# Factor-Based Analysis of Asset Returns

## Asset Allocation

June 17, 2013

CalPERS | Investment Office
Asset Allocation

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# Asset Allocation And Diversification

One goal of asset allocation is to build a well diversified portfolio (i.e., not putting all your eggs in one basket)…

The benefit of having a diversified portfolio is that if something bad happens to one asset in your portfolio …

…the other asset is not affected

# Asset Allocation And Diversification

One goal of asset allocation is to build a well diversified portfolio (i.e., not putting all your eggs in one basket)…

However, using the traditional asset allocation approach, it is difficult to uncover the "hidden" links (common risk factors) between asset classes.

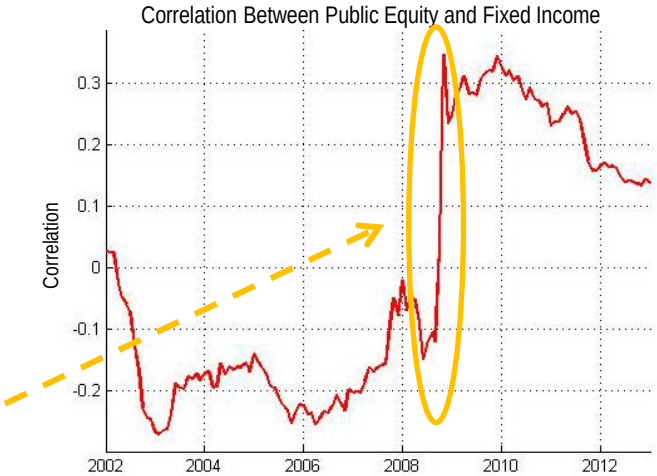
# Asset Allocation And Diversification

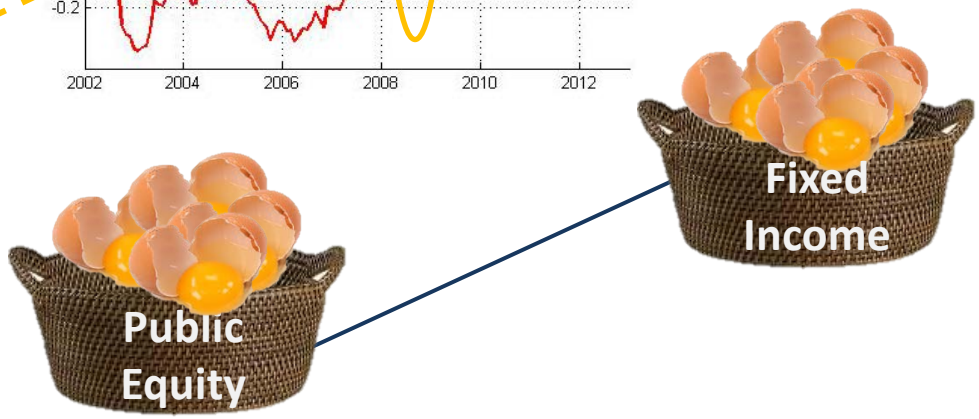
One goal of asset allocation is to build a well diversified portfolio (i.e., not putting all your eggs in one basket)…

For example, during the 2008 Financial Crisis, as Public Equity declined…

…Fixed Income was also affected.

The correlation between these two asset classes jumped from a negative value to a positive value.



# Asset Allocation And Diversification

One goal of asset allocation is to build a well diversified portfolio (i.e., not putting all your eggs in one basket)…

Allocating by risk factors ensures that if a single risk factor negatively affects a portfolio, the impact is contained within the allocation to that risk factor…

Allocation to Factor 2 stays intact.

Negative Impact of Risk Factor

# Nutrition Matters, So Do Factors

| 2010 ALM Workshop |
| --- |
| • The first step towards factor-based asset allocation was qualitatively categorizing each asset class into one risk bucket. |

# Nutrition Matters, So Do Factors

For example… Public Equity was categorized into the "Growth" risk bucket

| Public Equity |
| --- |
| Growth |

Fixed Income was categorized into the "Income" risk bucket

| Fixed Income |
| --- |
| Income |

If we use a soup analogy to represent each asset class to illustrate the similarities,… the approach in 2010 would be similar to saying…

…Clam Chowder Soup only contains Protein just as Public Equity only contains the Growth risk factor.

**Clam Chowder Soup**

**Nutrition Facts**
Serving Size: 227 g

Amount Per Serving
Calories: 220 Calories from Fat: 90
% Daily Value*
Protein

…or, Tomato Basil Soup only contains Vitamins just as Fixed Income only contains the Income risk factor.

**Tomato Basil Soup**

**Nutrition Facts**
Serving Size: 243 g

Amount Per Serving
Calories: 49 Calories from Fat: 0
% Daily Value*
Vitamins

# Nutrition Matters, So Do Factors

*Clam Chowder Soup*
(Public Equity)

*Tomato Basil Soup*
(Fixed Income)

**Nutrition Facts**

Serving Size: 227 g

Amount Per Serving:

Calories: 220 Calories from Fat: 90

| | % Daily Value |
|---|---|
| **Total Fat** 10 g | 15% |
| **Total Carbohydrate** 23 g | 8% |
| **Protein** 9 g | |
| **Vitamin A** 6% • **Vitamin C** | 0% |
| **Calcium** 15% • **Iron** | 4% |

Basic Nutrients:

1. Fats
2. Carbohydrates
3. Proteins
4. Vitamins
5. Minerals

**Nutrition Facts**

Serving Size: 243 g

Amount Per Serving:

Calories: 49 Calories from Fat: 0

| | % Daily Value |
|---|---|
| **Total Fat** 0 g | 0% |
| **Total Carbohydrate** 10 g | 3% |
| **Protein** 2 g | |
| **Vitamin A** 10% • **Vitamin C** | 120% |
| **Calcium** 2% • **Iron** | 2% |

# Nutrition Matters, So Do Factors

… now, let's think of these nutrients as the factors that explain asset class returns …

**Public Equity**

**Factor Exposure**

Serving Size: 1 Asset Class

Amount Per Serving:

Total Risk: Y%

% Contribution to Total Risk

| | |
|---|---|
| Factor 1 | X% |
| Factor 2 | X% |
| Factor 3 | X% |
| Factor 4 | X% |
| Factor 5 | X% |

Basic Factors:

1. Factor 1
2. Factor 2
3. Factor 3
4. Factor 4
5. Factor 5

**Fixed Income**

**Factor Exposure**

Serving Size: 1 Asset Class

Amount Per Serving:

Total Risk: Y%

% Contribution to Total Risk

| | |
|---|---|
| Factor 1 | X% |
| Factor 2 | X% |
| Factor 3 | X% |
| Factor 4 | X% |
| Factor 5 | X% |

# Nutrition Matters, So Do Factors

**2013 ALM Workshop**

- As the second step towards factor-based asset allocation, our goal today is to introduce the factor-based framework and quantitatively decompose each asset class into multiple risk factors.

**Public Equity**

**Factor Exposure**

Serving Size: 1 Asset Class

| Amount Per Serving | Total Risk: Y% |
|---|---|
| | % Contribution to Total Risk |
| Factor 1 | X% |
| Factor 2 | X% |
| Factor 3 | X% |
| Factor 4 | X% |
| Factor 5 | X% |

**Private Equity**

**Factor Exposure**

Serving Size: 1 Asset Class

| Amount Per Serving | Total Risk: Y% |
|---|---|
| | % Contribution to Total Risk |
| Factor 1 | X% |
| Factor 2 | X% |
| Factor 3 | X% |
| Factor 4 | X% |
| Factor 5 | X% |

**Fixed Income**

**Factor Exposure**

Serving Size: 1 Asset Class

| Amount Per Serving | Total Risk: Y% |
|---|---|
| | % Contribution to Total Risk |
| Factor 1 | X% |
| Factor 2 | X% |
| Factor 3 | X% |
| Factor 4 | X% |
| Factor 5 | X% |

**Real Estate**

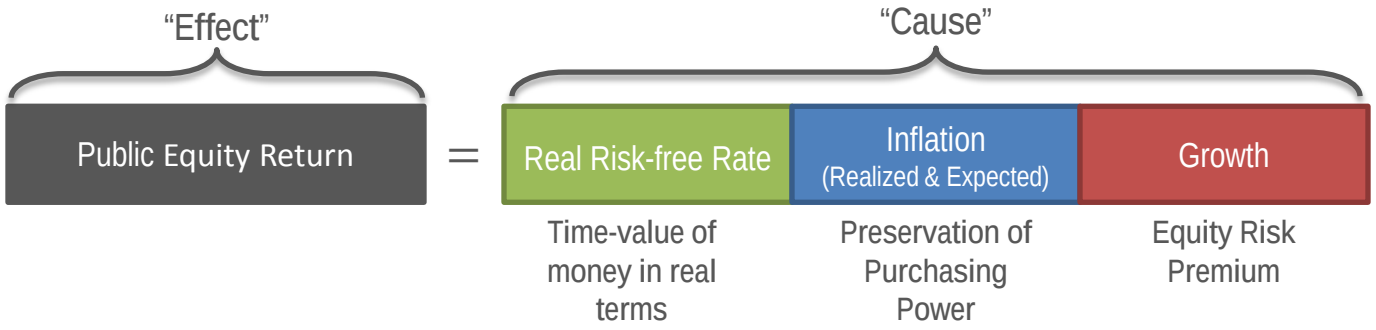
**Factor Exposure**

Serving Size: 1 Asset Class

| Amount Per Serving | Total Risk: Y% |
|---|---|
| | % Contribution to Total Risk |
| Factor 1 | X% |
| Factor 2 | X% |
| Factor 3 | X% |
| Factor 4 | X% |
| Factor 5 | X% |

# Why Use Factors?

1. Address the cause rather than the effect




2. More precise quantification of diversification benefits

3. Low and stable correlations

4. Consistent framework for all asset classes

# What Is a Factor-Based Framework?

- Our factor-based framework uses macro-economic and market factors.
- Using macro-economic and market factors is generally the most intuitive approach.
- Inflation Rates and Interest Rates are examples of macro-economic and market factors.

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# Identifying Factors

- The difficulty with a factor-based approach is identifying the right factors that would best explain the risks and returns of asset classes.

- Characteristics of a good risk factor:
  1. Sensible
  2. Statistically significant
  3. Relevant to investors
  4. Good data quality
  5. Tradable (ideally)

# Peers' Approach

- Some pension funds are in the process of transitioning to a factor-based allocation framework.

| Fund | Risk Class | Included Assets |
|---|---|---|
| CalSTRS[1] | Growth Risk | US Equity, Non-US Equity, Private Equity, Credit, High Yield, Real Estate (Core) |
| | Private Growth | Private Equity, Real Estate (Value Added), Real Estate (Opportunistic) |
| | Absolute Return | Interest Rates, MBS, US T-Bonds, Hedge Funds |
| | Growth Diversify | Long US Treasuries, TIPS, Commodities, Cash |
| | Inflation Risk | Bank Loans, TIPS |
| | Interest Rates | Hedge Funds, Commodities |
| | Interest Rate Uncertainty | Real Estate (Core), Infrastructure, Commodities |
| Alaska Permanent Fund Corporation[2] | Cash | Liquid investments with duration of less than 12 months |
| | Interest Rates | U.S. Treasury bonds and non-U.S. government bonds |
| | Company Exposure | U.S. and non-U.S. stocks, Corporate investment grade and high yield bonds, bank loans and private equity |
| | Real Assets | Real estate, infrastructure and TIPS |
| | Special Opportunities | Absolute return, distressed debt, commercial mortgage backed bonds |

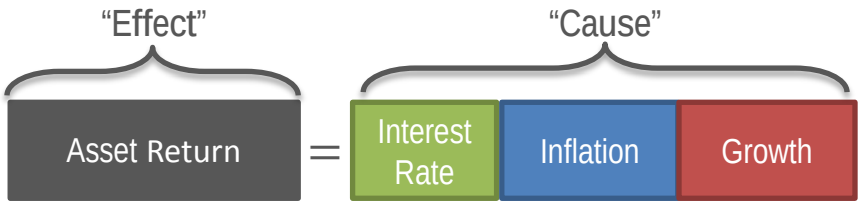
- Shifting from the conventional asset class based approach to a risk-factor-based approach is a new frontier, and we do not expect an industry consensus at this time.



1. CalSTRS, "2012 – 2013 Asset-Liability Session IV", 2013
2. Global Investment Conference, "Balancing Strategic Asset Allocation with Dynamic Asset Allocation", 2011

# The Approach We Are Using

- Most institutions use three core categories of macro-economic and market factors:
  - Interest Rate
  - Inflation
  - Growth




- To enhance precision, we further subdivide these categories into five factors.

| | |
|---|---|
| Interest Rate | 1. Real Interest Rate |
| Inflation | 2. Realized Inflation Rate<br>3. Expected Inflation Rate |
| Growth | 4. Volatility<br>5. Growth |

# 1. Real Interest Rate

**Intuition:** It is natural for investors to expect a rate of return above the inflation rate (i.e., to earn a positive real rate of return) because of the time value of money.

**Today:**
An investor puts $100 in a savings account with a nominal interest rate*.

**Nominal Interest Rate**
**3.0%**

**1 Year Later:**
The investor collects $103 for his principal and interest.

A basket of goods
Cost: $100

**Inflation**
**3.0%**

Same basket of goods
Cost: $103

| Nominal Interest Rate | − | Inflation | = | Real Interest Rate |
|---|---|---|---|---|
| 3.0% | | 3.0% | | 0.0% |

However, from the perspective of purchasing power, which is measured by the cost of goods and services…

… Inflation has eroded the investment's purchasing power by 3%...

… the real interest rate (or the growth of purchasing power) is 0% because the earned interest was just enough to cover the decline in purchasing power due to inflation.



* Nominal interest rate is the interest rate without any adjustments for inflation. Examples include the interest rates of savings accounts, certificate of deposit (CD), and home mortgage rates.

# 2. Realized Inflation Rate

- In the United States, the realized inflation rate refers to the change in the Consumer Price Index (CPI).
- **Intuition**: The realized inflation (CPI) is relevant because it is used:
  - Widely in pension contracts for cost of living adjustments (COLA);
  - As a reference for Inflation-linked securities such as Treasury Inflation-Protected Securities (TIPS).
    - For example, the coupon payments of TIPS are calculated by the following*:

If CPI increases from 100 to 110…

| Date | Face Value ($) | Coupon Rate | CPI | Coupon Payment ($) |
|---|---|---|---|---|
| 12/31/2012 | $1,000 | 3% | 100 | |
| 12/31/2013 | | | 110 | $33 |

$$(\$1{,}000) \cdot (3\%) \cdot \left({}^{110}/_{100}\right) = \$33$$

* For illustrative purposes only.

# 3. Expected Inflation Rate

- **Intuition**: The expected inflation rate is relevant because it is the component of expected return that affects purchasing power.
- The distinctions between the two forms of inflation are:
  - Realized inflation – Represented by the CPI and backward-looking;
  - Expected inflation – Market implied and forward-looking; also known as break-even inflation.
- Central banks, such as the Federal Reserve, monitor the expected inflation rate since it greatly influences realized inflation and ultimately the central bank's ability to achieve stable prices*.

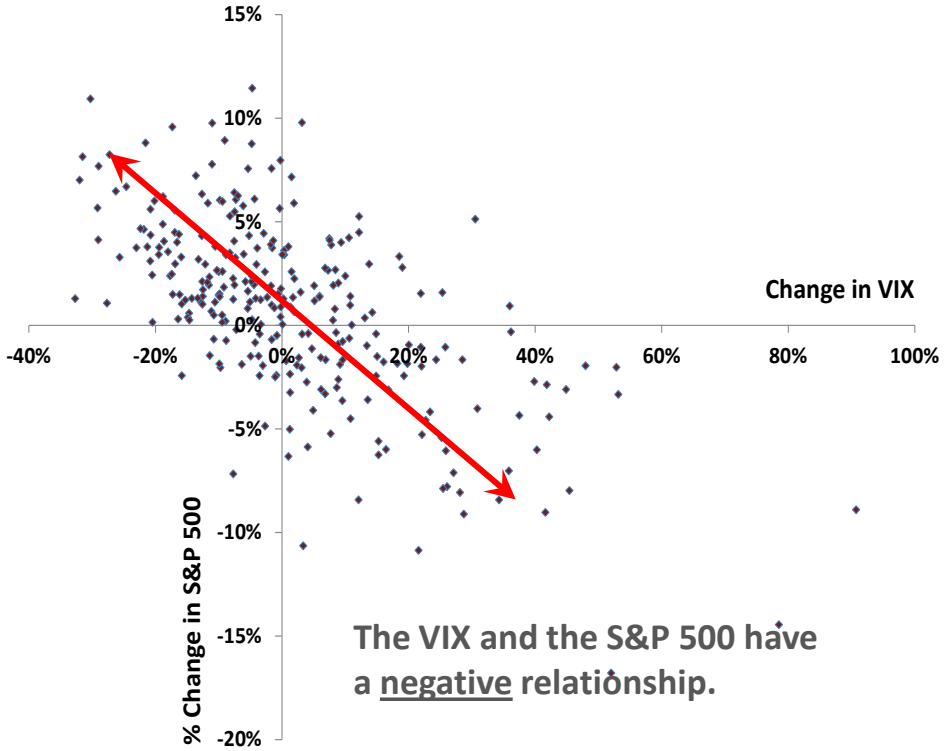
| Inflation Expectation | Monetary Policy |
|---|---|
| Rising Inflation (↑) | Restrictive |
| Declining Inflation (↓) | Expansionary |



* http://www.federalreserve.gov/newsevents/speech/bernanke20070710a.htm

# 4. Volatility

- **Intuition**: Investors, in general, are risk-averse. As the Volatility Index*, a measure of risk, rises, investors are less willing to hold risky assets.




- Empirical studies** have shown that the higher the volatility, the lower the return of public equity.
- This relationship has implications across all asset classes.

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* Chicago Board Options Exchange (CBOE) Volatility Index. See appendix for details.
** Giot, Pierre, *Relationship Between Implied Volatility Indexes and Stock Index Returns*, The Journal of Portfolio Management, Spring 2005, Vol. 31, No.3
** Duffee, Gregory, *Stock returns and volatility A firm-level analysis*, Journal of Financial Economics, April 1993

# 5. Growth

- **Intuition**: Growth matters to asset returns because this factor is often viewed as the equity premium of the expected return.
- What is growth? Common approaches of estimating the Growth factor include:

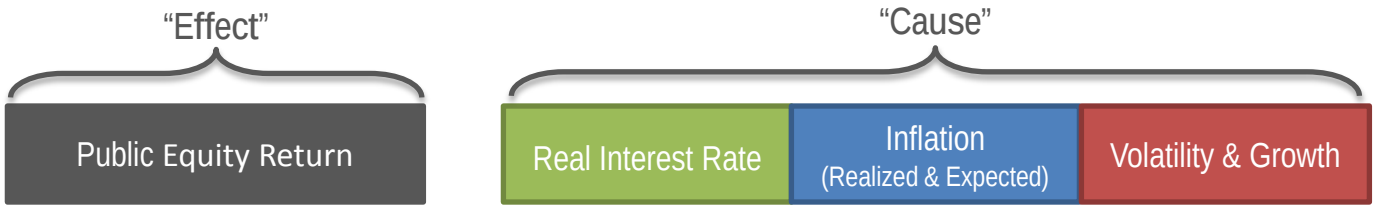
| Approach | Proxy for Growth Factor | Potential Issue |
|---|---|---|
| I | GDP Growth | • The correlation between economic growth and equity market returns may not be significant.*<br>• China is an example of high economic growth (2002 to 2011) that did not translate into good equity returns. |
| II | Public Equity Index (S&P 500 Index) | • Public equity index returns are also driven by factors, and therefore, may not be helpful in explaining equity concentrated portfolio returns. |
| III | Growth Style Index (Russell Growth Index) | • Very little difference was found in the explanatory power of equity index returns when the proxy for Growth factor was the Russell Growth or Value Index. |

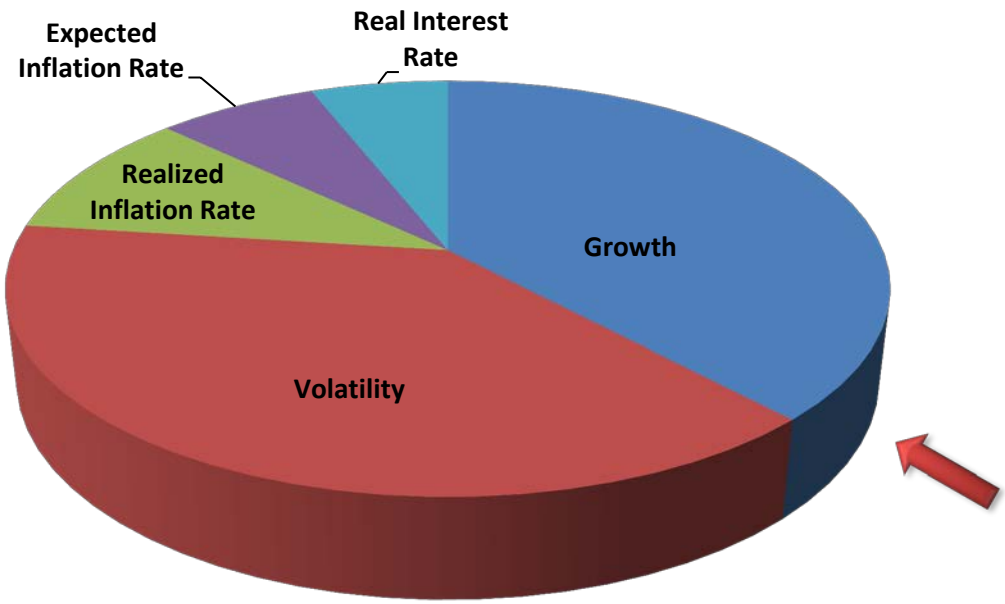


* Ritter, J., 2005, "Economic growth and equity returns", *Pacific-Basin Finance Journal*
* Sandte, H. 2012, "Stock Markets vs GDP Growth: A Complicated Mixture", *Viewpoint, BNY Mellon Asset Management*

# 5. Growth (continued)

- Rather than use these conventional proxies, we define the Growth factor as what remains from an equity index return after removing the contributions from the four other factors.




Step 1: Determine the contributions of the four other factors.

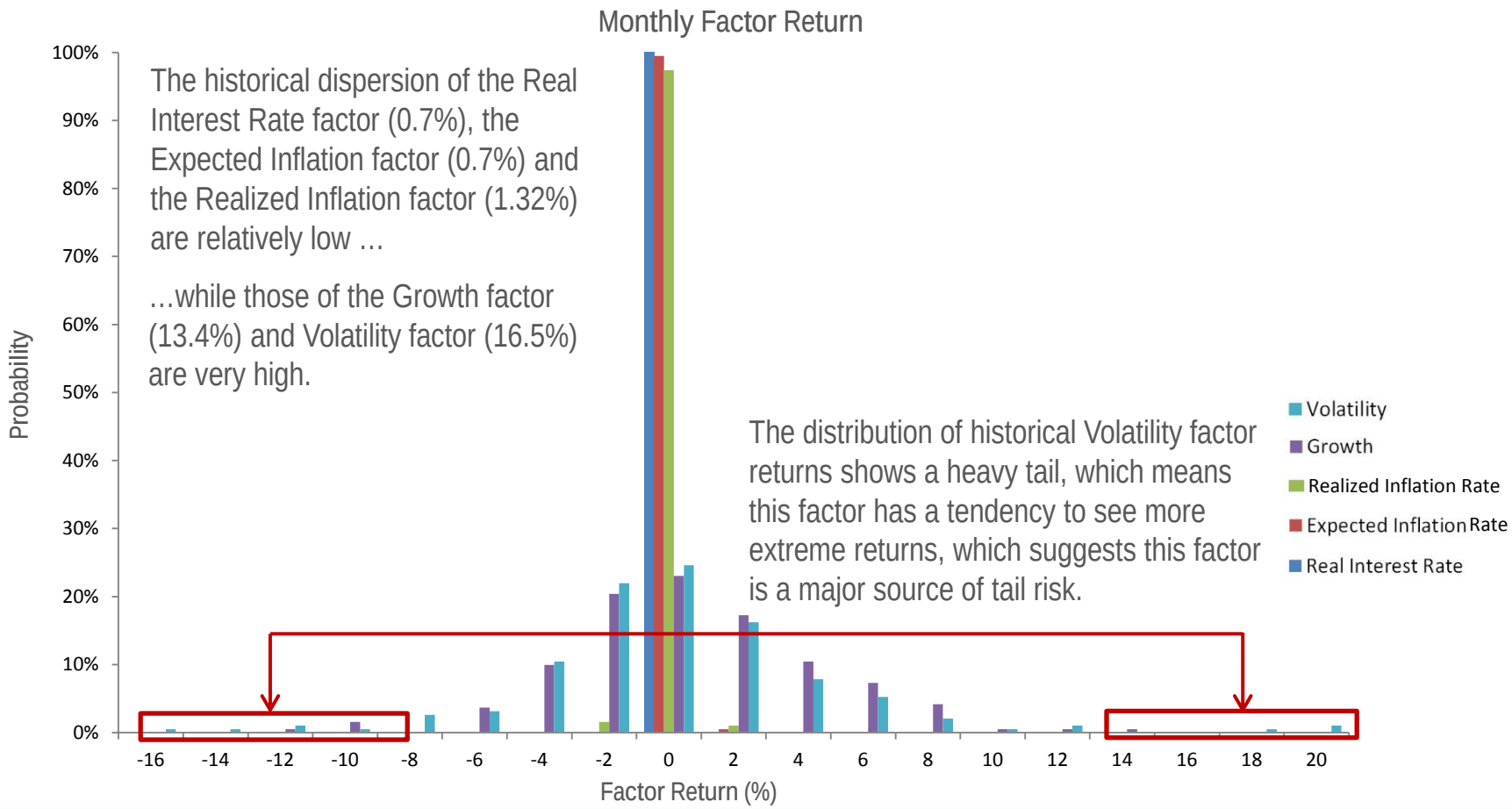
Step 2: Remove the contribution from each of the four other factors from the equity index return* …

… the Growth factor is simply the remaining component.

* Details in appendix.

# Historical Factor Returns

- The distributions of historical factor returns are vastly different.




The historical dispersion of the Real Interest Rate factor (0.7%), the Expected Inflation factor (0.7%) and the Realized Inflation factor (1.32%) are relatively low …

…while those of the Growth factor (13.4%) and Volatility factor (16.5%) are very high.

The distribution of historical Volatility factor returns shows a heavy tail, which means this factor has a tendency to see more extreme returns, which suggests this factor is a major source of tail risk.



Factor returns from 1997 to 2012 (191 monthly returns).

# Historical Factor Returns

- Why does the Volatility factor matter? The negative impact of Volatility tends to rise quickly and fall gradually which suggests… when Volatility matters, it REALLY matters.

Data from 1997 to 2012 (191 monthly returns).

# Stable Correlations Between Factors

- Stable correlations make return and risk forecasting more reliable.

  Using stable correlations to forecast risk and returns is similar to aiming at a relatively stable target.

  However… if the correlations are not stable, forecasting would be more like trying to aim at a randomly moving target.

Stable Correlations

Unstable Correlations

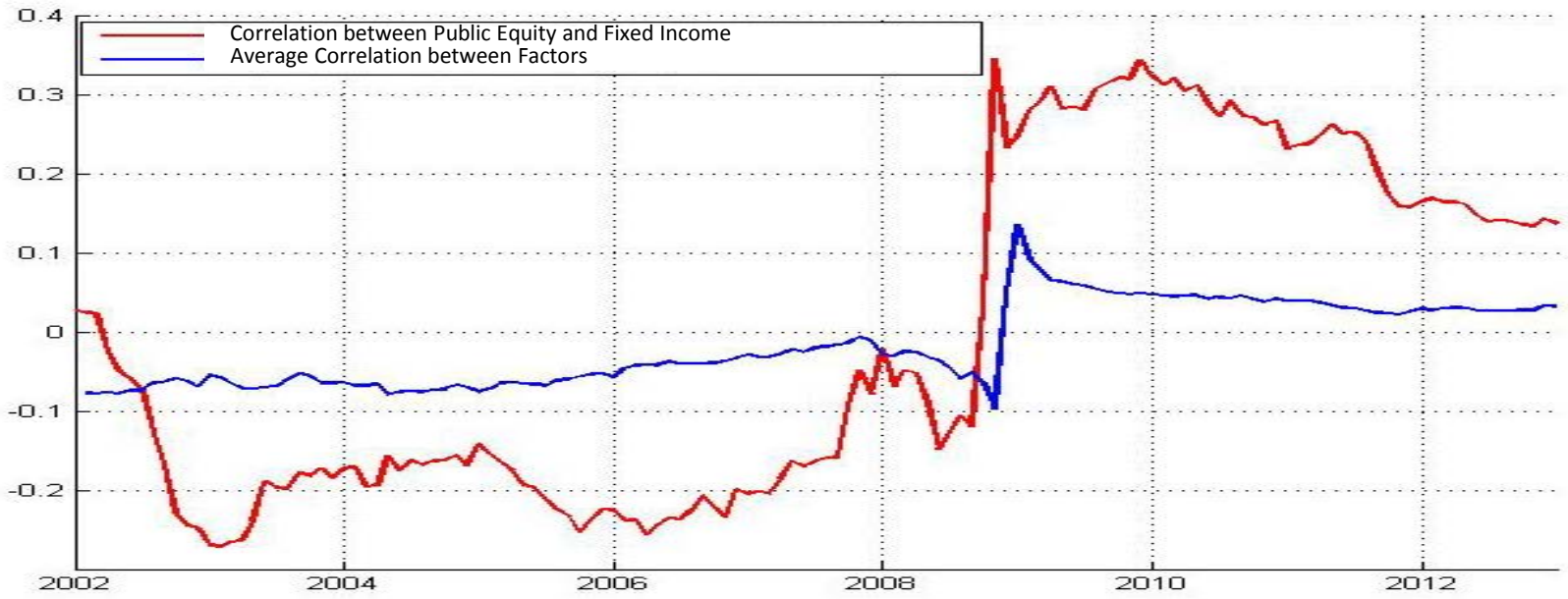


Monthly data are used for calculating correlations.

# Stable Correlations Between Factors

- Stable correlations make return and risk forecasting more reliable.
- Correlations between factors are generally more stable than correlations between asset classes.

**Rolling Correlation (5-year rolling window)**






Monthly data are used for calculating correlations.

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# Factor Exposure of Asset Class Benchmark: Background

- We use a factor model to decompose benchmark returns to obtain the factor exposure of each asset class.

+ = Positive exposure: Factor ↑ Asset Class Return ↑

− = Negative exposure: Factor ↑ Asset Class Return ↓

"$n/s$" = Exposure is not significant:

- The $R^2$-value of a factor model is an indicator of how well the model explains asset returns.

# Factor Exposure of Asset Class Benchmark: Results

- The higher the $R^2$, the higher the explanatory power of the factors.

| Asset Class | Factor Exposure | | | | | $R^2$ |
|---|---|---|---|---|---|---|
| | Real Interest Rate | Realized Inflation Rate | Expected Inflation Rate | Volatility | Growth | |
| Public Equity | + | $n/s$ | + | − | + | 0.92 |
| Private Equity[1] | $n/s$ | $n/s$ | + | − | + | 0.71 |
| Fixed Income | − | $n/s$ | − | − | + | 0.88 |
| Real Estate[1,2] | $n/s$ | + | + | $n/s$ | + | 0.71 |

- The decomposition of asset classes used capital returns except for the Private Equity

* Total sample size is 59 quarters (1997 to 2012). The magnitude of factor exposure is indicated by the symbol size.

[1] Returns are de-smoothed to reflect "true" volatility of illiquid asset classes.

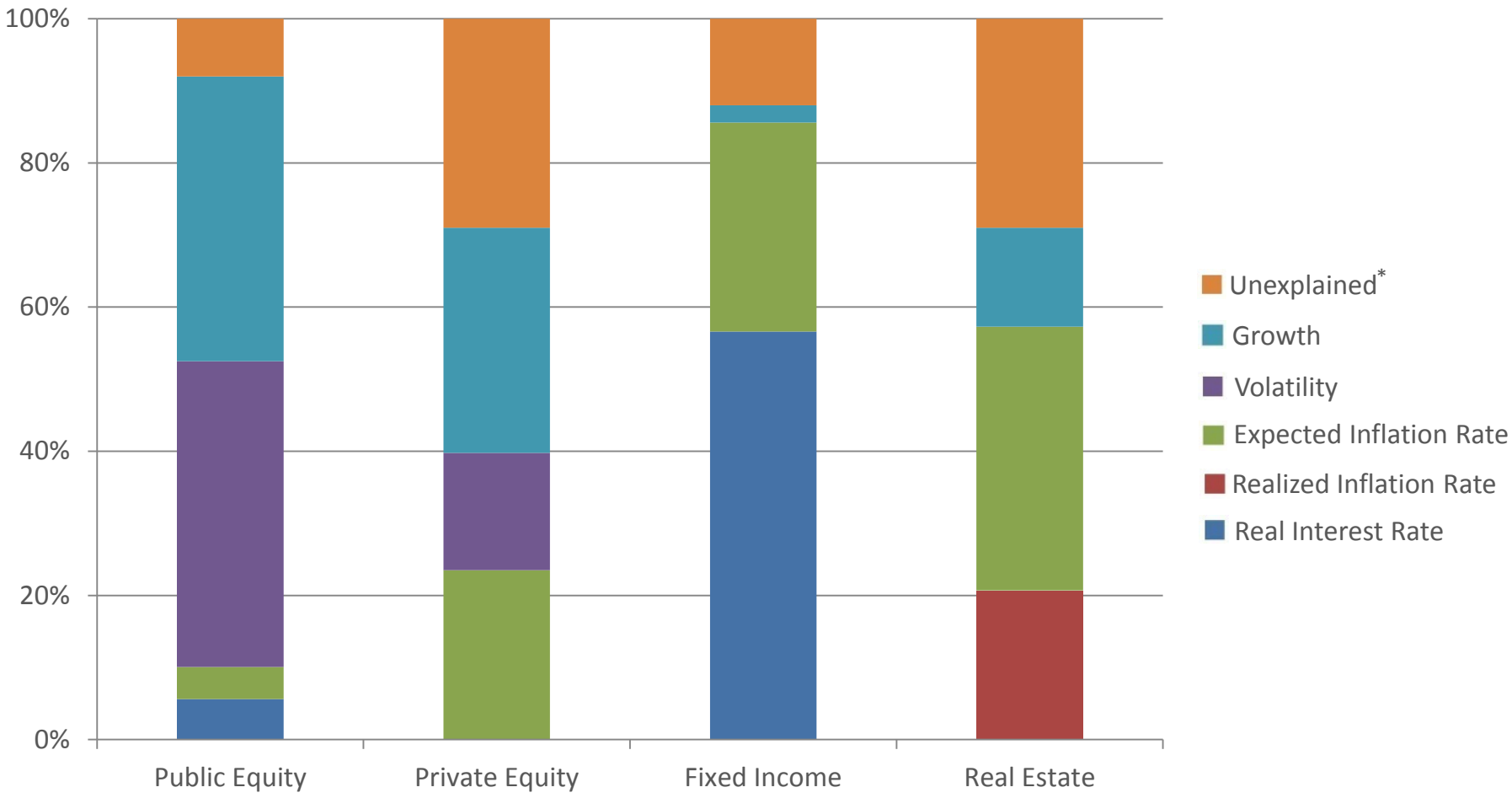
[2] Lagged returns which have significant impacts are included to account for autocorrelation, which represents the degree of similarity (correlation) between a given historical return series with a lagged version of itself over different time periods.

+ = Positive exposure

− = Negative exposure

"$n/s$" = Non-significant exposure

# Risk Contributions of Factors to Asset Classes




* "Unexplained" represents the percentage of risk that cannot be explained by the five factors. This may be due to unknown factors not included in the model or risk that is only specific to an asset class.

# Factor Exposure of Total Fund Policy Benchmark

- The results of the decomposition of the Total Fund Policy Benchmark:

| Portfolio | Factor Exposure | | | | | $R^2$ |
|---|---|---|---|---|---|---|
| | Real Interest Rate | Realized Inflation Rate | Expected Inflation Rate | Volatility | Growth | |
| Total Fund Policy Benchmark | 1.64 | 0.62 | 3.68 | -0.41 | 0.59 | 0.84 |

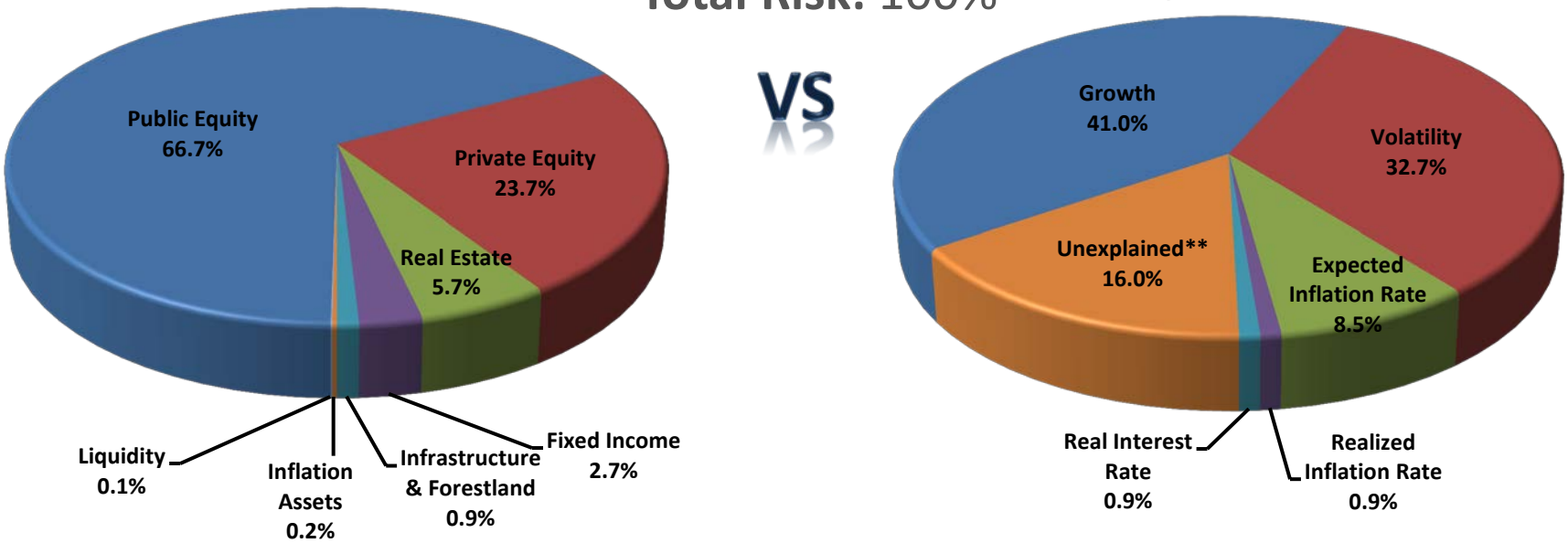
- This factor model explains 84% of the Total Fund Policy Benchmark returns.
- The factor exposures indicate how the risk factors affect the Benchmark expected return. For example:
  - An increase of 1% in the Growth factor will increase the Benchmark expected return by 0.59%.
  - An increase of 1% in the Volatility factor will decrease the Benchmark expected return by 0.41%.

* Weights are from the Total Fund Policy Benchmark as of July 1, 2011 (shown in the appendix).

# Risk Contributions to Total Fund Policy Benchmark

- Total Fund Policy Portfolio is dominated by equity-like risks.
- Two main risk factors: (1) Growth and (2) Volatility
- Difficult to completely separate Volatility from Growth.

**By Asset Class*** **Total Risk:** 100% **By Factor**






* The asset class volatility and correlations are based on the 2013 ALM Workshop capital market assumptions.
** "Unexplained" category represents the portion of asset returns that cannot be explained by the five factors.

# Now that we have the nutritional content of each asset class…

## Public Equity

### Factor Exposure

Serving Size: 1 Asset Class

Amount Per Serving

Total Risk ($R^2$): 92%

| | % Contribution to Total Risk |
|---|---|
| **Real Interest Rate (Vitamins)** | 5.6% |
| **Realized Inflation (Minerals)** | 0.0% |
| **Expected Inflation (Carbohydrates)** | 4.5% |
| **Volatility (Total Fat)** | 42.4% |
| **Growth (Protein)** | 39.5% |

## Private Equity

### Factor Exposure

Serving Size: 1 Asset Class

Amount Per Serving

Total Risk ($R^2$): 71%

| | % Contribution to Total Risk |
|---|---|
| **Real Interest Rate (Vitamins)** | 0.0% |
| **Realized Inflation (Minerals)** | 0.0% |
| **Expected Inflation (Carbohydrates)** | 23.5% |
| **Volatility (Total Fat)** | 16.2% |
| **Growth (Protein)** | 31.3% |

## Fixed Income

### Factor Exposure

Serving Size: 1 Asset Class

Amount Per Serving

Total Risk ($R^2$): 88%

| | % Contribution to Total Risk |
|---|---|
| **Real Interest Rate (Vitamins)** | 56.6% |
| **Realized Inflation (Minerals)** | 0.0% |
| **Expected Inflation (Carbohydrates)** | 29.0% |
| **Volatility (Total Fat)** | 0.0% |
| **Growth (Protein)** | 2.4% |

## Real Estate

### Factor Exposure

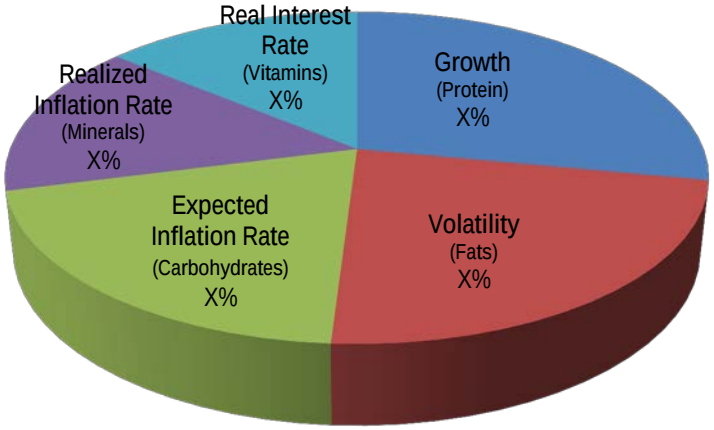
Serving Size: 1 Asset Class

Amount Per Serving

Total Risk ($R^2$): 71%

| | % Contribution to Total Risk |
|---|---|
| **Real Interest Rate (Vitamins)** | 0.0% |
| **Realized Inflation (Minerals)** | 20.7% |
| **Expected Inflation (Carbohydrates)** | 36.6% |
| **Volatility (Total Fat)** | 0.0% |
| **Growth (Protein)** | 13.7% |

# …once we know how much of each nutrient we want …






Source of image http://www.sequoiaprod.com/tag/italian/

…we can look for the recipe of the desired soup.



Source of image http://www.sequoiaprod.com/tag/italian/

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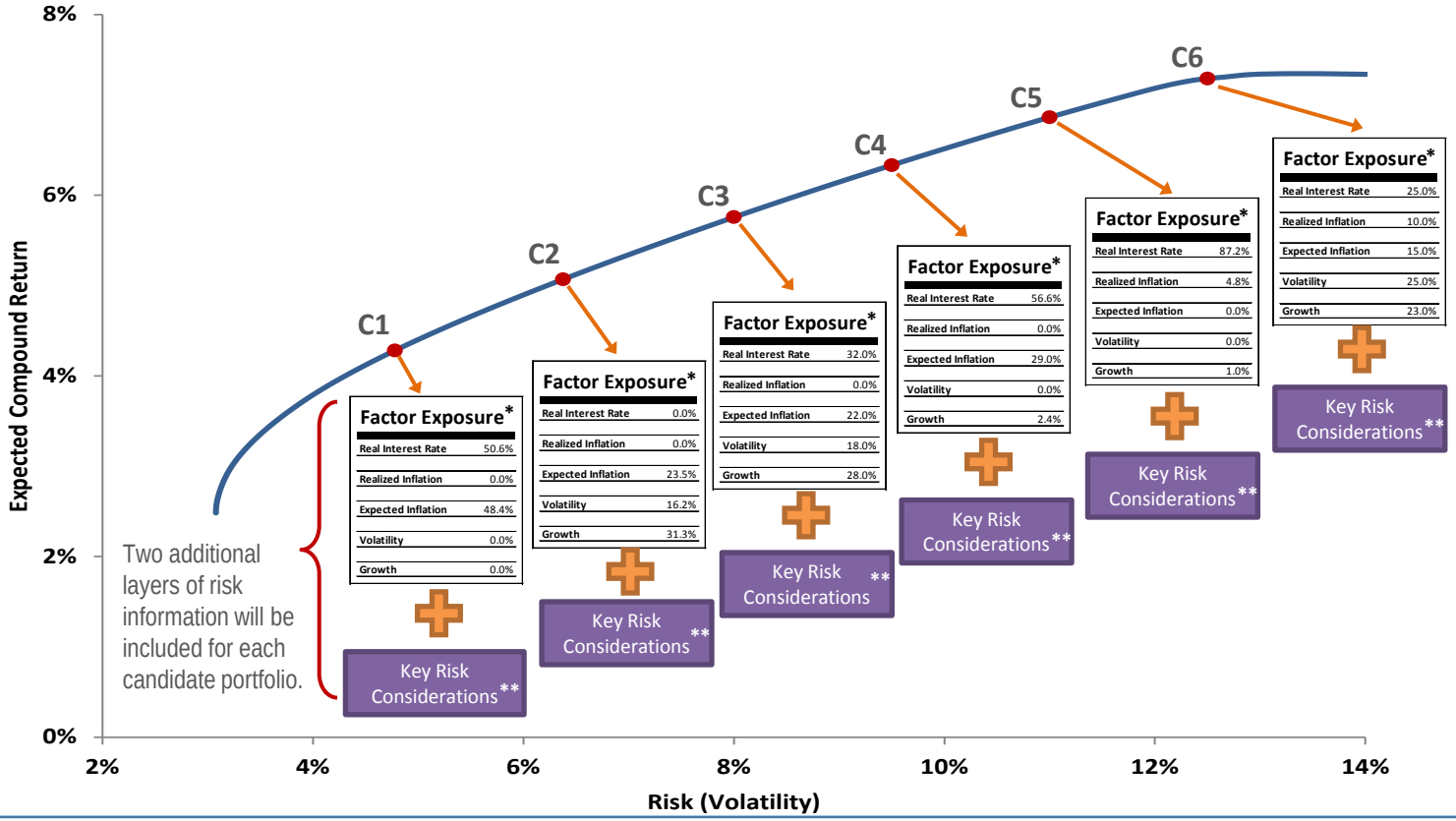
# Conclusion

- Decomposing asset returns using macro-economic and market factors provides a more transparent risk and return profile of a portfolio.

- This transparency is especially useful in building a portfolio because it helps mitigate the unintentional over-allocation/under-allocation to risk factors, which is a challenge for the traditional asset allocation approach.

# Next Steps

In the 2013 ALM process, we will continue to apply the conventional asset class based approach in identifying the candidate portfolios. In addition, we will reveal the factor exposures of the candidate portfolios. This enhancement will allow the selection of the Policy Portfolio to be more risk-factor conscious.



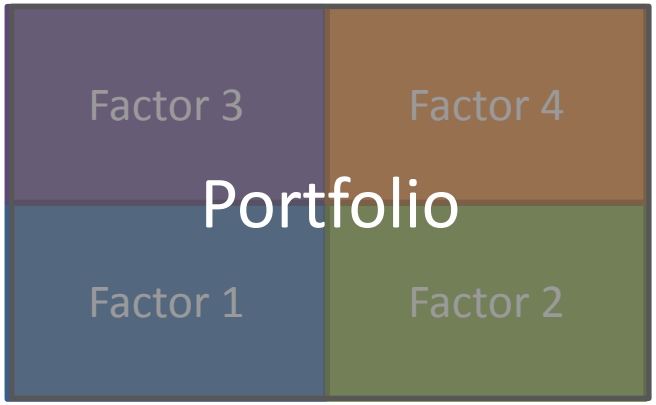



* Factor exposure values are only for illustrative purposes.
** Key risk considerations include Funding Level, Employer Contribution Rate, Employer Contribution Volatility Rate, and Warning Track.

# Beyond 2013

- The factor-based asset allocation proposes an alternative approach of portfolio construction using risk factors.

First we build the portfolio by identifying the right amount of factor exposures...




...then we determine the optimal allocation to each asset class to achieve this factor exposure.

**Using the factor-based allocation avoids the problem of unintentionally over-allocating/under-allocating certain risk factors.**

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# Income Factor: Cash Yield

- In our risk-factor-based framework, the Income factor is not considered as a risk factor since it is relatively stable; however, it can be an important source of cash flow for benefit payments.

| Asset Class | Cash Yield | Total Fund Policy Benchmark Weight | Methodology | Source |
|---|---|---|---|---|
| **Public Equity** | 2.73% | 49.10% | Dividend yield of FTSE All World (trailing 12 month). | Bloomberg |
| **Fixed Income** | 3.70% | 15.90% | Coupon yield of Barclays Long Liability Index. | Barclays Capital |
| **Real Estate (RE)** | 2.00% | 10.00% | Estimate provided by INVO Real Asset. | INVO RE |
| **Private Equity** | 0.00% | 14.00% | Operating under assumption NO income generation from this asset class. PE (with LBO focus) is mostly driven by exit multiple and capital appreciation. | n/a |
| **Infrastructure/ Forestland (IFG)** | 2.50% | 3.00% | Estimate provided by INVO Real Asset/Infrastructure/Forestland. | INVO RE/IFG |
| **Inflation Assets** | 0.88% | 4.00% | Inflation Assets include TIPS (75%) and Commodities (25%). 75% of the coupon yield of TIPS Index is used because commodities do not generate income. | Barclays Capital |
| **Liquidity** | 2.78% | 4.00% | Coupon yield of Custom Index (75% Barclays Capital 2-10 YR Treasury Index and 25% Barclays Capital 1 month T-bill Index). | Barclays Capital |
| **Total** | 2.35% | 100% | | |

# Proxies of Potential Factors

- Asset returns can be explained by the following set of factors:

| Factor | Proxy |
|---|---|
| Real Interest Rate | Yield of the 10-Year U.S. TIPS (Datastream) |
| Realized Inflation Rate | U.S. CPI Urban Consumers MoM NSA (Bloomberg) |
| Expected Inflation Rate | The difference between yields of the 10-Year U.S. Treasury and the 10-Year U.S. TIPS (Datastream) |
| Volatility | Chicago Board Options Exchange Volatility Index (Bloomberg) |
| Growth | Residual of regressing the custom pro-cyclical index return against returns of other factors including real interest rate, realized inflation rate, expected inflation rate and volatility. |

# Statistical Characteristics of Factors

- The distributions of all factor returns are non-normal.

| Factor | Annualized Mean (%) | Annualized Volatility (%) | Skewness | Kurtosis |
|---|---|---|---|---|
| Real Interest Rate | -0.26 | 0.72 | 0.54 | 5.46 |
| Realized Inflation | 2.32 | 1.32 | -1.02 | 7.79 |
| Expected Inflation | -0.04* | 0.72 | 0.49 | 7.56 |
| Volatility | -0.09* | 16.49 | 0.81 | 7.15 |
| Growth | 6.10 | 13.43 | 0.20 | 3.97 |

Data from 1997 to 2012 (191 monthly returns in total).
* Not statistically significant at 5% significance level

# Correlations Between Factors

- To be effective and to complement one another, each pair of factors should be independent or has a low correlation with each other.
- Correlations between factors are shown to be either not statistically significant or relatively low.

| Factor | Real Interest Rate | Realized Inflation | Expected Inflation | Volatility | Growth |
|---|---|---|---|---|---|
| Real Interest Rate | 1.00 | | | | |
| Realized Inflation | – | 1.00 | | | |
| Expected Inflation | – | 0.32* | 1.00 | | |
| Volatility | – | – | -0.30* | 1.00 | |
| Growth | – | – | – | – | 1.00 |



* Only statistically significant values at 5% level are shown. 191 monthly returns in total (from 1997 to 2012). Using a larger sample size (monthly rather than quarterly) will generally give a more stable estimate of correlation. Using quarterly data will increase the standard error of correlation from about 0.08 to 0.13.

# Asset Class and Proxy Index

| Asset Class | Proxy Index |
|---|---|
| Public Equity | FTSE All World Price Index |
| Private Equity | Cambridge US Private Equity Index* |
| Fixed Income | Barclays Long Liability Index |
| Real Estate | NCREIF ODCE Index Price Index |
| Inflation Linked Bonds | Barclays US Treasury Inflation Notes Index |
| Treasuries | Barclays US Aggregate Treasury Index* |
| Absolute Return Strategies (ARS) | HFRI Fund of Fund Composite Index* |

* The index is a benchmark commonly used in the industry; however, it is not the benchmark used at CalPERS.

# Factor Exposure of Asset Class Benchmark: Results

- The higher the $R^2$, the higher the explanatory power of the factors.

| Asset Class | Factor Exposure | | | | | $R^2$ |
|---|---|---|---|---|---|---|
| | Real Interest Rate | Realized Inflation Rate | Expected Inflation Rate | Volatility | Growth | |
| Public Equity | + | $n/s$ | + | − | + | 0.92 |
| Private Equity[1] | $n/s$ | $n/s$ | + | − | + | 0.71 |
| Fixed Income | − | $n/s$ | − | − | + | 0.88 |
| Real Estate[1,2] | $n/s$ | + | + | $n/s$ | + | 0.71 |
| Inflation Linked Bonds[2] | − | + | $n/s$ | $n/s$ | + | 0.93 |
| Treasuries | − | $n/s$ | − | $n/s$ | $n/s$ | 0.99 |
| Forestland[1,2] | $n/s$ | + | $n/s$ | $n/s$ | $n/s$ | 0.17 |
| Commodities[2] | $n/s$ | + | + | $n/s$ | $n/s$ | 0.54 |
| Absolute Return Strategies (ARS) | $n/s$ | $n/s$ | + | − | + | 0.61 |

- The decomposition of asset classes used capital returns except for the Private Equity

+ = Positive exposure
− = Negative exposure
"$n/s$" = Non-significant exposure

* Total sample size is 59 quarters (1997 to 2012). The amplitude of factor exposure is indicated by symbol size.
1 Returns are de-smoothed to reflect "true" volatility of illiquid asset classes.
2 Lagged returns which have significant impacts are included to account for autocorrelation, which represents the degree of similarity (correlation) between a given historical return series with a lagged version of itself over different time periods.

# Factor Exposure of Asset Class Benchmark: Results

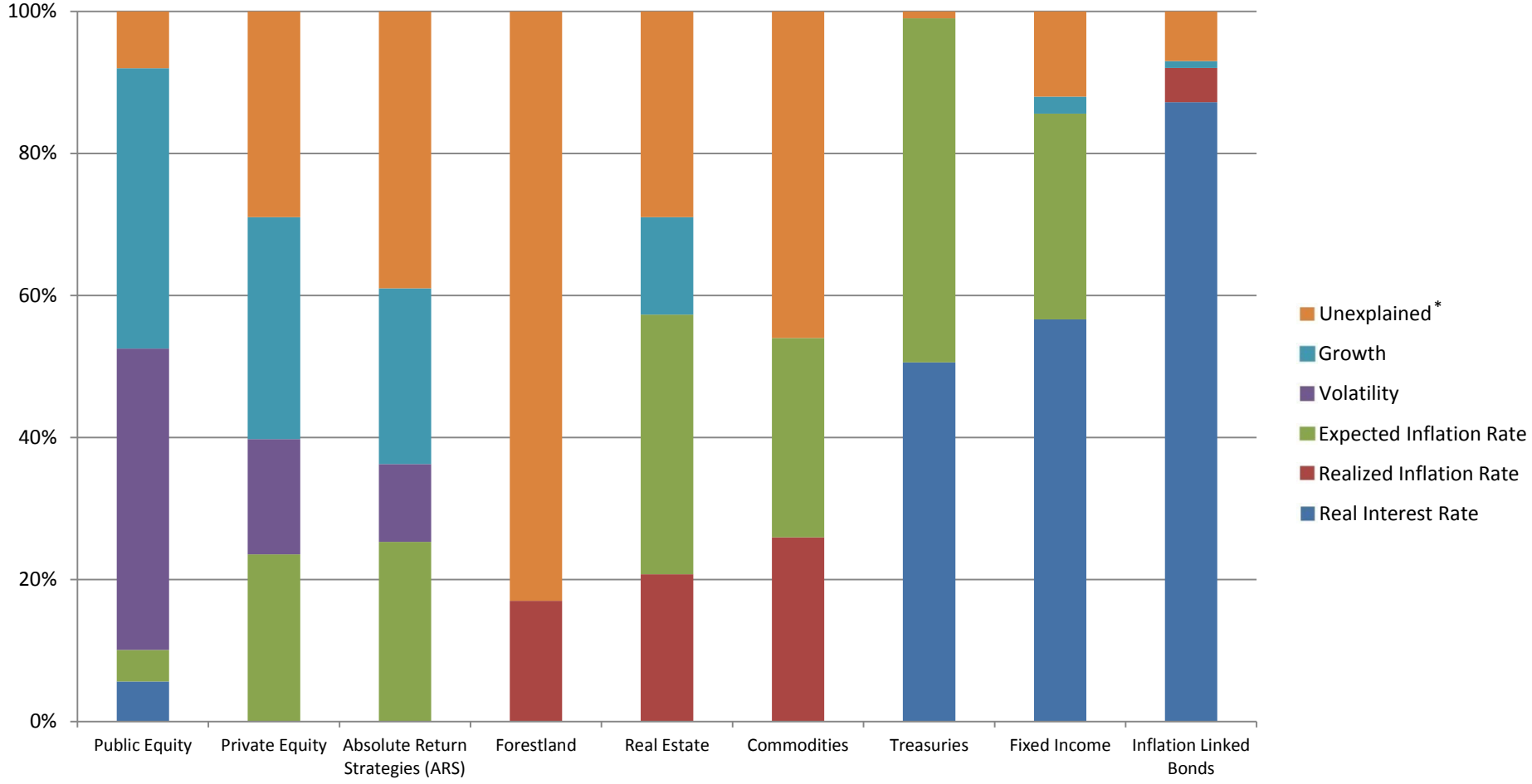
- The numerical factor exposures of the asset class benchmarks.

| Asset Class | Factor Exposure | | | | | $R^2$ |
|---|---|---|---|---|---|---|
| | Real Interest Rate | Realized Inflation Rate | Expected Inflation Rate | Volatility | Growth | |
| Public Equity | 6.22 (0.00) | 0.22 (0.65) | 3.56 (0.01) | -0.72 (0.00) | 0.88 (0.00) | 0.92 |
| Private Equity[1] | 4.71 (0.06) | -0.78 (0.44) | 11.04 (0.00) | -0.38 (0.00) | 0.76 (0.00) | 0.71 |
| Fixed Income | -6.34 (0.00) | 0.00 (0.99) | -4.50 (0.00) | -0.06 (0.00) | 0.07 (0.00) | 0.88 |
| Real Estate[1,2] | -0.82 (0.71) | 4.22 (0.04) | 11.27 (0.01) | 0.07 (0.49) | 0.41 (0.00) | 0.71 |
| Inflation Linked Bonds[2] | -7.14 (0.00) | 0.91 (0.00) | 0.67 (0.07) | 0.01 (0.59) | 0.04 (0.01) | 0.93 |
| Treasuries | -4.84 (0.00) | -0.06 (0.23) | -4.70 (0.00) | 0.00 (1.00) | 0.00 (0.98) | 0.99 |
| Forestland[1,2] | -2.45 (0.17) | 2.82 (0.04) | 1.31 (0.53) | 0.05 (0.52) | 0.12 (0.16) | 0.17 |
| Commodities[2] | -7.73 (0.07) | 8.32 (0.00) | 16.05 (0.01) | -0.23 (0.25) | -0.05 (0.80) | 0.54 |
| Absolute Return Strategies (ARS) | 0.99 (0.37) | 0.23 (0.60) | 4.34 (0.00) | -0.11 (0.04) | 0.25 (0.00) | 0.61 |

- The decomposition of asset classes used capital returns except for the Private Equity: Cambridge Associate Index.
- Total sample size is 59 quarters (1997 to 2012). p-Values are shown in parentheses

[1] Returns are de-smoothed to reflect "true" volatility of illiquid asset class.
[2] Lagged returns which have significant impacts are included to account for autocorrelation.

# Risk Contributions of Factors to Asset Classes




* "Unexplained" represents the percentage of risk that cannot be explained by the five factors. This may be due to unknown factors not included in the model or risk that is only specific to an asset class.

# Risk Contribution of Factors to Asset Class Benchmarks

| Asset Class | Risk Contribution (%) | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Real Interest Rate | Realized Inflation Rate | Expected Inflation Rate | Volatility | Growth | Unexplained* | |
| Public Equity | 5.6% | 0.0% | 4.5% | 42.4% | 39.5% | 8.0% | 100.0% |
| Private Equity** | 0.0% | 0.0% | 23.5% | 16.2% | 31.2% | 29.0% | 100.0% |
| Fixed Income | 56.6% | 0.0% | 29.0% | 0.0% | 2.4% | 12.0% | 100.0% |
| Real Estate | 0.0% | 20.7% | 36.6% | 0.0% | 13.7% | 29.0% | 100.0% |
| Inflation Linked Bonds | 87.2% | 4.8% | 0.0% | 0.0% | 1.0% | 7.0% | 100.0% |
| Treasuries | 50.6% | 0.0% | 48.4% | 0.0% | 0.0% | 1.0% | 100.0% |
| Forestland | 0.0% | 17.0% | 0.0% | 0.0% | 0.0% | 83.0% | 100.0% |
| Commodities | 0.0% | 25.9% | 28.1% | 0.0% | 0.0% | 46.0% | 100.0% |
| Absolute Return Strategies (ARS) | 0.0% | 0.0% | 25.3% | 11.0% | 24.8% | 39.0% | 100.0% |
| Total Fund Policy Benchmark‡ | 0.9% | 0.9% | 8.5% | 32.7% | 41.0% | 16.0% | 100.0% |

* "Unexplained" represents the percentage not explained by factor decomposition.
‡ Total Fund Policy Benchmark is the weighted average of the factor loadings using the 2010 ALM workshop weights.

# De-smoothing Methodology

- De-smoothing methodologies were applied to correct the bias introduced by asset return smoothing. We considered two de-smoothing methods:

| Method I* | Method II** |
|---|---|
| $r_t = \frac{r_t^s - \alpha r_{t-1}^s}{1-\alpha}$ | $r_t = \frac{r_t^s - \alpha_1 r_{t-1}^s - \alpha_2 r_{t-2}^s}{1-\alpha_1-\alpha_2}$ |

where $r_t$ is the de-smoothed return, $r_t^s$ is the smoothed (observed) return, $\alpha$ is the memory coefficient for Method I; $\alpha_1$ and $\alpha_2$ are the first and second order memory coefficients for Method II.



* Kinlaw, W., Kritzman M. and Turkington D. (2012), "*Liquidity and Portfolio Choice*"
** Marcato G. and Key, T (2007), "*Smoothing and Implications for Asset Allocation Choices*"

# De-smoothing Methodology (continued)

- "Method I" is relatively easy to implement; however, "Method II" (or other higher order methods) might be more effective in uncovering the "true" volatility of an illiquid asset class and its correlations with other asset classes.

- Application of de-smoothing methods on the NCREIF ODCE real estate index (NCREIF ODCE)

| NCREIF ODCE | Before De-smoothing | After De-smoothing Method I | After De-smoothing Method II |
|---|---|---|---|
| Volatility (Annualized) | 6.71% | 25.62% | 18.77% |
| Sample Autocorrelation (Lag = 1) | 0.87 | 0.38 | *0.15** |
| Correlation with FTSE All World | *0.13** | 0.40 | 0.39 |

- De-smoothing with Method II is more effective in reducing autocorrelations of illiquid asset returns.



* Not statistically significant at 5% level. Quarterly data from 1994 to 2012 (74 quarters in total).

# 2013 ALM Workshop: Asset Class Forecasts

| | Compound Return | Volatility |
|---|---|---|
| **Fixed Income** | 2.76% | 7.00% |
| **Public Equity** | 7.75% | 17.40% |
| **Private Equity** | 9.33% | 25.00% |
| **Real Estate** | 7.00% | 14.00% |
| **Infras. & Forestland** | 7.00% | 11.00% |
| **Inflation Assets** | 2.95% | 7.25% |
| **Liquidity (Treasuries)** | 1.95% | 3.00% |
| **ARS** | 5.89% | 7.00% |

| Forecasted Correlation Matrix | Fixed Income | Public Equity | Private Equity | Real Estate | Infras. & Forestland | Inflation Assets | Liquidity (Treasuries) | ARS |
|---|---|---|---|---|---|---|---|---|
| **Fixed Income** | 1.00 | | | | | | | |
| **Public Equity** | 0.21 | 1.00 | | | | | | |
| **Private Equity** | 0.12 | 0.73 | 1.00 | | | | | |
| **Real Estate** | 0.13 | 0.37 | 0.38 | 1.00 | | | | |
| **Infras. & Forestland** | 0.20 | 0.27 | 0.20 | 0.50 | 1.00 | | | |
| **Inflation Assets** | 0.25 | 0.03 | 0.01 | 0.10 | 0.20 | 1.00 | | |
| **Liquidity (Treasuries)** | 0.50 | 0.00 | 0.00 | 0.05 | 0.20 | 0.14 | 1.00 | |
| **ARS** | 0.06 | 0.50 | 0.35 | 0.27 | 0.20 | 0.00 | 0.10 | 1.00 |

# Total Fund Policy Benchmark

- The Total Fund Policy Benchmark as of July 1, 2011 is composed of the following categories:

| | |
|---|---|
| Growth: | 63% |
| Income: | 16% |
| Real Assets: | 13% |
| Inflation: | 4% |
| Liquidity: | 4% |

# Growth Factor

- What equity index is used to decide the Growth factor?
  - We used a custom pro-cyclical index*, which is a subset of the global equity index and is more sensitive to economic growth.
  - This custom index is a weighted sector index that is positively correlated with economic fluctuations.
  - The sectors** used are (1) Financials, (2) Information Technology, (3) Consumer Discretionary, (4) Energy and (5) Industrials.

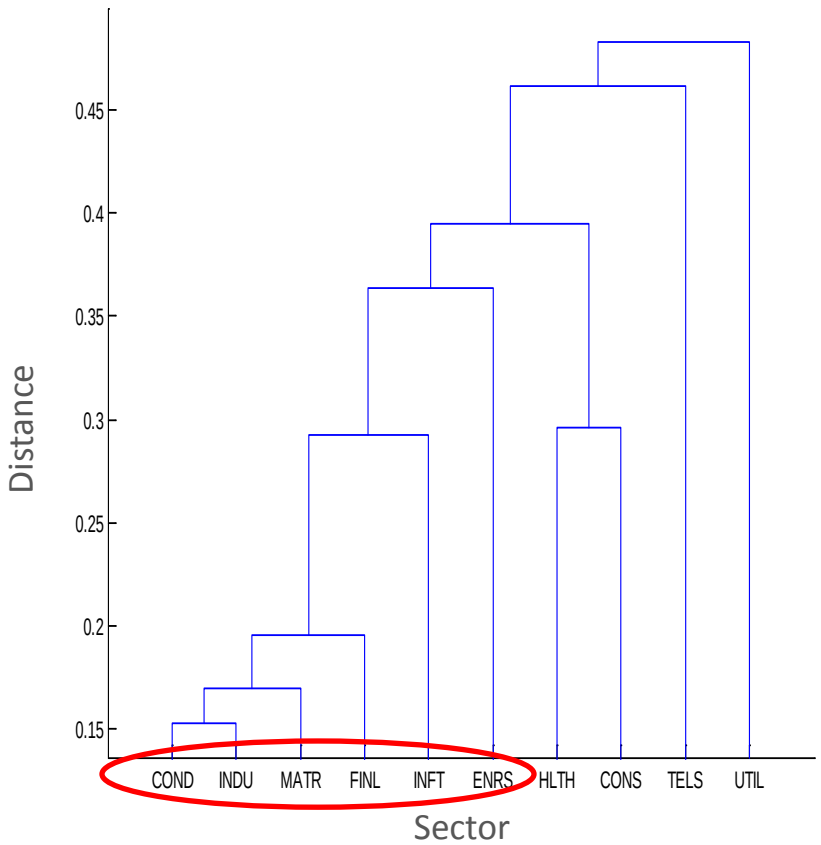


* In contrast, a Growth factor represented by a counter-cyclical index has much less explanatory power of public equity index return.

** Defined by Global Industry Classification Standard (GICS)

# Growth Factor (continued)

- The majority of public equity return variance can be explained by the five pro-cyclical sector returns.
  - The total weight of these five sectors makes up more than 70% of the S&P 500 index
- The pro-cyclical sectors give a clearer definition of "growth".
- The cluster analysis shows that six sectors (including Material, which only represents about 3% of S&P 500 Index) can be grouped into one category.*






* The distance between sectors is measured by *1 minus correlation*. For example, the correlation between Consumer Discretionary (COND) and Industrial (INDU) is 0.85, therefore the distance between the two sectors is 0.15, which is the shortest among all sectors. These two sectors then form a new group. In the next step, we search again for the shortest distance among the new group and the rest of the eight sectors to form another new group. The process is repeated until only two groups are left.

# Pro-Cyclical vs. Counter-Cyclical Index

- The sectors included in the two indices are:

| Pro-Cyclical Index | |
|---|---|
| Financials | Energy |
| Information Technology | Industrials |
| Consumer Discretionary | |

| Counter-Cyclical Index | |
|---|---|
| Utilities | Consumer Staple |
| Health Care | Telecommunications |

- Using the decomposition of public equity (excluding the Growth factor) as the baseline, adding the Growth factor extracted from the pro-cyclical index proxy increased the explanatory power of the factor model from 0.57 to 0.91. Conversely, using the Growth factor derived from the counter-cyclical index only marginally increased the $R^2$ from 0.57 to 0.67.

| Asset Class | Factor Exposure | | | | | $R^2$ | Sample Size |
|---|---|---|---|---|---|---|---|
| | Real Interest Rate | Realized Inflation | Expected Inflation | Volatility | Growth | | |
| Public Equity (Pro-Cyclical) | 0.00* | 0.00* | 2.99 | -0.72 | 0.74 | 0.91 | 191 Months |
| Public Equity (Counter-Cyclical) | 0.00* | 0.00* | 2.99 | -0.72 | 0.54 | 0.67 | 191 Months |
| Public Equity (excluding Growth Factor) | 0.00* | 0.00* | 2.99 | -0.72 | n/a | 0.57 | 191 Months |

* *All data that are not significant (at 5% level) are assigned to be zero.*