Equity in Central Bank Portfolios

Static and Dynamic Allocation

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Outline

- Introduction: do equities make sense within a CB portfolio?
- Static allocation to equities, within a simple risk/reward framework
- Dynamic allocation to equities based on valuation ratios – a long-term historical study based on a “no view” optimization framework

Introduction: Equity in Central Bank Portfolios?

- **"Classic" investment goals for Central Bank reserves portfolios:**
  - Capital preservation – minimize risk of losses
  - Maximize liquidity – make sure funds can be available immediately when needed
  - Grow the national wealth – but only as a secondary goal, subject to the first two
  - Avoid "headline risk"
- **To include equity in a Central Bank portfolio, we would need to conclude either:**
  - that a (small?) allocation to equity can be perfectly consistent with these goals
  - that the above guidelines do not fully reflect the current set of priorities
- **Factors that could help motivate an allocation to equity:**
  - Increase in size of reserve portfolio could increase the priority of asset growth relative to the other return goals stated above
  - Concern about cost of holding reserves: low interest rates, FX exposure, inflation
  - Negative correlation between equity and fixed income could make equity a good hedge against rising rates

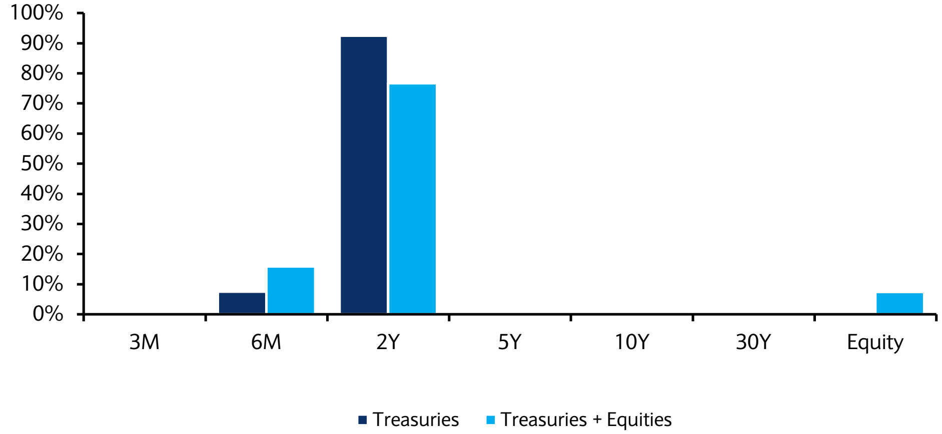
Risk vs. Reward: A Simple Historical Case Study

- **We consider an asset allocation problem for Central Banks using a purely historical approach based on limiting worst-case performance**
- **The optimization criterion: maximize average return, subject to a constraint on worst-case loss in a given review period**
- **Example of worst-case loss constraints: what static asset allocation would have produced the highest average return such that:**
  - cumulative returns over any 6-month period >= -50bp
  - cumulative returns over any 12-month period >= 0
  - worst portfolio drawdown observed from high-water mark >= -100bp
- **We carry out each such analysis twice:**
  - Using asset classes defined by six on-the-run Treasuries of different maturities: 3mo, 6mo, 2yr, 5yr, 10yr, 30yr
  - Using the above Treasury asset classes plus an equity asset class represented by a broad market total return index of US equities (MSCI Total Return Index)

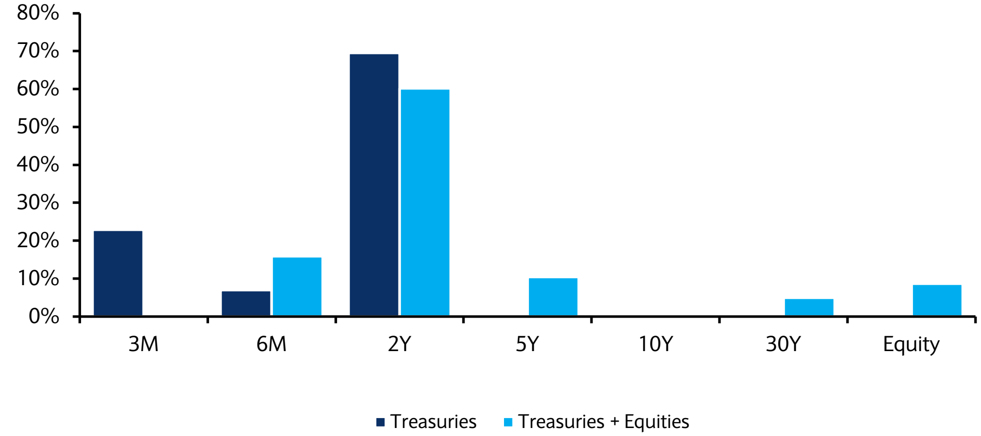
Static Allocation: Historical Case Study Results

In-sample Optimization based on asset return data from Jan 1981 – Feb 2015

Optimal Portfolio w Worst Case 6mo Return >= -50bp



Optimal Portfolio w Worst Case 12mo Return >= 0



- We compare the optimal static portfolios using two different formulations of our in-sample optimization, based on worst case returns over horizons of 6 and 12 months
- When using the longer 12-month horizon, including equity makes a bigger difference:
  - the Treasury-only portfolio gets more conservative, shifting to the 3-month
  - with equity, a more diversified portfolio is obtained, with a greater allocation to risky assets (long bonds and equities)
- Due to the negative correlation between bond and equity returns over this period, adding equity does not necessarily require shortening duration

Source: Barclays Research

Static Allocation Results (continued)

In-sample Optimization based on asset return data from Jan 1981 – Feb 2015

Portfolio	Avg Tsy Duration	Equity Allocation	Long Bond Allocation	Worst 6mo Return	Worst 12mo Return	Max. Drawdown	Sharpe Ratio
Opt.(Tsy Only, 6mo>-50bp)	1.77	0.0%	0.0%	-0.5%	-0.6%	-1.46%	0.61
Opt. (w Equity, 6mo>-50bp)	1.51	7.4%	0.0%	-0.5%	-0.3%	-1.59%	0.76
Tsy 2y	1.87	0.0%	0.0%	-0.7%	-0.7%	-1.62%	0.61
Opt. (Tsy Only, 12mo>0)	1.48	0.0%	0.7%	-0.2%	0.0%	-1.01%	0.61
Opt. (w Equity, 12mo>0)	2.32	8.6%	4.9%	-1.5%	0.0%	-2.61%	0.73

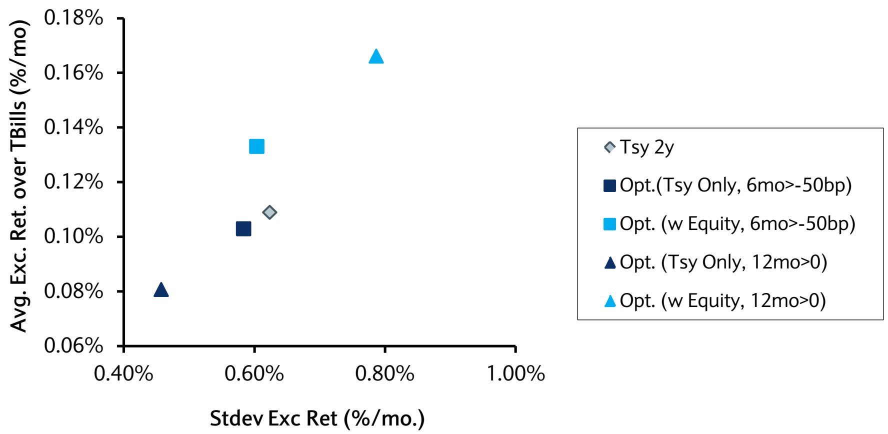
- Note that the 2-Year Treasury benchmark has achieved worst-case returns below our targeted levels of -50bp over 6 months and 0bp over 12 months
- Including equity assets under either optimization criterion improves the realized Sharpe ratio of the optimal portfolio, from about 0.6 to over 0.7
- However, the addition of equity can degrade the maximum drawdown in the optimal portfolio relative to that of the Treasury-only optimal portfolio

Source: Barclays Research

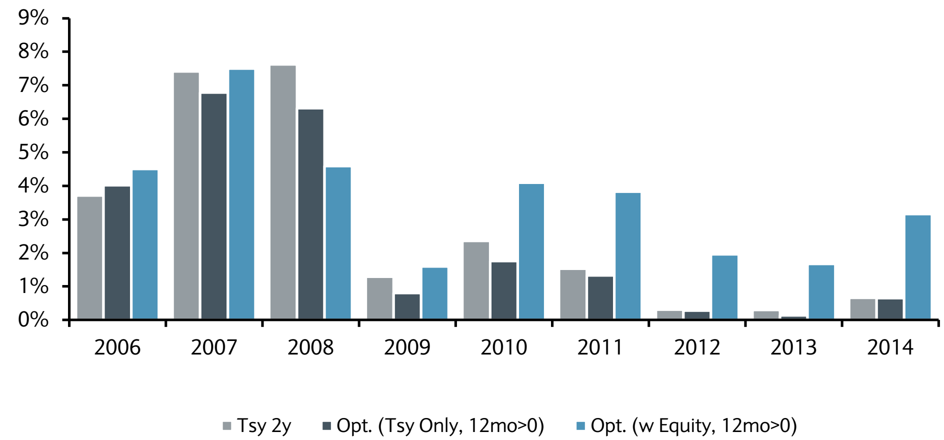
Static Allocation Results (continued)

In-sample Optimization based on asset return data from Jan 1981 – Feb 2015

Risk vs. Return Tradeoff by Optimization Rules



Performance Comparison in recent Calendar Years



- Adding equity improves the risk/return tradeoff (Sharpe Ratio)
- To meet the 12-month no-loss constraint with only Treasuries requires a very conservative portfolio; with equities we take more risk and earn more return
- The optimal Treasury-only portfolio based on the 12mo horizon underperformed the 2yr over the past several years; with equity, it underperformed the 2yr in 2008 and outperformed in the 6 years since then.

Source: Barclays Research

Dynamic Asset Allocation Based on “No View” Optimization

Portfolio allocation for Performance – “No-view” Portfolio Optimization

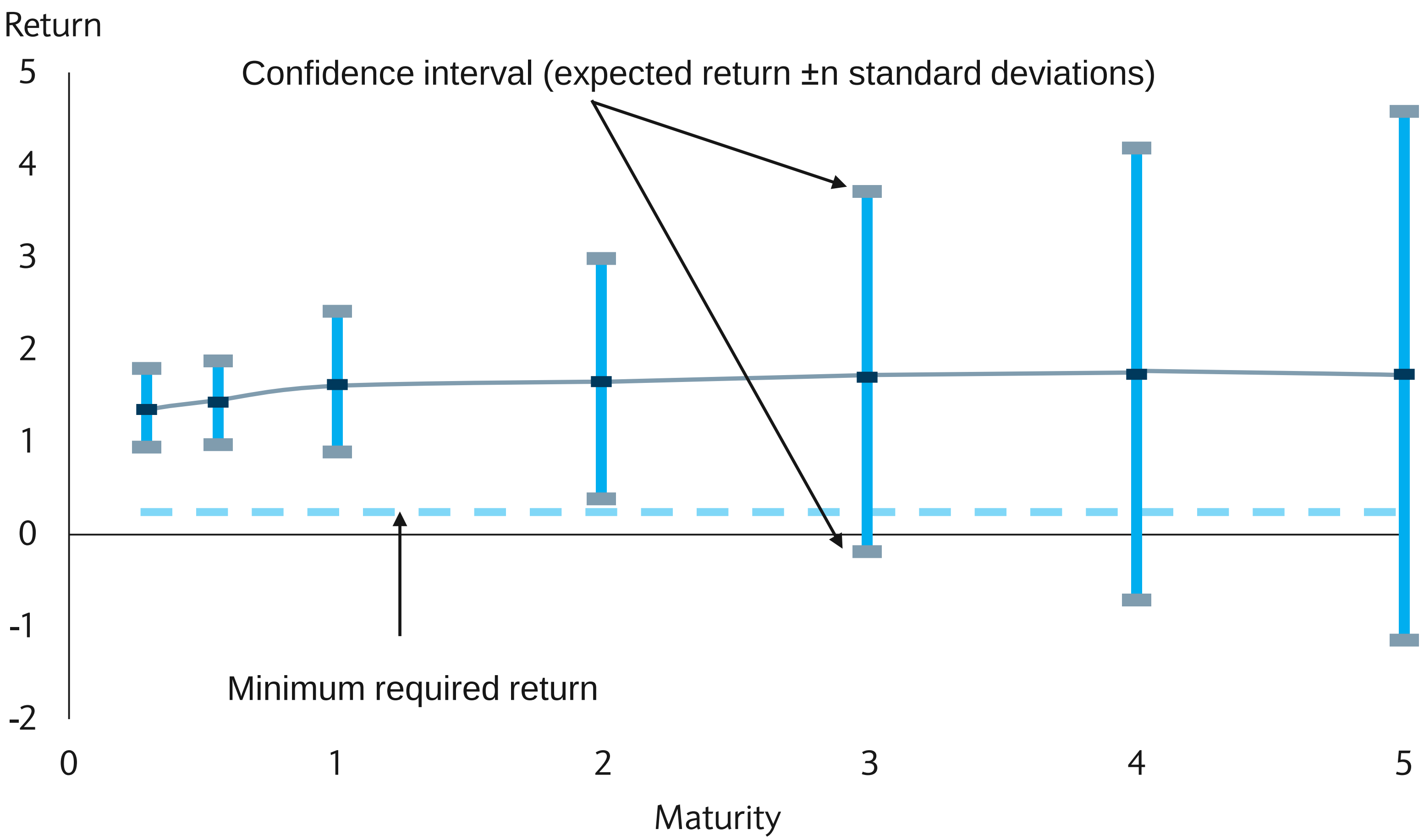
- Use a “no-view” statistical optimization to maximize expected return subject to a constraint on worst-case return
- Focus on capital preservation while obtaining moderate outperformance
- Choose only highly liquid investment assets
- Use historical data to project asset return volatility
- Use current yield curve as the basis for expected asset returns

Risk-return Tradeoff in the Strategy Formulation

- Expected return for each asset is based on its carry
  - For bonds we assume an unchanged yield curve, so expected return includes:
    - carry return proportional to the yield of the bond
    - plus adjustments for rolldown and convexity
  - For equities, we use the Shiller earnings-to-price ratio
    - Uses current price divided by 10-year rolling inflation-adjusted earnings
    - Measure of the long-term return potential for equities
- Return volatility is estimated based on historical returns
- Worst case return constrains the risk we put into the strategy, expressed as either:
  - A fixed lower bound on returns (e.g., 0% total monthly return)
  - A floating lower bound on returns : *n* standard deviations below expected benchmark returns

“No-view” Optimization

“No-view” statistical optimization



Source: Barclays Research

Optimization Procedure

- The objective is to find the portfolio with positive weights that solve

$$\max \sum_i w_i r_i$$

$$s.t. \sum_i w_i (r_i - n\,\sigma_i) \geq r_{\min}$$

- This formulation assumes perfectly correlated losses in all assets in the worst case. We use an alternate version that relies on historical asset covariances.

- The choice of *n* determines the level of confidence that the minimum return threshold will not be violated.

Number of Standard Deviations	Confidence Level
1.0	84.1%
1.5	93.3%
2.0	97.7%

Source: Barclays Research

Strategy Parameters

- Horizon over which the minimum return constraint is imposed
  - A shorter horizon reduces the risk-taking ability of the strategy
  - A longer horizon may lead to higher long-term performance at the expense of higher return volatility

- Required minimum return threshold

- Confidence level of achieving required minimum return:
  - Higher confidence of avoiding losses reduces risk appetite

- Duration constraints

- Asset concentration constraint

Including Equities in This “No View” Framework

- One main difference between our “No View” optimization framework and standard Mean-Variance Optimization (MVO) is in the choice of expected returns
- For Treasury assets, we use an unchanged yield curve assumption, in which each asset earns its current yield, plus adjustments for rolldown and convexity
- How can we form an estimated return estimate for equities that is consistent with this approach?
- For equities, we have chosen to use the Shiller earnings to Price ratio:
  - Take the average earnings over the past 10 years, adjusted for inflation
  - Divide by current price to get a measure of expected “earnings yield”
  - This can give a measure of the long-term return potential for equities consistent with the yield-based approach we use for bonds

Brief Historical Review of Shiller Equity Valuation Indicators

- We document historical performance of US bond /equity portfolios in the period from 1926 through 2011
  - Equities outperformed bonds considerably over the sample period
  - Combining bonds and equities improves portfolio Sharpe ratio

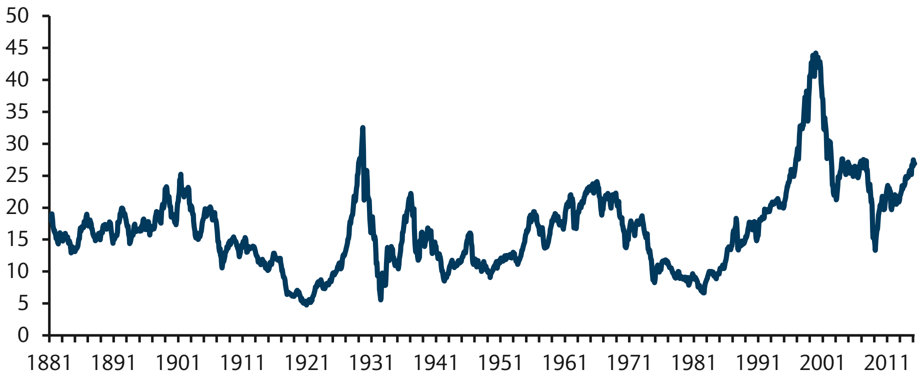
- We demonstrate that valuation indicators can provide a useful signal for future long horizon equity returns:
  - Cyclically Adjusted Price Earnings Ratio (CAPE) is negatively related to long-term total and dividend returns
  - The ratio of the Cyclically Adjusted Earning Yield over Treasury yield is positively related to performance of equities over Treasury bonds

Cyclically Adjusted Price-Earnings Ratio (CAPE)

- Price-earnings (PE) ratio is a simple valuation indicator for equity markets
  - A high PE ratio might indicate richness of the stock market
  - A low PE ratio might indicate cheapness of the market
- Shiller in 1988 (and Benjamin Graham and David Dodd in 1934) suggested that for the purpose of examining valuation ratios, one should use earnings averaged over a substantial time period

- Shiller introduced cyclically adjusted PE (CAPE) ratio: S&P 500 divided by the average inflation-adjusted earnings from the previous 10 years
- CAPE is appropriate for use over long time horizons because it smoothes out the peaks and valleys in earnings

Historical CAPE Ratio of S&P 500 Index

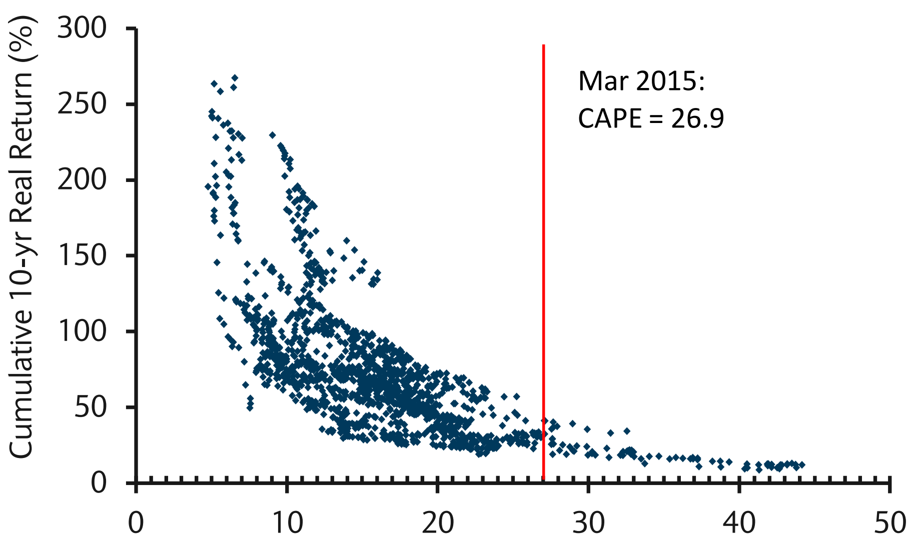


Source: Robert Shiller Data

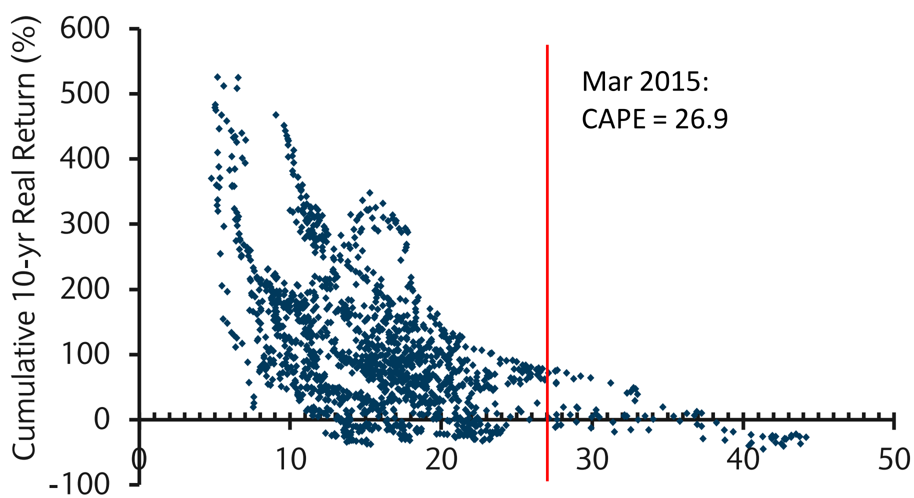
CAPE as an Indicator of Long-Term Equity Performance

- We analyze whether CAPE ratio is related to future long-horizon performance of the equity market
- Using overlapping samples of monthly returns from January 1881 to March 2015, we plot subsequent equity dividend and total returns over a 10yr horizon against CAPE ratios
- Two diagrams below show that subsequent dividend returns and total returns of the equity market over the 10yr horizon are negatively related to the CAPE ratio

10yr Future Dividend Returns vs. CAPE Ratio



10yr Future Total Returns vs. CAPE Ratio

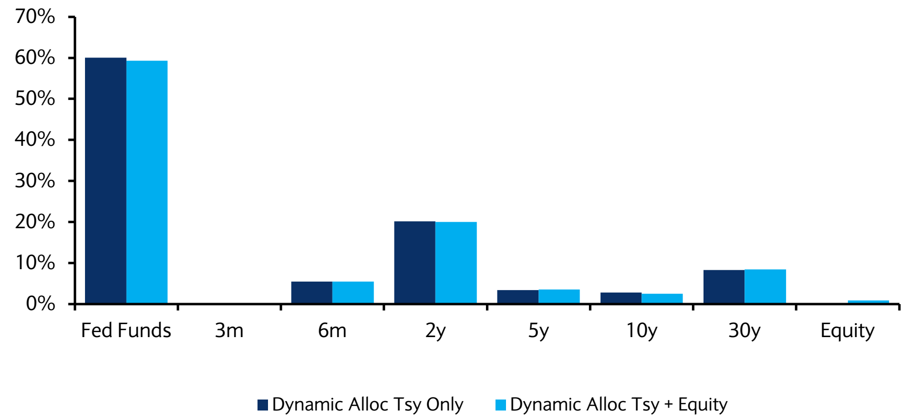


Source: Robert Shiller Data, Barclays Research

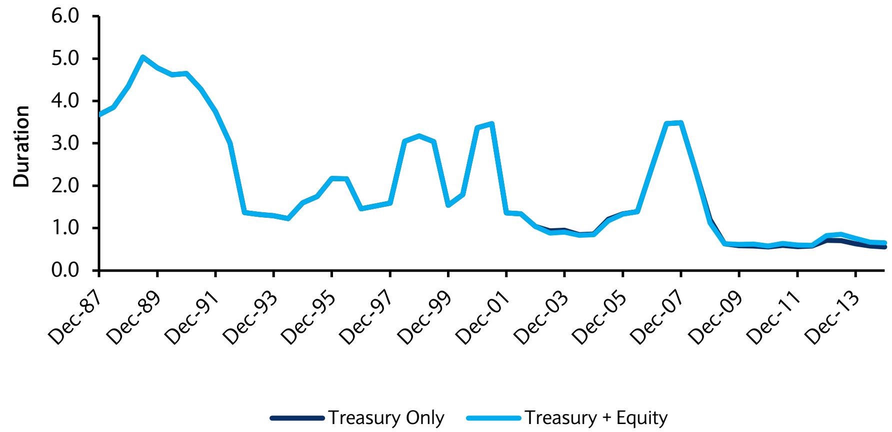
Dynamic Allocation Using “No View” Optimization

Historical backtest of results, semi-annual rebalancing, Dec 1987 – Dec 2014

Average Allocations: Worst Case 6mo Return >= -50bp

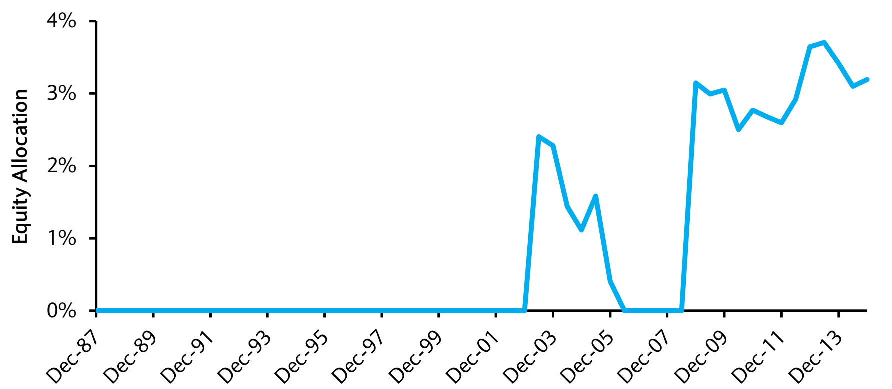


Time Series of Optimal Portfolio Durations



- We choose a fairly risk-averse strategy formulation:
  - Require 6mo returns >= -50 bp with 95% confidence
- We run twice, with and without equity asset
- Allocations vary a lot; we show long-term average weights, time series for duration and equity allocation
- In many months, equity allocation is zero
- When add equity, duration can increase or decrease

Time Series of Optimal Equity Allocations



Source: Robert Shiller Data, Barclays Research

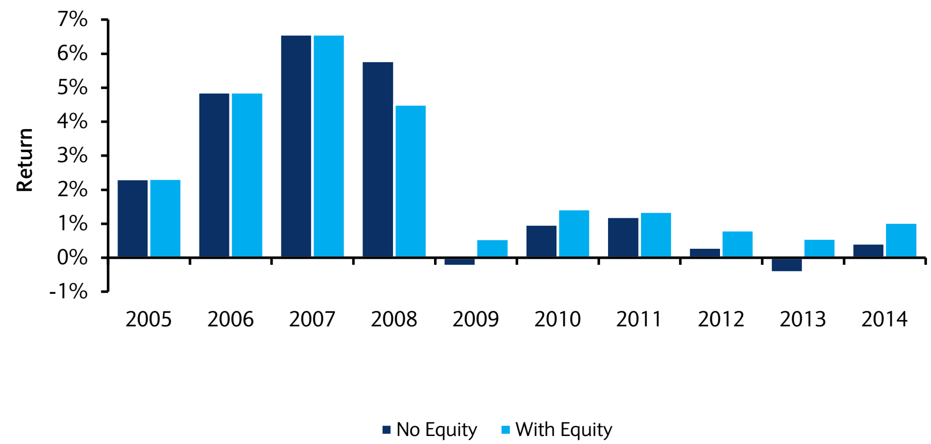
Dynamic Allocation Using "No View" Optimization

Historical performance, semi-annual rebalancing, Dec 1987 – Dec 2014

Long Term Performance of Dynamic Optimal Portfolios

	Treasuries Only	Treasuries + Equity
Average return (%/year)	4.43	4.53
Average Duration	2.01	2.01
Min. Return target met (%)	98%	100%
Confidence (%)	95%	95%

Strategy Performance in Recent Calendar Years



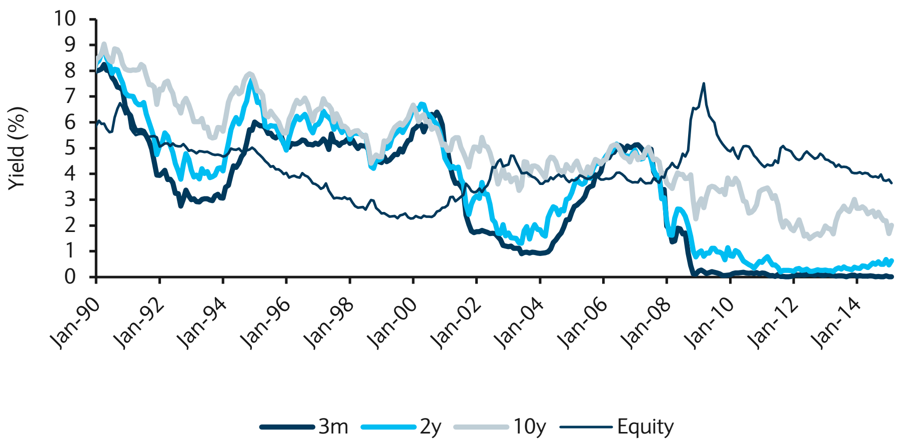
- Over longer term, including a small equity allocation gives a small increase to returns
- With equity, we did not breach our minimum return threshold; both backtested strategies stayed within specified confidence limit
- In recent years, inclusion of equity has roughly same effect that we saw in static allocation case:
    - Decreased portfolio performance in 2008
    - Moderate improvement in portfolio performance in each year since 2008

Source: Robert Shiller Data, Barclays Research

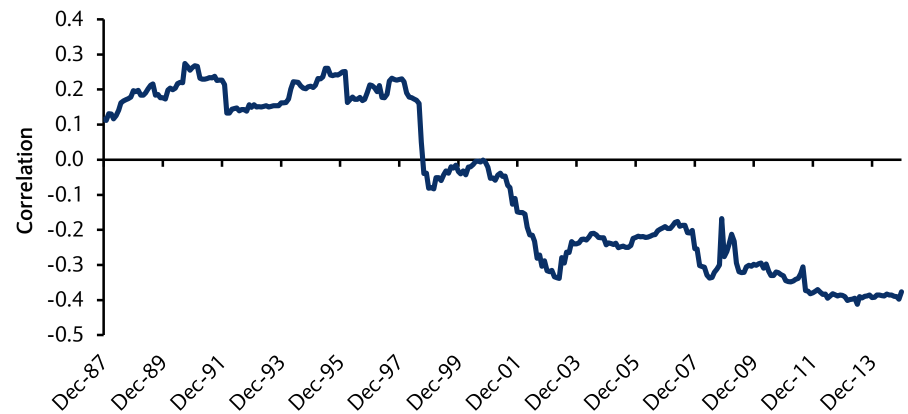
Exploring the Dynamic Drivers of Equity Allocation

Treasury and Equity Yield Levels and Return Correlations, Dec 1987 – Dec 2014

Equity Earnings Yield vs. Treasury Yields



Trailing Return Correlation of Equity and 10-Yr Treasury



- When Treasury yields exceed equity earnings yields, optimizer has little incentive to include equity
- Since 2008, cyclically adjusted earnings yield for equity looks attractive compared to Treasuries
- An additional argument for including some equity is as a diversification of Treasury risk, given the negative correlation between stocks and bonds that has held sway in the current regime.
- We plot the return correlation of Treasury 10yr bonds with equities, using monthly data and exponential weighting with a 3-year half-life.

Source: Robert Shiller Data, Barclays Research

Conclusions

- Every official institution has its own particular goals, needs, constraints, concerns
- The examples in this presentation can all be customized
- A conservative, risk-averse investment philosophy does not necessarily mean that equity has no place in the portfolio

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