measure, risk premia—an asset’s return relative to a risk-free rate. However, studying risk factors permits a more refined distinction to be made between uncertainty and return and therefore provides much greater insight into the causes of the differences in return between assets.

1.2 Risk factor examples

To illustrate what we mean by risk factors, in Figure 1 below we consider the yield components for various fixed-income assets. The green bars represent the total yield on each of five different types of fixed-income asset, with the blue boxes showing the component factors that contribute to the yield available.

FIGURE 1: COMPONENT RISK FACTORS THAT DRIVE FIXED-INCOME YIELDS



Source: Milliman Australia and Innova Asset Management

One can see the different risk factor building blocks that make up the yield that is available on each of these assets.

There is no universal agreement on the appropriate taxonomy of risk factors that govern asset class returns. Figure 2 below outlines the approaches that various institutions have taken to defining and using various risk factors.

FIGURE 2: SUMMARY OF RISK FACTORS USED BY VARIOUS INSTITUTIONS

ENTITY	FIXED INCOME	EQUITY	OTHER
Norway Government Pension Fund (Nagy 2010)	Term, credit Aa, credit Baa, credit high-yield	Value / growth, small cap / large cap, momentum, volatility	FX carry, liquidity
Danish Pension Fund PKA (Rohde et al 2010)	Interest rates, credit	Equity (developed / emerging / frontier markets, small cap, low volatility, dividends, implied volatility, momentum, value, quality, merger arbitrage, liquidity, other)	Commodities, inflation-protected assets (ILB, real estate, infrastructure)
Blackrock (Ransenberg 2012)	Real rates, inflation, credit		Liquidity, political, economic
Deutsche Bank (Jones 2011)	Duration, credit, illiquidity	Size, value, momentum	Commodity, alternatives, growth, inflation volatility, liquidity, carry
Goldman Sachs (O'Neill 2013)	Real rates	Equity risk premium	Real assets (e.g. gold, real estate, commodities)
Goldman Sachs (Asl et al 2012)	Term	Equity	Funding, liquidity, FX, emerging markets
PIMCO (Parikh 2012)	Real rates, inflation, term	Multi-factor productivity, dividend yields, growth (earnings, GDP), valuation levels (PE, treasury yields)	Volatility

Briand et al (2009) outline the risk premia framework that MSCI Barra[1] use for modelling asset returns. They define three categories of risk premia:

1. Asset-class – Excess returns above cash arising from the bearing of risk relative to a cash investment.
2. Style – Returns relating to certain common characteristics across securities.
3. Strategy – Returns derived from a particular investment strategy.

The return on any portfolio can be decomposed into these 'beta' return elements, plus an 'alpha' return element accounting for non-systematic/relative fund returns. Indeed, they argue that much of what most fund managers call traditional 'alpha' is in fact 'beta' exposure to risk premia. Notably, Deutsche Bank (Jones 2011) uses a very similar categorisation into asset class, style and systemic/macro, with the latter relating to growth, inflation volatility and liquidity

Regardless of the ultimate purpose, one of the first steps is to identify the various asset risk factors that may be of interest or to which an existing investment may be exposed. Instead of undertaking this at the security level, it is perhaps easiest to start with a qualitative mapping of risk factors to asset classes, as shown in the figures below.

FIGURE 3: RISK FACTORS FOR FIXED-INCOME ASSET CLASSES

FIXED INCOME	REAL CASH	ACTUAL INFLATION	EXPECTED INFLATION	DURATION	CREDIT / DEFAULT	LIQUIDITY	GEO. / POLITICAL
Official cash	✔	✔					
Bank bills	✔	✔	✔				
Inflation swaps		✔	✔				
Inflation-indexed gov't bonds	✔	✔		✔			
Nominal gov't bonds	✔		✔	✔			
Inflation-indexed corporate bonds	✔	✔		✔	✔		
Nominal investment-grade corp. bonds	✔		✔	✔	✔		
High-yield bonds	✔		✔	✔	✔	✔	
Emerging sovereign bonds	✔		✔	✔	✔	✔	✔
Global investment-grade bonds hedged	✔		✔	✔	✔		✔
Global high-yield	✔		✔	✔	✔	✔	✔
Infrastructure	✔	✔	✔	✔	✔	✔	✔

FIGURE 4: RISK FACTORS FOR EQUITIES

EQUITIES	DIVIDEND YIELDS	EARNING GROWTH	VALUATION (P/E)	SECTOR / INDUSTRY	STYLE FACTORS	GEO. / POLITICAL	CURRENCY
Dividend swaps	✔						
Index futures		✔	✔				
Market index	✔	✔	✔				
Large / small cap, growth / value, momentum	✔	✔	✔		✔		
Sector index	✔	✔	✔	✔			
Developed markets	✔	✔	✔			✔	✔
Emerging markets	✔	✔	✔			✔	✔

FIGURE 5: RISK FACTORS FOR PROPERTY AND INFRASTRUCTURE

OTHER	CASH FLOW YIELDS	INFLATION	EARNING GROWTH	VALUATION (P/NTA)	LIQUIDITY	GEO. / POLITICAL
Property	✔	✔	✔	✔	✔	
Infrastructure	✔	✔	✔	✔	✔	✔

There are many more asset classes that could be added to the above lists. We agree with Bhansali et al (2012) in that whilst there is a vast array of asset classes, there are only a relatively small number of risk factors. This is perhaps not surprising, given that securities are fundamentally calls on the income generated by a private entity, a group of individuals or a government body, each of which is subject to similar economic, environmental, political and social drivers. Of these, Bhansali et al. find that within their framework, global growth and global inflation are the two dominant factors in determining asset class returns.

1.3 Capturing risk factors

As a general rule, there are currently few risk factors which can be captured directly. Some risk factors are easier to invest in than others with the creation of investable proxies, such as indices. However, some factors are currently very difficult, if not impossible, to gain investment exposure to directly, such as GDP growth. In essence, many risk factors can be captured by taking a combination of long and short positions or by using a derivative-based strategy.

There are numerous examples in practitioner and academic literature of strategies to capture factors. Figure 6 outlines some non-exhaustive examples of each of these risk factors used within the MSCI Barra framework, along with the investment strategy that can be used to gain exposure to each type of risk premia.

FIGURE 6: RISK PREMIA USED BY MSCI BARRA (SOURCE: BRIAND ET AL 2009)

ASSET CLASS	ASSET CLASS BETA	STYLE BETA	STRATEGY BETA
Fixed Income	Broad fixed-income markets	Credit spreads, high-yield spread, term structure spread	Convertible arbitrage
Equity	Broad equity markets	Size, value, momentum	Merger arbitrage
Currency	Broad currency markets		Carry trade, value, momentum
	ASSET CLASS STRATEGY USED TO GAIN EXPOSURE		
	Long positions	Long short positions	Long short positions

1.3.1 Real cash

Every asset class compensates investors for the time value of their money, as measured by the real cash rate. The most obvious ones are nominal cash (overnight and bank bills) and short-dated inflation indexed bonds, both of which compensate the investor for 'actual' inflation over the very near term.

Example
investment
strategies:

ƒ ƒ Buy cash.

ƒ ƒ Buy short-dated, inflation-indexed government bonds.

1.3.2 Inflation risk premium

1.3.2.1 Actual inflation

Inflation-linked bonds offer a readily accessible means of obtaining actual inflation returns, as their payoffs are a direct function of an inflation index. This type of investment can mitigate against the risk of inflation over long durations. Note that this does not consider potential basis risk between the inflation index and the investor's personal inflation rate. Over short durations, say out to 90 days, money market instruments such as bank bills will effectively provide returns linked to actual inflation. This is because market estimates of short-term inflation are generally very good, with relatively low residual risk.

An alternative way of accessing actual inflation is to use inflation derivatives, notably inflation swaps, which exchange payments based upon a fixed rate for ones based upon an inflation index. This is a zero-dollar investment that has a payoff of the excess of realised inflation over expected inflation. By investing capital in cash and entering into this derivative, the investor receives nominal cash (real cash plus actual short-term inflation), plus the excess of realised inflation over expected inflation. As such contracts are OTC, they involve an additional risk factor, the credit risk of the counterparty. Such credit risk can be largely or wholely mitigated through the use of collateralisation techniques or credit default swaps.

1.3.2.2 Expected inflation

Assets with cash flows that are denominated in nominal terms are effectively compensating investors for expected rather than actual inflation. This is because their market prices are set such that the nominal cash flows provide the investor sufficient compensation for their expectation of inflation, with no guarantee that this will be equal to actual inflation. Nominal bonds, particularly government bonds, provide expected inflation returns, although they also come bundled with duration returns. Corporate bonds also provide expected inflation returns, although they also come with additional credit risk (which can be mitigated), as well as duration risk

As investors are subject to inflation risk by investing in nominal fixed-income securities, they typically demand an inflation risk premium to compensate them for this risk. The difference between nominal and real yields at equivalent durations will reflect this inflation risk premium in addition to the best estimate of future inflation. These two components together are known as the breakeven inflation rate, as they represent the rate at which inflation needs to be over the investment horizon in order for investment returns from nominal and inflation-indexed securities to be equal.

Perhaps the cleanest source of expected inflation is through inflation swaps, where the investor takes the side of paying inflation-indexed cash flows and receiving fixed cash flows. This is a zero-dollar investment that has a payoff of the excess of expected inflation over realised inflation. By investing capital in cash and entering into this derivative, the investor receives nominal cash (real cash plus actual short-term inflation), plus the excess of expected inflation over realised inflation.

Example investment strategies:

ƒƒ Buy nominal government bonds and sell (i.e. short) inflation-indexed government bonds.

ƒƒ Long a nominal Treasury index and sell (i.e. short) a Treasury inflation-protected security index.[2]

1.3.3 Duration risk premium

Duration risk premium represents the additional risk premium that investors require in order to compensate them for being subject to capital risk. The duration risk premia is typically measured as the difference between the yield on a government bond and that of cash. It can be difficult to disentangle this risk premium from that of the inflation risk premium, as inflation expectations are not directly observable in the market (they are subjective estimates typically sourced from surveys).

The purest way to invest in the duration risk premium is to borrow continuously at the cash rate and invest in long-dated bonds. The difference in the bond cash inflows and the accumulated debt will be the duration risk premium (which can be negative). Clearly, the size of the duration risk premium in this instance will be dictated by the rate at which the institution or individual can borrow at, which may be higher than the yield on the bond, giving rise to a negative duration risk premium. Due to this reason, most institutions and individual investors access the duration premium through long-only investments directly in government bonds.

Example investment strategies:

ƒƒ Buy nominal government bonds and borrow cash.

ƒƒ Long a Treasury 20+ years index and sell (short) a Treasury 1- to 3-year index.[3]

1.3.4 Credit risk premium

The yield on a corporate bond relative to a government of equivalent duration, currency, etc. will contain a level of compensation for the expected level of default on the corporate bond. However, investors in such bonds will also require compensation for being exposed to this risk of default. In theory, all bonds come with some risk of default, though bonds issued by governments, especially those of developed countries, are traditionally considered to be free of default risk and hence the associated yield does not contain a credit risk premium. Bonds issued by corporate entities will carry a credit risk premium linked to the perceived creditworthiness of the bond. This will typically be measured by its credit rating.

To capture the credit risk premium, one could hold some combination of government and corporate debt. Sometimes capturing the credit risk premium in this way also captures other risk premia associated with corporate debt, such as the liquidity premium due to the lower marketability compared with government debt.

An alternative method to capture credit risk premium (for a specific company) would be to invest in derivative instruments such as credit default swaps (CDSs). Under a CDS, the investor pays a premium(s) and in return receives a payment if the issuing company defaults on its bond payments. CDSs are usually OTC derivatives and therefore come packaged with a premium to cover the associated risk of the CDS writer defaulting on the contract.

Example investment strategies:

ƒƒ Long in US high-quality credit index and sell (short) US Treasury index.[4] ƒƒ Enter into a credit default swap.

ƒƒ Buy a company's nominal corporate debt and sell (short) nominal government bonds (of the same duration).

1.3.5 Volatility risk premium

The return from securities with a volatile value will contain a volatility risk premium to compensate investors for bearing the risk of actual volatility differing from expected volatility. This may occur in times of market turmoil and high investor uncertainty. A volatility risk premium is normally associated with investments such as equities and derivative instruments, but could theoretically apply to any security.

Example investment strategies:

ƒƒ Buy an option (call or put) and delta hedge it.

ƒƒ Enter into a variance swap (pay fixed receive realised volatility).

1.3.6 Liquidity risk premium

The return on investments that are illiquid will tend to contain a liquidity risk premium. Typical examples of such investments include infrastructure, direct property and venture capital. However, liquidity risk premiums can also be found in more standardised and liquid asset classes, such as:

ƒƒ Treasury bonds, where off-the-run[5] bonds tend to trade at lower prices relative to on-the-run bonds.

ƒƒ Corporate bonds, which typically have liquidity during normal market conditions, but for which demand can evaporate under stressed capital market conditions.

Example investment strategies:

ƒƒ Buy off-the-run and sell on-the-run treasury bonds.

ƒƒ Invest directly into illiquid asset classes such as infrastructure, direct property and venture capital.

1.3.7 Geographic risk premium

The same securities in different countries can trade at significant premiums to one another, reflecting the different drivers of risk factors in each country. A good example of this is in the European Union (EU), whereby government bonds will trade at very different levels for countries within the EU, reflecting the different likelihoods of default, despite a high degree of economic and financial interdependence amongst them.

Example investment strategies:

ƒƒ Buy foreign government bonds and hedge the currency risk. This results in an investor return of the domestic cash rate plus the foreign government duration risk premium.

1.3.8 Value premium

This is a 'Fama and French' type of risk factor relating to investment in equities. The premium arises due to the difference in return achieved (and risk taken on) by investing in value stocks (stocks thought to be undervalued) and growth stocks (stocks that are expected to increase in value at a rate over and above the market average).

Example investment strategies:

ƒƒ Long a developed country equity value index and short a developed country equity growth index.[6] ƒƒ Long MSCI Value index and sell (short) MSCI Growth index.[7]

1.3.9 Size premium

This is another 'Fama and French' type of risk factor relating to investment in equities. Such a premium arises due to the additional risk associated with equity investment in small-sized companies, often measured by their market capitalisation.

Example investment strategies:

ƒƒ Long a developed country equity small-cap index and short a developed country large-cap index.[8] ƒƒ Long Russell 3000 Index and sell (short) Russell 1000 Index.[9]

2 PORTFOLIO CONSTRUCTION AND MANAGEMENT

2.1 Traditional portfolio construction

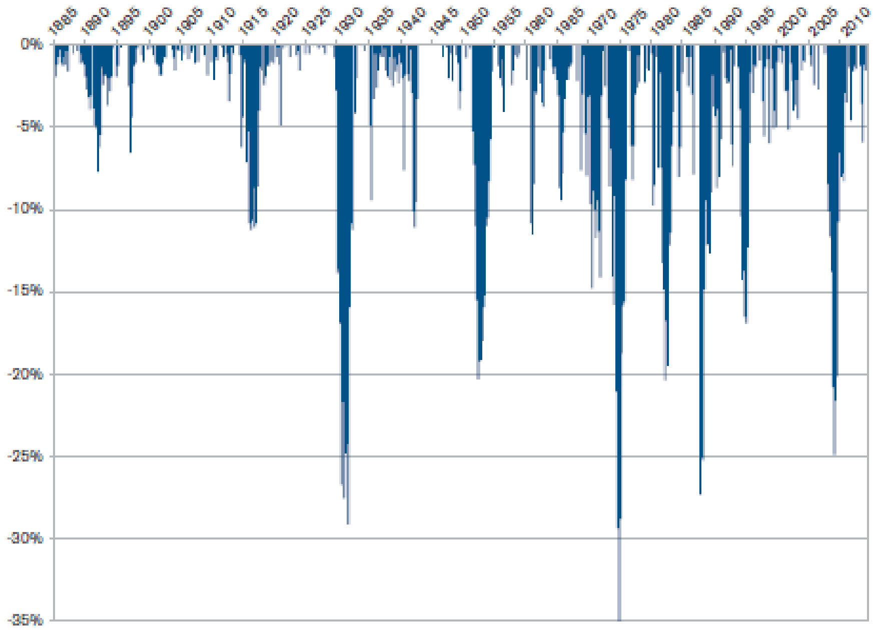
Investment portfolio construction has traditionally centred on the idea that by investing across uncorrelated assets, usually termed ‘asset classes’, a superior outcome in terms of risk versus return can be achieved. In work carried out by Harry Markowitz in the 1950s, such an optimal portfolio was thought to contain about 60% US equities and 40% US government bonds. Since then, this approach has been widely adopted and has led to investment strategies that combined:

ƒƒ ‘Growth’ assets, which will provide you with a positive return premium above cash (US equities in the example above).

ƒƒ ‘Defensive’ assets, which will perform well and smooth out overall returns in times of stress (US government bonds).

However, all too often, the concept of risk has been equated with a single measure, volatility, which is at best a proxy for the uncertainty associated with future asset returns. Alongside the simplifying assumption of fixed correlations between asset classes, strategies that were intended to provide both growth and protection too often provided neither to the end investor. This is demonstrated by the figure below: a 110-year chart of the drawdowns (the peak-to-trough decline during a specific period) that a 60/40 Australian equity/bond portfolio experienced

FIGURE 7: PORTFOLIO DRAWDOWNS (PEAK TO TROUGH) OF 60% AUSTRALIAN EQUITIES 40% AUSTRALIAN GOVERNMENT BONDS



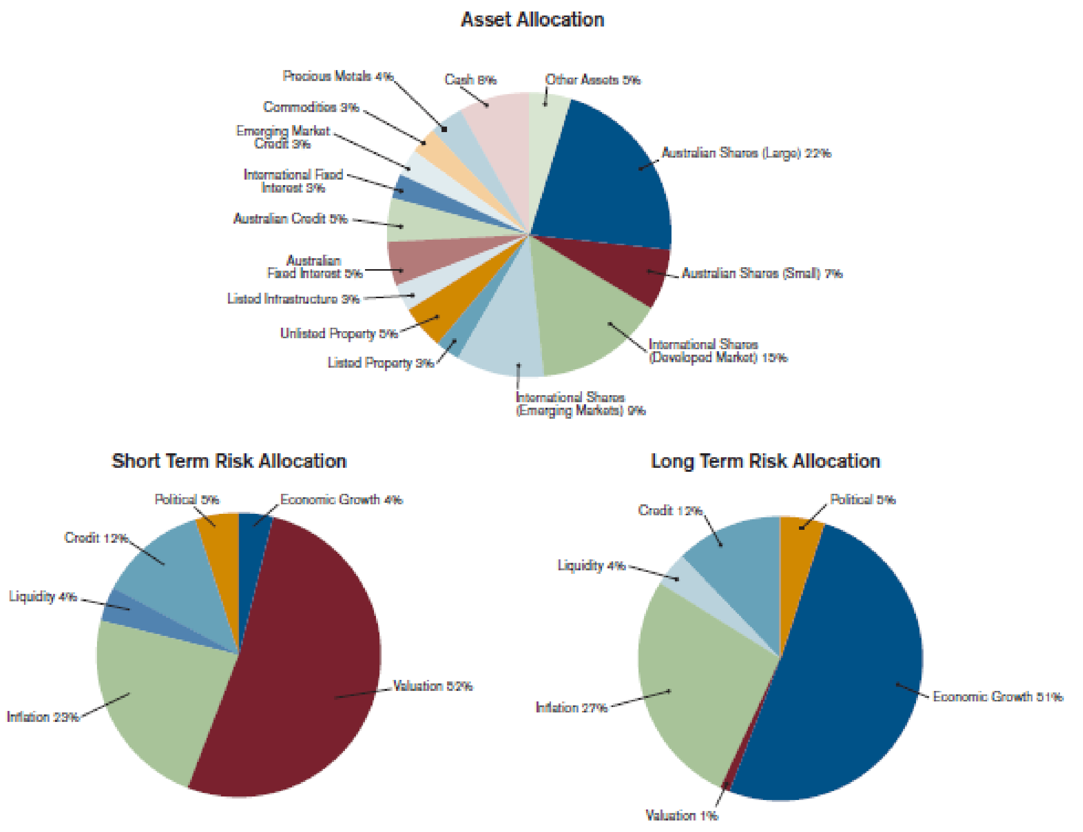
Source: Milliman based upon Global Financial Data

Essentially, if ‘growth assets’ go down, the whole portfolio goes down. In other words, the concept of risk reduction has been completely misunderstood.

In an attempt to reduce the level of risk within investment portfolios, advisers and money managers have tried to increase diversification to reduce risk by investing in ‘new’ asset classes, instead of just equities and bonds. This has included property, infrastructure, distressed debt, commodities and various hedge fund strategies. However, even with increased investment in a wider range of assets, diversification is no guarantee of increased risk protection, particularly during times of stress when it is needed most. Under the asset class method of constructing investment portfolios, ideally the asset classes should be independent of one another and cover the whole investible universe. If we look through the lens of a risk factor framework, most of these ‘asset classes’ are exposed to the same risks as either equities or bonds—or both. Furthermore, some of these exposures will only become obvious in times of stress, when the lack of independence can be particularly detrimental to the performance of the portfolio

In the figure below, we have reproduced a portfolio that looks like it is well diversified and is a broad representation of a typical ‘balanced’ portfolio, including various ‘diversifying’ asset classes. This portfolio’s asset allocation is compared with its risk allocation in both the short (1 year) and long term (10 years). Risk allocation is derived based upon the impact of downside stress tests, which vary from short to long term

FIGURE 8: MORE ASSET CLASSES ≠ DIVERSIFICATION



Source: Milliman Australia and Innova Asset Management

Please note that in this example we have assumed a starting valuation of all assets to be aligned with long-term averages; therefore, over the long term, change in price due to change in market valuation should theoretically be negligible.[10] As can be seen from the above, the underlying risk factor exposure depends on over which time horizon the portfolio is viewed. In the short term, inflation and valuation are the main drivers of risk whereas over the long term, risk is driven by inflation and economic growth. Over both time horizons, whilst the number of asset classes used in the above portfolio is large, the diversification of risk is not.

We can observe that the historical weaknesses in constructing resilient portfolios have been driven by a fundamental misunderstanding of the dynamics of risk and the sources of uncertainty. A focus on the allocation of capital rather than risk means that traditional approaches fail to capture the common causal drivers that exist across issuers, geographical locations and asset classes, and how they change over time.

Some of the main problems with the traditional approach are that:

ƒƒ The 60/40 result was very specific for the particular time period and data set for which it was tested. ƒƒ Volatility/standard deviation is used as the primary measure of risk.

ƒƒ Traditional portfolios have almost all of their risk budget tied up in equities.

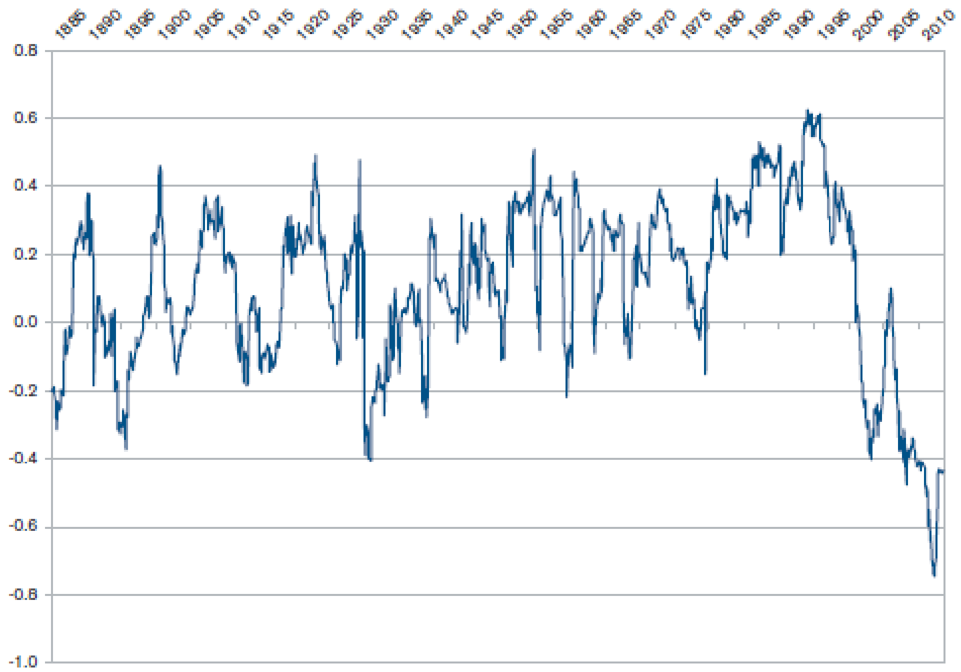
ƒƒ This large exposure to equities leads to over-exposure to the drivers of equity risk.

ƒƒ These same equity risk drivers may also exist in other asset classes (including ‘new’ ones), meaning that portfolios are not as diversified as they seem.

In addition to the above problems, much of the academic and mathematical background to the optimisation techniques used in traditional portfolio construction require a vast amount of data to calibrate for items such as the expected return of each asset, the standard deviations and the correlations between assets. The results are also very sensitive to the initial assumptions which place a great reliance on the quality of the data and associated statistical analyses. Perhaps most importantly, many techniques assume stable return distributions and correlations over time and in varying economic conditions or regimes.

For example, one of the underlying assumptions of the 60/40 model is that equities and bonds are negatively correlated and stable. The problem is that this is not always the case. From the 1960s to 2000, the correlation was largely positive, in both falling markets (such as the 1970s) and rising markets (1982 onwards).

FIGURE 9: ROLLING 3-YEARLY AUSTRALIAN EQUITY AND NOMINAL GOVERNMENT BOND RETURN CORRELATIONS (MONTHLY FREQUENCY)



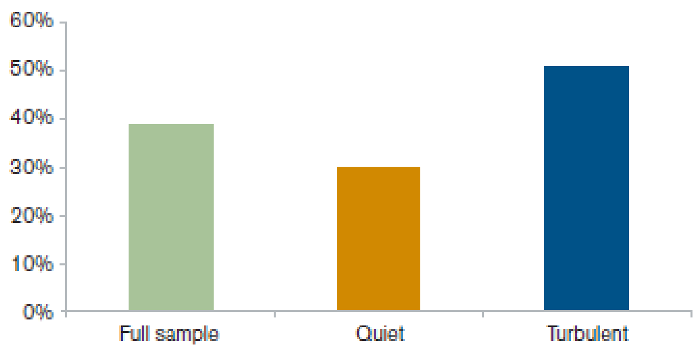
Source: Milliman based upon Global Financial Data

The article ‘The Myth of Diversification: Risk Factors vs. Asset Classes’ by PIMCO (2010) states that:

> *From January 1970 to February 2008, when both the U.S. and world ex-U.S. stock markets—as represented by monthly returns for the Russell 3000 and MSCI World Ex-U.S. indexes, respectively—were up more than one standard deviation above their respective full-sample mean, the correlation between them was −17%. In contrast, when both markets were down more than one standard deviation, the correlation between them was +76%.*

Also taken from the same article, the figure below shows that not only is the correlation between asset classes relatively high, but it also varies between ‘calm’ and ‘turbulent’ periods.

FIGURE 10: AVERAGE CROSS-CORRELATIONS (MARCH 1994 - DECEMBER 2009)



Source: *The Myth of Diversification: Risk Factors vs. Asset Classes*, PIMCO 2010

Furthermore, Straatman (2013) notes that cross-asset-class correlations have increased systematically over recent decades due to:

ƒƒ Globalisation of companies, industries and markets and economies. *ƒƒ* Synchronised quantitative easing monetary policies.

ƒƒ Financial engineering.

Therefore, we can see that the relationships between asset classes seem far from static over time and demonstrate strong regime dependence. Such dynamics are hard to allow for using the traditional approaches to portfolio construction, suggesting that new techniques should be considered.

2.2 Benefits of risk factor asset allocation

As described in Briand at al. (2009), in an ideal world, investors would be able to construct portfolios consisting of a large number of independent units generating attractive risk-adjusted returns governed by known and stable return distributions. This is, in part, the goal of risk-factor-based asset allocation.

Over recent years, risk factor investment frameworks have started to reach into the mainstream academic and practitioner literature. Not surprisingly, this is being accompanied by an increasing trend towards risk factor investing amongst professional asset management firms. As discussed in the previous section, there is now widespread agreement that many asset classes often end up being driven by the same risk factor, which undermines thinking about asset classes as relatively heterogeneous security classification structures.

Assessment of risk factors is arguably more forward-looking than the use of traditional mean-variance optimisation methods, which attempt to allocate capital to asset classes based upon distributional assumptions typically calibrated from past data. Also, by identifying the risk factors common to multiple asset classes, we can develop a much deeper understanding of how the behaviour of asset returns are linked (i.e. correlated) and therefore begin to build more robust, resilient portfolios. Considered another way, by looking at the risk factors contained in their portfolios, investors can better forecast how the portfolio may perform under different future economic conditions and understand the true underlying risk exposures

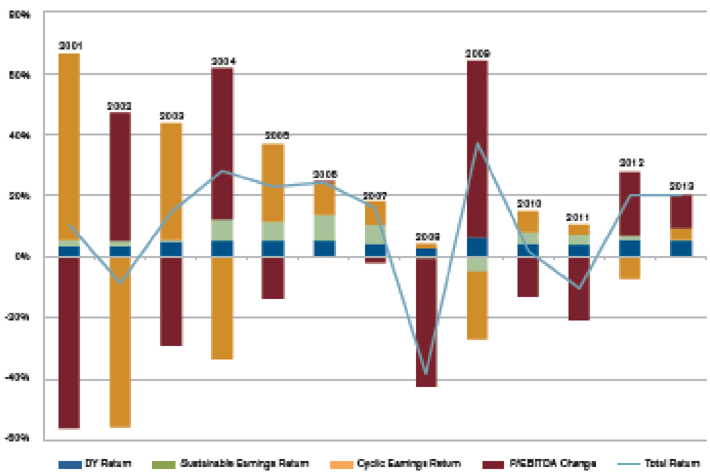
Taken a step further, under a risk factor allocation process, it would be possible to decompose the past performance of a particular portfolio into the various, relevant risk factors. This has been completed below in

Figures 11-14 for:

ƒƒ Australian equities: the S&P/ASX 200 Accumulation Index ƒƒ Australian nominal government bonds

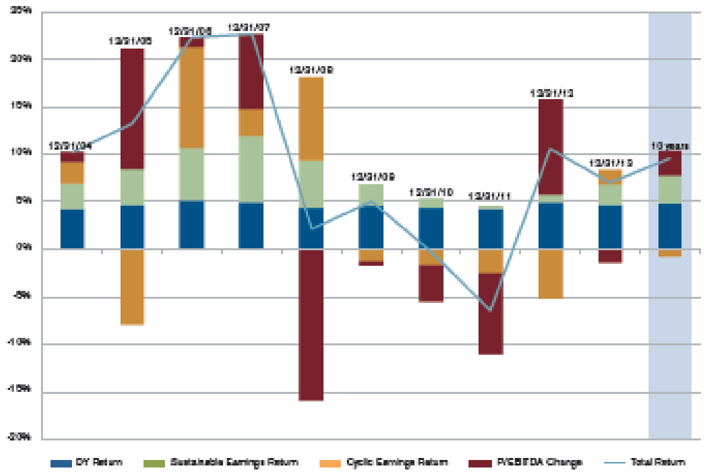
ƒƒ Australian corporate bonds

FIGURE 11: EQUITY MARKET TOTAL RETURN DECOMPOSITION – ANNUAL



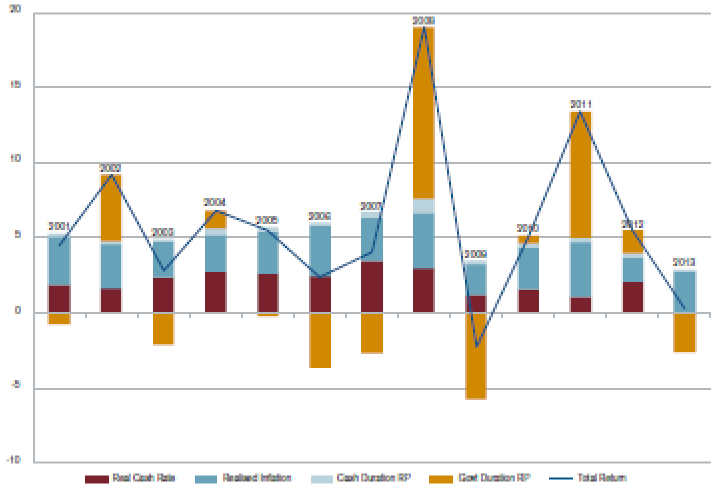
Source: Milliman and Innova analytics, Bloomberg data

FIGURE 12: EQUITY MARKET TOTAL RETURN DECOMPOSITION – ROLLING 4-YEAR RESULTS



Source: Milliman and Innova analytics, Bloomberg data

FIGURE 13: NOMINAL GOVERNMENT BOND MARKET TOTAL RETURN DECOMPOSITION – ANNUAL



Source: Milliman and Innova analytics, Bloomberg data

FIGURE 14: CORPORATE BOND MARKET TOTAL RETURN DECOMPOSITION – ANNUAL

Source: Milliman and Innova analytics, Bloomberg data

The above charts clearly show that whilst valuation risk factors are the primary driver of returns on an annual basis, they mean revert over longer periods of time, resulting in the cash-flow risk factors becoming much more important. This is evident in the reduction in volatility evident in the rolling 4-yearly equity results compared with the annual results. Over the timeframe examined, the starting P/EBITDA was very close to the subsequent long-term average. However, we would expect valuation return to have a much greater influence on returns if the starting P/EBITDA valuation were substantially above the long-term average (such as in late 2004/early 2005) or below (such as in late 2008/early 2009).

This is consistent with Shiller (2006), who suggests that when P/E has been high, subsequent 10-year returns are low, and when the P/E has been low, subsequent 10-year returns are high

The correlations between the asset classes and risk factors over this time period are shown in the following figures.

FIGURE 15: ASSET CLASS AND RISK FACTOR CORRELATIONS. ANNUAL DATA FROM 2002 TO 2013

	EQUITY	GOV'T. BONDS	CORP. BONDS
Equity	1.00		
Gov't. Bonds	-0.89	1.00	
Corp. Bonds	-0.61	0.74	1.00

	DY	SER	CER	VR	CS RP	GD RP	CD RP	RI	RCR
Dividend Yield	1.00								
Sustainable Earnings Return	-0.03	1.00							
Cyclic Earnings Return	0.34	-0.31	1.00						
Valuation Return	0.50	-0.15	-0.78	1.00					
Credit Spread RP	0.87	-0.23	0.18	0.61	1.00				
Govt Duration RP	-0.77	-0.08	-0.32	-0.41	-0.85	1.00			
Cash Duration RP	-0.59	-0.10	-0.19	-0.38	-0.70	0.71	1.00		
Realised Inflation	-0.72	0.30	-0.04	-0.57	-0.79	0.55	0.45	1.00	
Real Cash Rate	-0.17	0.47	0.02	-0.24	-0.40	0.09	0.45	0.11	1.00

Source: Milliman and Innova analytics, Bloomberg data

The above analysis shows the misleading picture presented by the correlations at an asset class level over this period. Government and corporate bonds appear to be strongly positively correlated. However this masks the fact that the reason for this is that they share the same underlying risk factors (cash, inflation, duration), with the exception being credit spreads which were significantly negatively correlated with all of them. The negative correlation between equities and corporate bonds is similarly masking the fact that there was a significant positive correlation between credit spreads and both dividend yields and valuation returns, both of which would be expected from a fundamental perspective.

2.3 Stability of correlations

One big drawback of the traditional approaches to portfolio construction is the assumption that the relationship between asset class returns is stable both over time and under different regimes. Many authors have justified the superiority of a risk factor investment approach by pointing to the fact that historic correlations between risk factors are generally lower than those between asset classes. This includes Podkaminer (2013), Briand et al. (2009) and Jones (2011). For example, Figure 16 shows the risk premia correlations derived by Briand et al. (2009).

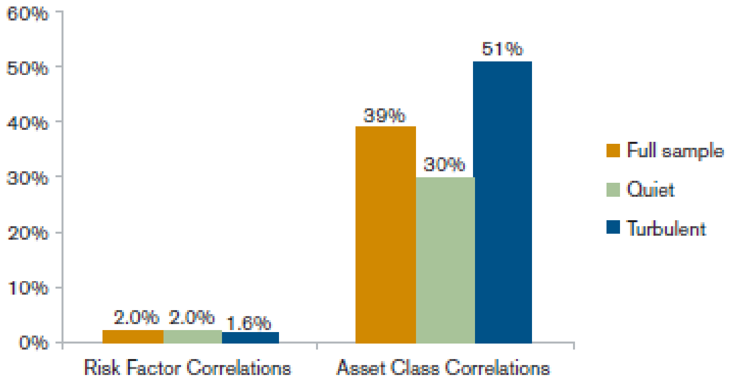
FIGURE 16: RISK PREMIA CORRELATIONS FROM MAY 1995 TO OCTOBER 2008

	VALUE	SIZE	MOMENTUM	CREDIT SPREAD	HIGH YIELD SPREAD	TERM SPREAD	MERGER ARBITRAGE	CONVERTIBLE ARBITRAGE	CARRY TRADE	CURRENCY VALUE	CURRENCY MOMENTUM
Value	1.00										
Size	0.11	1.00									
Momentum	-0.47	0.15	1.00								
Credit Spread	0.07	0.06	0.15	1.00							
High Yield Spread	0.06	0.26	0.20	0.56	1.00						
Term Spread	-0.05	-0.02	0.18	0.04	-0.09	1.00					
Merger Arbitrage	-0.02	0.18	0.33	0.29	0.49	-0.12	1.00				
Convertible Arbitrage	-0.02	0.18	0.52	0.25	0.39	0.17	0.44	1.00			
Carry Trade	0.00	0.10	0.35	0.41	0.45	0.08	0.37	0.58	1.00		
Currency Value	0.10	-0.04	-0.19	0.20	0.20	-0.03	0.00	-0.20	0.32	1.00	
Currency Momentum	-0.10	-0.20	-0.14	-0.13	-0.26	0.01	-0.20	-0.20	-0.01	-0.05	1.00

Source: Briand et al 2009

Returning to the analysis detailed in the article 'The Myth of Diversification: Risk Factors vs. Asset Classes' (2010), in line with the above results, it can be demonstrated that correlations between risk factors are lower than those between asset classes and also seem to be more stable across varying economic conditions. This is shown in the figure below. The risk factors considered were equity, size, value, momentum, duration, emerging market spread, mortgage spread, corporate spread, swap spread, real estate and commodities

FIGURE 17: AVERAGE CROSS CORRELATIONS (MARCH 1994 - DECEMBER 2009)



Source: The Myth of Diversification: Risk Factors vs. Asset Classes, PIMCO 2010

Analysis by Jones (2011) of Deutsche Bank found similar results with respect to lower correlations, where 50% of 200 pairwise correlations of long/short strategies spanning seven asset classes and three risk premia (value, carry and momentum) were negative, with only two being above +0.5. However, they also found various temporal features to historic analysis of risk premia, including:

ƒƒ They exhibit significant time-variability, for example illiquidity, which tends to be highest just after the start of a period of stress. ƒƒ Regime dependence - mean-reversion based strategies seem to require benign liquidity and low stress conditions to pay off. ƒƒ Systemic macro strategies tend to perform well in times of stress when positive feedback loops dominate negative ones.

2.4 What does a risk factor portfolio look like?

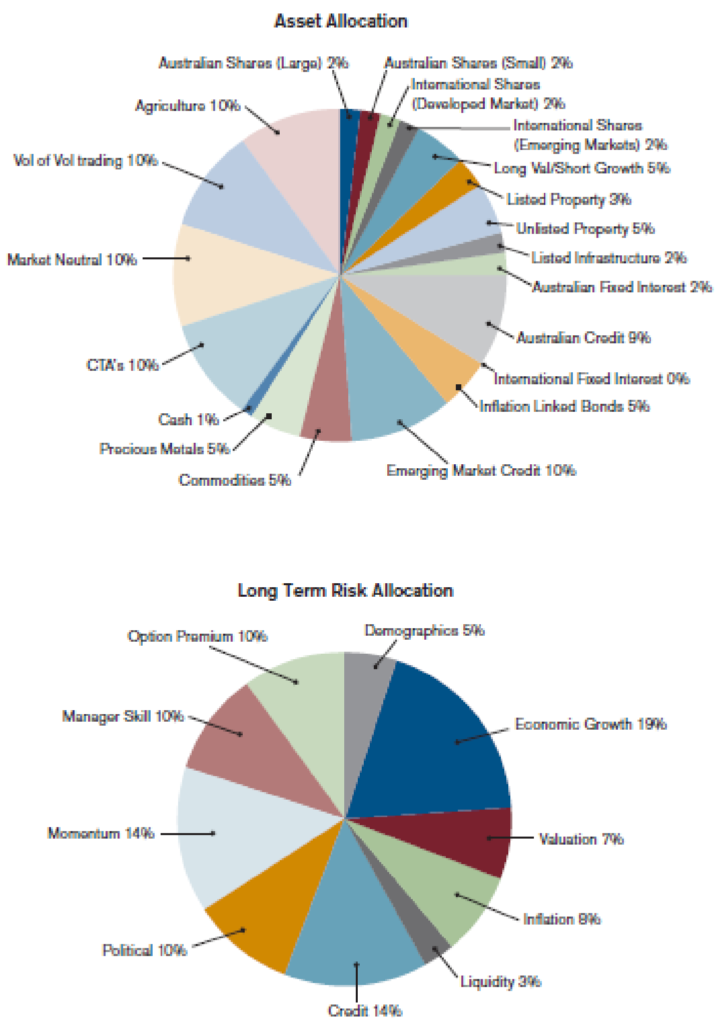
As mentioned previously, there is no set definition of a risk factor. We have taken 10 example factors and derived the exposure that different asset classes have to those 10 factors. The 10 factors are: economic growth, valuation, inflation, liquidity, credit, political risk, momentum, manager skill, option premium and demographic shifts.

This is by no means an exhaustive list, but helps to frame the mindset one would take when reviewing asset classes and their risk factor exposures. It should be noted that at different points in time, different assets will have more or less exposure to some of these factors, but this has not been considered for the purposes of this example.

We need to begin with two assumptions. First, we are not adjusting the allocation to asset classes due to higher ex-ante return forecasts, and second, we are not tailoring our risk factor exposures to those that best suit any particular client. We are therefore making a naïve assumption that we want to spread our risks as much as we can, irrespective of current market conditions or the needs of the client.

Given that, a portfolio constructed in a risk factor framework could look something like Figure 18:

FIGURE 18: A PORTFOLIO DIVERSIFIED BY RISK FACTORS



Source: Milliman Australia and Innova Asset Management

The asset classes used to build the portfolio in Figure 18 are very similar to the portfolio from Figure 8, but the risk allocations are very different and far more balanced. The risk-factor-based analysis has enabled greater diversification of risk

2.5 Risk factor portfolio performance versus traditional approaches

A number of authors have carried out investigations that demonstrate that a risk-factor-based approach to portfolio construction achieves better risk-adjusted returns compared with traditional approaches. For example:

- Briand, Nielson and Stefek (2009) found that using an equal weighting across 11 style and strategy risk premia from 1995 to 2008, would have generated similar returns to traditional 60/40 portfolios but with 65% less volatility.
- Podkaminer (2013) found that a simple factor portfolio 'historically achieved a slightly higher level of return than the traditional portfolio while taking on about one quarter of the volatility'. Research by Deutsche Bank[11] showed that a volatility-weighted portfolio of 21 factors from 1995 to December 2011 offered higher compound returns with lower volatility than equities, world government bonds or a hedge fund composite portfolio.
- Dimitris et al. (2011) constructed and analysed risk premia portfolios using a mean-variance optimisation process subject to various types of constraints. The resulting performance of various risk premia exhibited temporal stability characteristics as well as temporal instabilities in the case of growth and volatility premia. They concluded that it is possible to improve risk-adjusted performance through the

combination of value and risk-based portfolio strategies.

It should be noted, however, that most of these studies consider 'reduced risk' to mean 'reduced volatility', and therefore, while these examples provide supporting evidence of the benefits of risk factor portfolio construction, they do not tell the whole story.

2.5.1 A brief warning

In contrast to the viewpoints expressed in other papers, Idzorek et al. (2013) contested that neither an asset-class- nor a risk-factor-based approach is inherently superior to the other, even though correlations between risk factors are typically lower than those of asset classes. They concluded that, in principle, the same result could be achieved for a traditional approach (such as an asset class framework) if some typical restrictions are relaxed. For example,

ƒƒ Use of the same opportunity sets: Ensure that the same underlying security sets are used for each approach, such as permitting investment in derivatives.

ƒƒ Ensure the same portfolio construction constraints: Asset-class-based portfolios are predominantly long only, whilst risk-factor-based portfolios typically allow or require short selling in order to manufacture some risk factors.

The analysis was based upon both a mathematical investigation under an idealised world, as well as back-testing analysis over various periods of history. They demonstrated that in a perfect world where there is a one-to-one mapping of risk factors to asset classes, and in the absence of superior information, optimising across risk factors in an unconstrained way is equivalent to optimising across asset classes similarly unconstrained.

In light of this analysis, we need to be very clear about the reason for the adoption of risk-factor-based asset allocation: There appear to be no fundamental advantages based on risk/return relative to an asset class approach.

2.5.2 The advantages of the risk factor approach

While there may not be any fundamental advantages from adopting a risk-factor-based approach in terms of risk/return payoff, there are a number of important benefits which make such an approach superior to many traditional asset class methods. These benefits include:

ƒƒ A more natural framework for formulating forward-looking long-term assumptions relevant to longer-term investors. *ƒƒ* A more transparent view into the drivers of diversification in the portfolio.

ƒƒ An increased ability to understand, predict and explain the drivers of performance over different time horizons and regimes. *ƒƒ* An identification of the advantages of using certain short positions or derivatives as necessary to better diversify risk factors.

ƒƒ The ability to use causal/Bayesian approaches to enhance the construction of resilient portfolios using modern risk management techniques, which is discussed further in the next section.

2.6 Practical challenges of risk factor asset allocation

Unfortunately, while risk factor asset allocation addresses some of the drawbacks present with traditional approaches such as increasing investor's understanding of their true underlying risk exposures, it is not the 'silver bullet' for all investors' needs.

There are well-documented challenges with risk factor asset allocation which may help to explain why this approach is not more prevalent within the industry. Podkaminer (2013) and Idzorek et al. (2013) list the following challenges facing those adopting a risk factor approach:

ƒƒ Risk-factor-based asset allocation is not macro-consistent; it would not be possible for all investors to hold the same portfolio due to the frequent need for long/short positions in some assets.

ƒƒ The need to determine a set containing all significant risk factors.

ƒƒ Frequent portfolio rebalancing (and the associated fees and transaction costs). *ƒƒ* Derivation of forward-looking assumptions.

ƒƒ The difficulties in capturing

some risk factors. ƒƒ Use of derivatives and short positions.

To elaborate further on the last two points, since direct investment is currently unavailable for many risk factors, extreme offsetting positions or derivatives may be required to gain exposure to these risk factors. Such strategies may fall afoul of existing investment rules and portfolio constraints. Even in the absence of such constraints, we may only be able to approximately replicate certain risk factors; for others there may be no current mechanism to access them at all.

With regards to forward-looking assumptions, in the previous section we highlighted research that showed that risk factors exhibit various temporal features and regime dependence. Such characteristics are difficult to model fully using traditional statistical techniques.

Many of these challenges will no doubt be addressed as risk-factor-based investment frameworks gain traction and see wider market adoption, either through bespoke solutions or potentially the introduction of new risk-based (rather than asset-based) instruments.

2.7 Summary

Traditional allocation approaches assume that investing in a wider range of assets or asset classes will lead to a lower risk portfolio. Furthermore, it was believed that the correlation between asset classes was relatively stable. Recent experience has uncovered a number of issues with this approach, including:

ƒƒ Many assets have the same underlying risk factor exposures, meaning that they are more correlated than first thought. ƒƒ The correlations between assets class exhibit temporal and regime dependence.

In addition, when considering the riskiness of various portfolios and portfolio construction techniques, volatility was considered the key measure. This may not be the only measure of risk relevant to investors.

Instead of constructing portfolios using the traditional asset class approach, risk factor portfolio construction can lead to a greater understanding of portfolio risk exposures, as risk factors tend to have lower and more stable correlations (though still exhibit some temporal/regime dependence). In Section 3 we look at causal models, such as Bayesian networks, which offer an alternative to traditional statistical methods (such as fitting to historical data) to explain asset returns and correlations. The resulting return estimates reflect the non-linear dynamics of how performance can change according to the underlying economic and business drivers. Such models provide not only a forecast of future returns but also a transparent explanation behind that forecast. In fact, causal models:

ƒƒ Provide a framework for explicitly capturing the non-linear system of relationships driving return.

ƒƒ Permit the transparent combination of historic data with expert judgement to derive forward-looking assumptions and facilitate a wide range of stress and scenario testing and reverse stress-testing