BARCLAYS

Quantitative Portfolio Strategy
Research

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Update on Bespoke Portfolio Construction Tools

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QPS Bespoke Research

- QPS research projects are often prompted by client inquiry
- Bespoke research efforts can take different forms, depending on the project:
  - One-time delivery of long-term historical analysis (for which results are not expected to change very fast)
  - Development of management decision aids (tools) for recurring problems, in which results are likely to change over time due to:
    - Changes in asset mix
    - Changes in manager's subjective views
    - Changes in asset risk/return as reflected in market data
    - Changes in portfolio positions, constraints, investment policy
    - Projects of this type often involve technology transfer to client
- Analytical tools delivered to client can involve:
  - Customization of a previously developed tool to fit a particular client's needs
  - Development of a new tool to address a new problem

Four Examples of QPS Portfolio Construction Tools

- **Optimal Risk Budgeting with Skill (ORBS)**
  - Tactical asset allocation tool
  - Optimal allocation of risk budget to a manager's directional market views
  - Customized to reflect portfolio risk dimensions and constraints
- **"Try and hold" spreadsheet**
  - Estimation of long-horizon expected returns of credit assets
  - Expected losses from forced sales for different ratings, maturities, sell triggers
- **Macro-Level Maximum Likelihood Scenario Definition**
  - Allows high-level scenarios based on macro views
  - Uses maximum likelihood analysis to project scenario effects on all asset classes and multi-asset portfolio returns
- **Optimal FX Hedging of Asset Portfolios**
  - Helps investors find the best FX hedge for a multi-currency portfolio
  - Considers correlations between asset returns and FX returns

Optimal Risk Budgeting with Skill (ORBS)

Optimal Risk Budgeting with Skill (ORBS)

The ORBS model optimizes allocation of active risk based on directional investor views

- **ORBS** (Optimal Risk Budgeting with Skill) supports tactical allocation decisions
  - Allocating active risk optimally across active views
  - Converting risk allocation into asset allocation
  - Based on qualitatively defined investor views
- Implemented on a fully transparent bespoke basis
- Contains stand-alone risk model
- Actively used by a variety of large investors running long/short as well as long-only strategies

Traditional approach	ORBS
• The manager provides explicit forecasts of equity index levels, changes in interest rates, credit spreads, etc • Expected return for each asset is computed given these forecasts • Risk is computed using historical volatilities and correlations of assets	• Manager provides directional views only on those factors where she/he holds an opinion • Skill at making directional calls is used to generate expected returns of strategies • Multi-factor risk model defines correlation structure between the payoffs of individual strategies

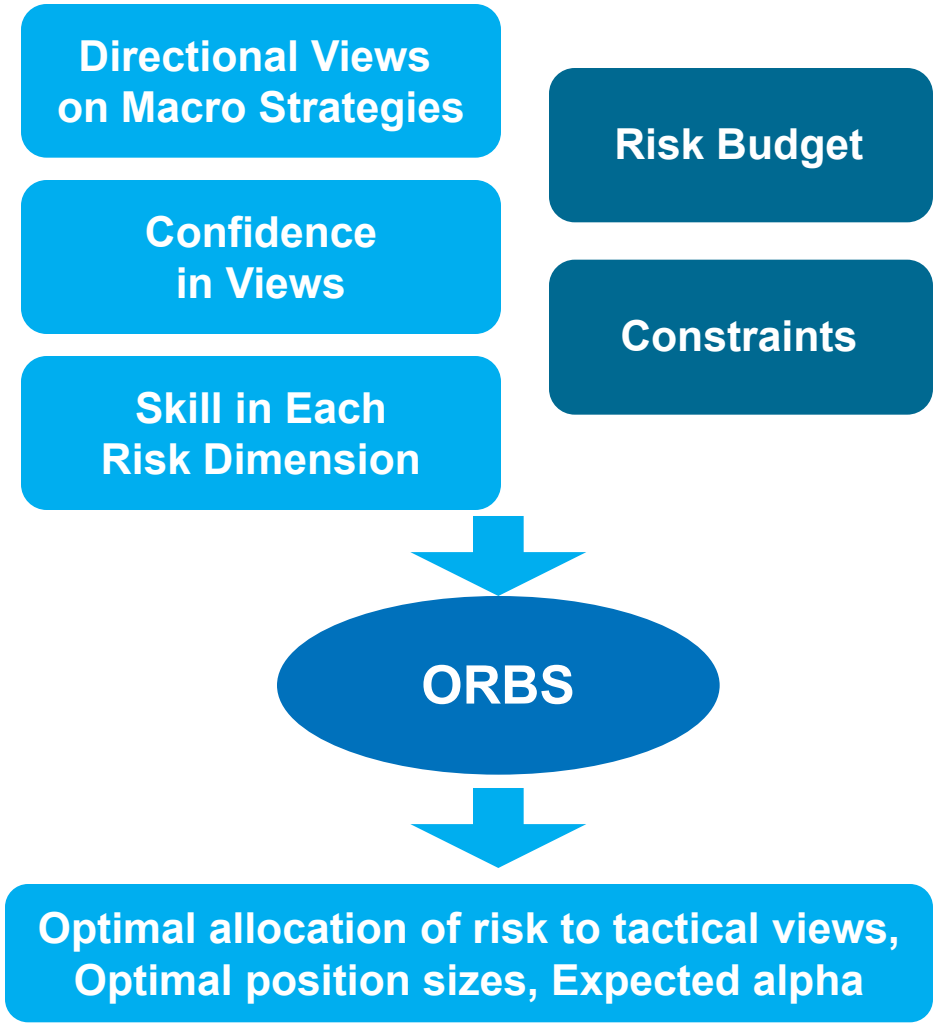
The ORBS Design Process

A bespoke tool for tactical allocation according to directional views

- Identify key strategies typically considered by the manager
- For each strategy:
  - What are relevant risk factors and metrics of exposure?
  - How is the view typically implemented? (Funding requirement)
  - Any explicit position risk limits?
  - Is it an outright view or a relative view?
- What is the portfolio risk budget? What additional constraints must be met? Consider turnover?
- Once specifications are approved by the investor, QPS begins implementation
- Upon completion, the application is delivered to the investor as an Excel spreadsheet

ORBS Applications

ORBS can help address many aspects of the portfolio management process



- The primary use of the ORBS application is tactical allocation:
  - Specify active views, skills and constraints
  - Find optimal allocation, expected performance, etc.
- By changing the inputs and observing the outputs, we can answer many more questions:
  - What is the performance cost of various funding or exposure constraints?
  - How much can performance be improved by adding an additional strategy dimension?
  - How much return can be expected given a risk budget and a set of constraints?
  - How do the results change when we change the calibration of the internal risk model?
- ORBS has been used in many different setting, eg:
  - Active management of absolute returns of benchmarked portfolios
  - Managing an absolute active return overlay (global macro strategies) covering fixed income, equity, FX

Source: Barclays Research

The Model Underlying ORBS

The concept of information ratio helps relate Alpha to Active Risk and Skill

- In *Active Portfolio Management* (1999, McGraw-Hill), Grinold and Kahn define the "fundamental law of active management" and postulate a linear relationship between skill (IC) and information ratio $IR \approx IC \cdot \sqrt{BR}$
  - The "information coefficient" (IC) is defined as the correlation between forecast and realized returns
  - The "breadth" (BR) of a strategy is defined as the number of independent decisions taken a year. For example, strategies that make a single decision each month have BR = 12
    - And we should expect information ratio to equal $skill \cdot \sqrt{12}$
- In various empirical "imperfect foresight" studies in fixed income markets, we found performance to depend on the number of independent decisions in a strategy and found a linear relationship between skill and information ratio. See a.o.
  - *Value of Security Selection vs Asset Allocation in Credit Markets – An Imperfect Foresight Study,* L. Dynkin and J. Hyman, June 2000
  - *Value of Skill in Macro Strategies for Global Fixed Income Investing*, L. Dynkin and J. Hyman, February 2010
- This leads us to express the return of a strategy as a function of active risk, skill and breadth

$$IR = \frac{\alpha}{TE} \Rightarrow \alpha \approx TE \cdot SKILL \cdot \sqrt{BREADTH}$$

Example ORBS Implementation

Selecting Strategies and Defining Views

In this example, the user defines risk budget, directional views, horizon, skill, allocation constraints for a menu of macro strategies in a "control" sheet

Active Strategies

Asset Class	Strategy	View	Horizon (month)	Skill
Equities	MSCI US	Neutral	1m	10%
Equities	MSCI EMU	Neutral	1m	10%
Equities	MSCI JP	Neutral	1m	10%
Equities	MSCI UK	Neutral	1m	10%
Duration	UST vs EUT	Bearish	1m	10%
Duration	JPT	Neutral	1m	10%
Duration	UKT	Neutral	1m	10%
Curve	UST 1-3 vs UST 7-10	Neutral	1m	10%
Curve	EUT 1-3 vs EUT 7-10	Bullish	1m	10%
Curve	JPT 1-3 vs JPT 7-10	Neutral	1m	10%
Curve	UKT 1-3 vs UKT 10+	Neutral	1m	10%
BE inflation	US CPI BE	Neutral	1m	10%
BE inflation	UK RPI BE	Bullish	1m	10%
BE inflation	US CPI BE vs EMU HICP BE	Neutral	1m	10%
Credit	Global IG Credit	Weak Bullish	1m	10%
Credit	US CORP HY vs EUR CORP HY	Neutral	1m	10%
Commodity	Energy vs Prec Metals	Neutral	1m	10%
Custom	G4 Treasuries	Neutral	1m	10%
Custom	Global Credit	Neutral	1m	10%
Custom	G3 Equities	Neutral	1m	10%

Risk Budget (%/yr)	0.5
Adjust IR	Yes
Ignore Benchmark	Yes

Optimize | Set All to Neutral | Restore Default

Strategic Benchmark and Allocation Constraints

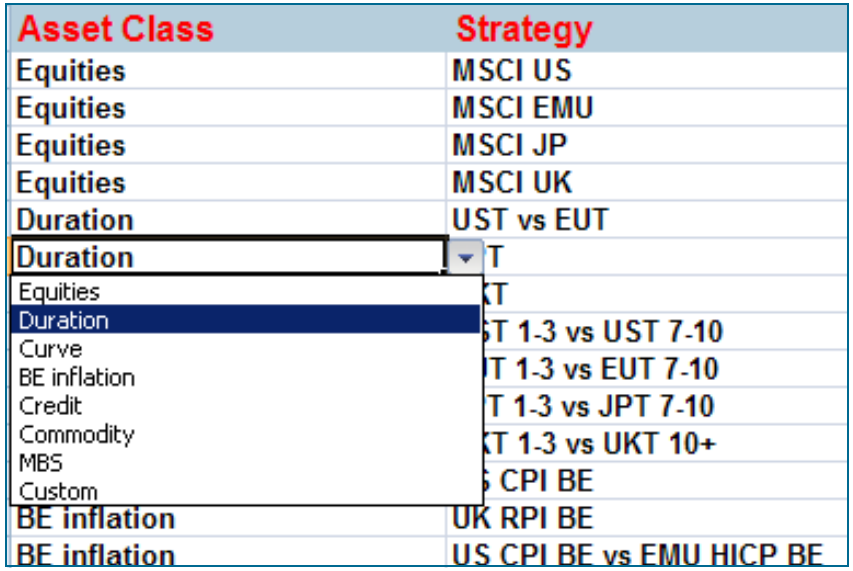
Asset	Benchmark	Min	Max	Net
CASH	0.0%	-25%	25%	-19.0%
MSCI US	20.0%	-25%	25%	0.0%
MSCI EMU	10.0%	-25%	25%	0.0%
MSCI JP	5.0%	-25%	25%	0.0%
MSCI UK	5.0%	-25%	25%	0.0%
MSCI EM	3.0%	-25%	25%	0.0%
UST 1-3	5.9%	-25%	25%	-2.6%
UST 3-7	5.7%	-25%	25%	-2.5%
UST 7-10	1.6%	-25%	25%	-0.6%
UST 10+	1.9%	-25%	25%	-0.8%
EUT 1-3	2.0%	-25%	25%	21.9%
EUT 3-7	1.9%	-25%	25%	1.6%
EUT 7-10	0.5%	-25%	25%	-4.2%
EUT 10+	0.6%	-25%	25%	1.3%
JPT 1-3	1.6%	-25%	25%	0.0%
JPT 3-7	1.5%	-25%	25%	0.0%
JPT 7-10	0.4%	-25%	25%	0.0%
JPT 10+	0.5%	-25%	25%	0.0%
UKT 1-3	1.2%	-25%	25%	0.0%
UKT 3-7	1.1%	-25%	25%	0.0%
UKT 7-10	0.3%	-25%	25%	0.0%
UKT 10+	0.4%	-25%	25%	0.0%
EM SOV	0.0%	-25%	25%	0.0%
EM LOC	0.0%	-25%	25%	0.0%
US CPI BE	5.0%	-25%	25%	0.0%
EMU HICP BE	5.0%	-25%	25%	0.0%
UK RPI BE	0.0%	-25%	25%	3.0%
Japan CPI BE	0.0%	-25%	25%	0.0%
US CORP IG	10.0%	-25%	100%	0.7%
US CORP HY	0.0%	-25%	100%	0.0%
EUR CORP IG	5.0%	-25%	100%	1.2%
EUR CORP HY	0.0%	-25%	100%	0.0%
EM CORP	0.0%	-25%	25%	0.0%
Energy	3.0%	-25%	25%	0.0%
Ind Metals	0.0%	-25%	25%	0.0%
Agriculture	0.0%	-25%	25%	0.0%
Prec Metals	2.0%	-25%	25%	0.0%
US MBS	0.0%	-25%	25%	0.0%
Total	100%			0.0%

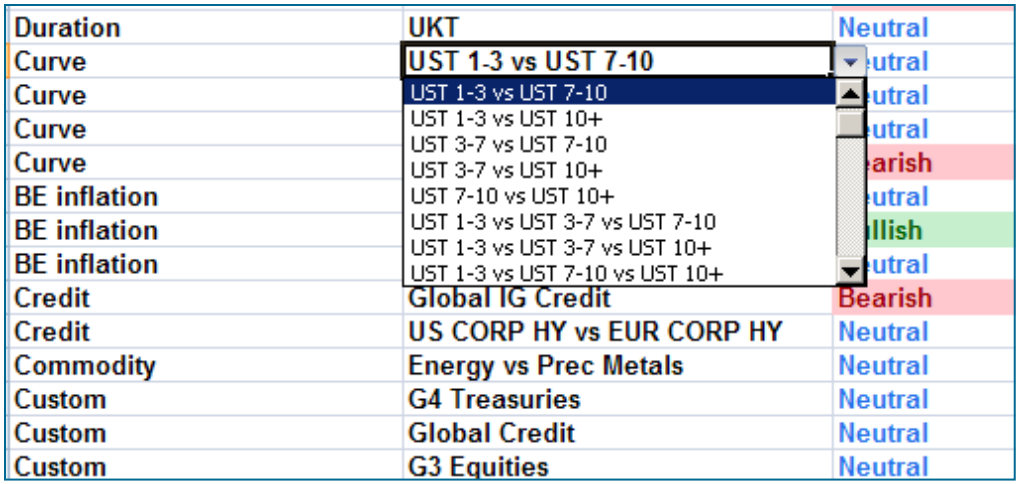
Source: Barclays Research

Selecting Active Strategies

The Controls sheet provides a menu of strategies

- In this example, the control sheet allows the user to select up to 20 active strategies in a two-step process:
  - Select strategy group
  - Select actual strategy
- The full set of available strategies can be very large
- All strategies are defined in terms of
  - Risk factor loadings
  - Cash consumption
- The ORBS optimization is performed on the selected set of strategies
- The optimization parameters (incl. covariances, constraints) are updated dynamically according to the selection of strategies





Source: Barclays Research

Define Active Views and Risk Budget

In this example, active strategies cover eight broad categories: equities, duration, curve, break-even inflation, credit spreads, commodity, MBS, and custom (incl. cross asset strategies)

Active Strategies

Asset Class	Strategy	View	Horizon (month)	Skill
Equities	MSCI US	Neutral	1m	10%
Equities	MSCI EMU	Neutral	1m	10%
Equities	MSCI JP	Neutral	1m	10%
Equities	MSCI UK	Neutral	1m	10%
Duration	UST vs EUT	Bearish	1m	10%
Duration	JPT	Neutral	1m	10%
Duration	UKT	Neutral	1m	10%
Curve	UST 1-3 vs UST 7-10	Neutral	1m	10%
Curve	EUT 1-3 vs EUT 7-10	Bullish	1m	10%
Curve	JPT 1-3 vs JPT 7-10	Neutral	1m	10%
Curve	UKT 1-3 vs UKT 10+	Neutral	1m	10%
BE inflation	US CPI BE	Neutral	1m	10%
BE inflation	UK RPI BE	Bullish	1m	10%
BE inflation	US CPI BE vs EMU HICP BE	Neutral	1m	10%
Credit	Global IG Credit	Weak Bullish	1m	10%
Credit	US CORP HY vs EUR CORP HY		1m	10%
Commodity	Energy vs Prec Metals		1m	10%
Custom	G4 Treasuries		1m	10%
Custom	Global Credit		1m	10%
Custom	G3 Equities	Neutral	1m	10%

Bullish
Weak Bullish
Neutral
Weak Bearish
Bearish

Risk Budget (%/yr)	0.5
Adjust IR	Yes
Ignore Benchmark	Yes

Optimize | Set All to Neutral | Restore Default

- The user can select from a flexible menu of directional or relative value strategies:
  - Bullish / weakly bullish (overweight)
  - Neutral (strategy is not used)
  - Bearish / weakly bearish (underweight)
- Each strategy is assigned an expected inform. ratio based on skill and horizon
  - Strategies can be specified on 1, 3, 6, and 12 month horizons
  - Skill is investor's probability to be right minus probability to be wrong in a directional call
- Overall portfolio risk budget specified as annualized volatility of active returns
- Information ratio adjustment helps reconcile conflicting views*

Source: Barclays Research

* - see "Managing Conflicting Views in Asset Allocation Decisions", Barclays Research

Define a Strategic Benchmark and Allocation Constraints

In this example, the user can define a strategic benchmark and allocation limits

- Active allocation can be relative to a selected benchmark or run as an absolute return mandate
- The user can enter benchmark weights for individual asset classes
- The user can specify allocation constraints as maximum active underweights and overweights
- Constraints can be specified relative to the benchmark and/or on the absolute net position

Strategic Benchmark and Allocation Constraints

Asset	Benchmark	Min	Max	Net
CASH	0.0%	-25%	25%	-19.0%
MSCI US	20.0%	-25%	25%	0.0%
MSCI EMU	10.0%	-25%	25%	0.0%
MSCI JP	5.0%	-25%	25%	0.0%
MSCI UK	5.0%	-25%	25%	0.0%
MSCI EM	3.0%	-25%	25%	0.0%
UST 1-3	5.9%	-25%	25%	-2.6%
UST 3-7	5.7%	-25%	25%	-2.5%
UST 7-10	1.6%	-25%	25%	-0.6%
UST 10+	1.9%	-25%	25%	-0.8%
EUT 1-3	2.0%	-25%	25%	21.9%
EUT 3-7	1.9%	-25%	25%	1.6%
EUT 7-10	0.5%	-25%	25%	-4.2%

Source: Barclays Research

Flexibility in Risk Calibration

Provides flexibility in calculating the factor covariance matrix by excluding individual observations, selecting various sample periods, and choosing different weighting schemes

Equal Weighting or Time Decay

Include all data or exclude specific months

Speed of Time Decay

Choose time period

Covariance Weighting

Time Decay

Include Data

All

Half-Life (month)

36 months

Restore Default Options

Beginning Date

199901

Ending Date:

201305

	Customized Covariance Matrix			
	Special 1	Special 2	Special 3	Used
Total size:	170	168	173	173
199901	1	1	1	1
199902	1	1	1	1
199903	1	0	1	1
199904	1	1	1	1
199905	1	1	1	1
199906	1	1	1	1
199907	1	1	1	1
199908	1	1	1	1
199909	1	1	1	1
199910	1	1	1	1
199911	1	1	1	1
199912	1	1	1	1
200001	1	1	1	1

Source: Barclays Research

Output: Projected Performance and Calibration Details

The output sheet displays portfolio projected performance

- Portfolio statistics include risk budget (allowed and consumed) expected alpha, and expected portfolio information ratio
- Optimization status is reported at the bottom of the summary table

Expected Active Risk and Alpha	
TE Budget (%/yr)	0.50
Total Portfolio TE (%/yr)	0.50
Total Portfolio Alpha (%/yr)	0.25
Information Ratio	0.49
Covariance matrix details:	
Method	Time Decay
Half Life (m)	36
Beginning Date	199901
Ending Date	201305
No of Months	173
Optimization Status	OK

Solver found a solution. All constraints and optimality conditions are satisfied.

- Risk model calibration details are provided in the portfolio optimization summary as well:
  - How are historical risk factor data weighted when calculating covariances: equally or using time decay?
  - In case of time decay, what is the half-life (in months)?
  - Starting date of the calibration sample
  - Ending date of the calibration sample
  - Number of observations in the calibration sample

Source: Barclays Research

Output: Optimal Risk Allocation

Report optimal allocation of risk and alpha across active strategies

- In this example, the risk allocation report includes:
  - Investor's views (direction)
  - ORBS active positions (direction)
  - Projected individual strategy information ratios
  - Isolated volatilities of individual strategies
  - Alpha contributions of individual strategies
  - % strategy risk contributions (% of portfolio variance attributed to individual strategies)
  - % strategy alpha contributions (% of portfolio alpha attributed to individual strategies)

Detailed Allocation of Systematic Risk and Alpha Across Strategies

Strategy	Investor View	ORBS Position	Expected Information Ratio	Isolated TEV (%/yr)	Alpha Contribution (%/yr)	Risk Contribution (% of total risk)	Alpha Contribution (% of total alpha)
UST vs EUT	Bearish	Short	0.33	0.24	0.08	32%	32%
EUT 1-3 vs EUT 7-10	Bullish	Long	0.31	0.24	0.08	30%	30%
UK RPI BE	Bullish	Long	0.32	0.25	0.08	32%	32%
Global IG Credit	Weak Bullish	Long	0.11	0.06	0.01	5%	5%

Source: Barclays Research

Output: Active Exposures and Allocations

Report active portfolio exposures to risk factors and corresponding allocations across market sectors

- In this example, we report active exposures to systematic risk factors
  - Exposure units can be measured in terms of
  - % Market Value for equities, commodities, and local currency EM
  - Years of duration for duration and curve views
  - Duration times spread (DTS) units for credit and sovereign spread views
- The table 'Summary Active Allocations' reports net active allocation in % market value
- Benchmark and final portfolio allocations for the asset classes affected by the tactical overlay are also reported

EXPOSURES

Summary Active Exposures

Factor	Unit	Index Exposure	Net Active Exposures	Isolated Risk, %/yr	% Risk Contrib
UST 1-3	OAD	1.9	-0.049	4%	3%
UST 3-7	OAD	4.5	-0.112	10%	12%
UST 7-10	OAD	7.9	-0.051	5%	6%
UST 10+	OAD	16.6	-0.128	12%	15%
EUT 1-3	OAD	1.9	0.410	39%	26%
EUT 3-7	OAD	4.4	0.073	6%	1%
EUT 7-10	OAD	7.5	-0.316	25%	5%
EUT 10+	OAD	13.2	0.173	12%	-4%
UK RPI BE	OASD	18.5	0.549	25%	32%
US CORP IG	DTS	10.5	0.074	3%	2%
EUR CORP IG	DTS	6.4	0.074	3%	3%

ALLOCATIONS

Summary Active Allocations

Assets	Net Active Allocations (%MV)
CASH	-19.0%
UST 1-3	-2.6%
UST 3-7	-2.5%
UST 7-10	-0.6%
UST 10+	-0.8%
EUT 1-3	21.9%
EUT 3-7	1.6%
EUT 7-10	-4.2%
EUT 10+	1.3%
UK RPI BE	**3.0%**
US CORP IG	0.7%
EUR CORP IG	1.2%

Source: Barclays Research

Defining Active Strategies

Strategies are defined in terms of exposures to systematic risk factors

- Strategies in different asset classes have different exposure units, e.g. :
- Long US equities:
  - exposure is measured in % MV;
  - risk is represented by the volatility of total returns of the MSCI US index (in this example)
- Long US treasuries:
  - exposure is measured in years of duration
  - risk is represented by the volatility of total returns of Barclays US Treasury Index (by maturity buckets) normalized by duration

									UST 1-3	UST 3-7	UST 7-10	UST 10+	EUT 1-3
							37	Strategy Name					
Strat ID	Exposure Units	Exposure	LHS	MID	RHS	Not per Exp Unit	Unit Notional	Exposure Units	OAD	OAD	OAD	OAD	OAD
16	OAD	1	UST			0.19	18.7%	UST	0.14	0.32	0.15	0.39	0.00
17	OAD	1	EUT			0.15	15.3%	EUT	0.00	0.00	0.00	0.00	0.07
18	OAD	1	JPT			0.13	12.6%	JPT	0.00	0.00	0.00	0.00	0.00
19	OAD	1	UKT			0.11	10.6%	UKT	0.00	0.00	0.00	0.00	0.00
20	OAD	1	UST		EUT	0.19	18.7%	UST vs EUT	0.14	0.32	0.15	0.39	-0.07
21	OAD	1	UST		JPT	0.19	18.7%	UST vs JPT	0.14	0.32	0.15	0.39	0.00
22	OAD	1	UST		UKT	0.19	18.7%	UST vs UKT	0.14	0.32	0.15	0.39	0.00
23	OAD	1	EUT		JPT	0.15	15.3%	EUT vs JPT	0.00	0.00	0.00	0.00	0.07
24	OAD	1	EUT		UKT	0.15	15.3%	EUT vs UKT	0.00	0.00	0.00	0.00	0.07
25	OAD	1	JPT		UKT	0.13	12.6%	JPT vs UKT	0.00	0.00	0.00	0.00	0.00
26	OAD	1	UST 1-3		UST 3-7	0.52	51.8%	UST 1-3 vs UST 3-7	1.00	-1.00	0.00	0.00	0.00
27	OAD	1	UST 1-3		UST 7-10	0.52	51.8%	UST 1-3 vs UST 7-10	1.00	0.00	-1.00	0.00	0.00
28	OAD	1	UST 1-3		UST 10+	0.52	51.8%	UST 1-3 vs UST 10+	1.00	0.00	0.00	-1.00	0.00

Source: Barclays Research

Defining Active Strategies – Funding Requirements

Strategies cash consumptions are defined consistently with risk exposures

- The cash consumption of individual strategies reflects
  - Strategy risk exposures such as unit of duration allocated to various part of the curve
  - Current market structure e.g. how much funding is required per unit of duration or of DTS
  - Implementation choices: cash vs. futures or swaps

		Strategy Name	CASH	UST 1-3	UST 3-7	UST 7-10	UST 10+	EUT 1-3	EUT 3-7	EUT 7-10	EUT 10+	JPT 1-3
Strat ID	Strategy Funding	Exposure Units	MV	MV	MV	MV	MV	MV	MV	MV	MV	MV
16	CASH	UST	-19.0%	7.6%	7.2%	1.9%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%
17	CASH	EUT	-15.2%	0.0%	0.0%	0.0%	0.0%	3.7%	4.8%	2.8%	3.8%	0.0%
18	CASH	JPT	-12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.9%
19	CASH	UKT	-10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20	CASH	UST vs EUT	-3.9%	7.6%	7.2%	1.9%	2.3%	-3.7%	-4.8%	-2.8%	-3.8%	0.0%
21	CASH	UST vs JPT	-6.5%	7.6%	7.2%	1.9%	2.3%	0.0%	0.0%	0.0%	0.0%	-2.9%
22	CASH	UST vs UKT	-8.8%	7.6%	7.2%	1.9%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%
23	CASH	EUT vs JPT	-2.7%	0.0%	0.0%	0.0%	0.0%	3.7%	4.8%	2.8%	3.8%	-2.9%
24	CASH	EUT vs UKT	-5.0%	0.0%	0.0%	0.0%	0.0%	3.7%	4.8%	2.8%	3.8%	0.0%
25	CASH	JPT vs UKT	-2.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.9%
26	CASH	UST 1-3 vs UST 3-7	-30.6%	52.6%	-22.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
27	CASH	UST 1-3 vs UST 7-10	-39.9%	52.6%	0.0%	-12.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
28	CASH	UST 1-3 vs UST 10+	-46.6%	52.6%	0.0%	0.0%	-6.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: Barclays Research

“Try and Hold” Estimation of Long-Horizon Credit Returns

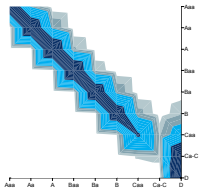
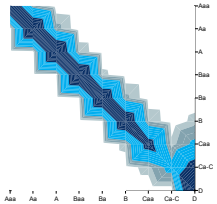
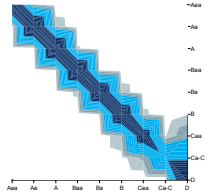
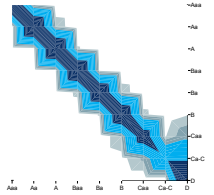
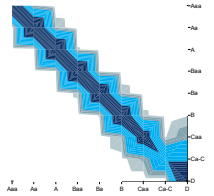
Estimating Long-Horizon Returns of Corporate Bonds

- Factors to consider:
  - Current spread levels
  - Likely changes to current spreads
  - Expected losses due to downgrades and defaults
- Historically, realized long-term excess returns of corporate index have been much less than average spreads – largely due to forced selling of downgraded bonds
- Conditioning on current spreads:
  - A higher spread environment promises greater excess returns
  - BUT … higher spreads have been linked to increased downgrade rates
- Our “Try and Hold” model provides a methodology for projecting expected returns of credit asset classes
- An interactive tool opens up this calculation and allows users to set all parameters according to their investment policy and preferred set of assumptions

Conditioning on Current Spread Environment

- At any given point in time, however, the spread environment is different:
  - Carry is estimated from current spread levels
  - Downgrade penalties can be estimated from current spread differentials
  - How should probabilities of defaults/downgrades (transition matrix) be adjusted when spreads are high (low) relative to long-term averages?
  - How far into the future can we project based on current spread levels?

Conditioning the “Try-and-Hold” Model on Current Spreads

Year	Downgrade Multiplier	
1	200%	
2	141%	
3	126%	
4	119%	
5	115%	

- A high spread environment
- Current spread differentials will determine the severity of loss upon forced sales
- When spreads are high, downgrade frequencies are increased for the first year by a multiplier
- Different multipliers are used in different years, such that the transition matrix reverts to the long-term one
- The spread environment is also assumed to revert to mean long-term levels
- Shown here: mean reversion with a half life of one year

Source: Barclays Research

Inputs to ‘Try & Hold’ model

- Data:
  - Long term ratings transition matrix (e.g. from Moody’s)
  - Current and long term spreads, by rating and maturity (2y, 5y and 10y)
- Assumptions:
  - Ratings-driven sell trigger (e.g. Sell at downgrade to Ba or lower)
  - Spread mean-reversion half life (currently calibrated to 1.3 years from a log spread process using annual data)
  - Transition factor – models dependence of downgrade rate on spread
    - Transition factor currently calibrated as 0.7 => If spreads are 2x long term then downgrades are 0.7 * 2 + 0.3 = 1.7x long-term average
  - Re-invest proceeds?
    - Yes => Cash from selling bond re-invested into bond of original rating and remaining maturity
    - No => Sold bonds cease to earn return => downgrades cause greater losses

Try & Hold tool screenshot – Inputs

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TRY AND HOLD CREDIT INVESTING MODEL

All user input cells are shaded in blue =>

PARAMETERS		COMMENTS
Spread data	Historical	Historical or user defined (input user defined spreads in sheet 'Spreads'
Analysis Date (for Spreads) : yyyymm	201602	
Horizon (yrs)	5	Maximum of 10 years
Bond Maturity (yrs)	5	Maximum of 10 years (integer inputs)
Sell Rule	Ba	
Spread half life	1.3	Half life for the logarithm of spread reverting to long term spreads
Transition factor	0.7	Multiplier for adjusting downgrade ratio using the spread ratio
Re-Invest proceeds from bonds sales?	Yes	

If Maturity < Horizon => Assumes re-investment in original maturity & rating bond (at prevailing spread)

Source: Barclays Research

Try & Hold tool screenshot – Main Output Table

- Main model output section: contains one full set of output calculations for each rating:
  - Cumulative probability of forced sale (due to downgrade) and default over horizon
  - Expected losses from forced sales and defaults
  - Total expected excess returns to horizon (cumulative and annualized)

ANALYSIS

	SPREADS		PROBABILITY		LOSSES			EXPECTED RETURNS		
Rating	**Spreads- Current**	**Spreads - LT**	**P (Sell)**	**P (Default)**	**Loss : Sold**	**Loss : Default**	**Total Losses**	**Expected Cumul. Carry**	**Expected Cumul. Exc. Ret.**	**Annualized Exc. Return**
Aaa	55	69	0.72%	0.09%	-0.06%	-0.05%	-0.11%	2.74%	2.63%	0.53%
Aa	99	90	2.72%	0.45%	-0.26%	-0.27%	-0.53%	4.93%	4.40%	0.88%
A	127	122	8.09%	0.66%	-0.76%	-0.40%	-1.16%	6.22%	5.06%	1.01%
Baa	235	177	31.19%	1.50%	-2.55%	-0.90%	-3.45%	10.91%	7.46%	1.49%
Ba	468	355	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
B	724	543	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Caa	1,500	939	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ca-C	6,014	2,406	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
IG	175	135								

Source: Barclays Research

Try & Hold tool screenshot – Sensitivity Analysis

- How do results vary by horizon?
- For a selected initial maturity, this table shows how results vary by horizon
- Just a single output field is reported at a time; a pulldown menu chooses which one

Select Maturity

Select Output Field

HORIZON ANALYSIS

Bond maturity ***5***

Annualized Return over various horizons for a bond of maturity 5 yrs

Annualized Return <= Can report a variety of fields

	Initial Rating =>			
Horizon (yrs)	***Aaa***	***Aa***	***A***	***Baa***
1	0.54%	0.87%	0.95%	0.92%
2	0.53%	0.87%	0.95%	1.13%
3	0.53%	0.87%	0.97%	1.28%
4	0.53%	0.87%	0.99%	1.40%
5	0.53%	0.88%	1.01%	1.49%
6	0.55%	0.87%	1.01%	1.36%
7	0.57%	0.86%	1.00%	1.30%
8	0.58%	0.85%	1.00%	1.27%
9	0.58%	0.84%	1.00%	1.27%
10	0.59%	0.84%	1.01%	1.28%

Source: Barclays Research

Try & Hold tool screenshot – Sensitivity Analysis

- Output when varying either bond maturity, analysis horizon or downgrade threshold

HORIZON ANALYSIS

Bond maturity	5

Annualized Return over various horizons for a bond of maturity 5 yrs

Annualized Return <= Can report a variety of fields

	Initial Rating =>							
Horizon (yrs)	*Aaa*	*Aa*	*A*	*Baa*	*Ba*	*B*	*Caa*	*Ca-C*
1	0.54%	0.87%	0.95%	0.92%	0.00%	0.00%	0.00%	0.00%
2	0.53%	0.87%	0.95%	1.13%	0.00%	0.00%	0.00%	0.00%
3	0.53%	0.87%	0.97%	1.28%	0.00%	0.00%	0.00%	0.00%
4	0.53%	0.87%	0.99%	1.40%	0.00%	0.00%	0.00%	0.00%
5	0.53%	0.88%	1.01%	1.49%	0.00%	0.00%	0.00%	0.00%
6	0.55%	0.87%	1.01%	1.36%	0.00%	0.00%	0.00%	0.00%
7	0.57%	0.86%	1.00%	1.30%	0.00%	0.00%	0.00%	0.00%
8	0.58%	0.85%	1.00%	1.27%	0.00%	0.00%	0.00%	0.00%
9	0.58%	0.84%	1.00%	1.27%	0.00%	0.00%	0.00%	0.00%
10	0.59%	0.84%	1.01%	1.28%	0.00%	0.00%	0.00%	0.00%

Vary Horizon

MATURITY ANALYSIS

Horizon (yrs)	5

Annualized Return for bonds of various maturities over a horizon of 5 yrs

Annualized Return <= Can report a variety of fields

	Initial Rating =>							
Maturity (yrs)	*Aaa*	*Aa*	*A*	*Baa*	*Ba*	*B*	*Caa*	*Ca-C*
1	0.46%	0.68%	0.95%	1.35%	0.00%	0.00%	0.00%	0.00%
2	0.44%	0.67%	0.91%	1.23%	0.00%	0.00%	0.00%	0.00%
3	0.47%	0.74%	0.94%	1.25%	0.00%	0.00%	0.00%	0.00%
4	0.50%	0.81%	0.97%	1.30%	0.00%	0.00%	0.00%	0.00%
5	0.53%	0.88%	1.01%	1.49%	0.00%	0.00%	0.00%	0.00%
6	0.57%	0.90%	1.01%	1.39%	0.00%	0.00%	0.00%	0.00%
7	0.61%	0.92%	1.01%	1.30%	0.00%	0.00%	0.00%	0.00%
8	0.65%	0.93%	1.01%	1.23%	0.00%	0.00%	0.00%	0.00%
9	0.69%	0.96%	1.02%	1.17%	0.00%	0.00%	0.00%	0.00%
10	0.73%	0.98%	1.04%	1.13%	0.00%	0.00%	0.00%	0.00%

Vary Maturity

DOWNGRADE THRESHOLD

Horizon (yrs)	5
Maturity (yrs)	5

Annualized Return for bonds of maturity 5 yrs using various sell threshold over a horizon of 5 yrs

Annualized Return <= Can report a variety of fields

	Initial Rating =>							
Sell threshold	*Aaa*	*Aa*	*A*	*Baa*	*Ba*	*B*	*Caa*	*Ca-C*
Aa	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
A	0.49%	0.77%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Baa	0.52%	0.85%	0.91%	0.00%	0.00%	0.00%	0.00%	0.00%
Ba	0.53%	0.88%	1.01%	1.49%	0.00%	0.00%	0.00%	0.00%
B	0.53%	0.91%	1.09%	1.81%	2.77%	0.00%	0.00%	0.00%
Caa	0.53%	0.92%	1.12%	1.93%	3.07%	2.62%	0.00%	0.00%
Ca-C	0.54%	0.92%	1.14%	1.98%	3.24%	3.32%	3.32%	0.00%
Default	0.54%	0.92%	1.14%	1.99%	3.30%	3.60%	4.76%	22.14%

Vary Sell Threshold

Source: Barclays Research

Scenario Analysis Tool

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Motivation

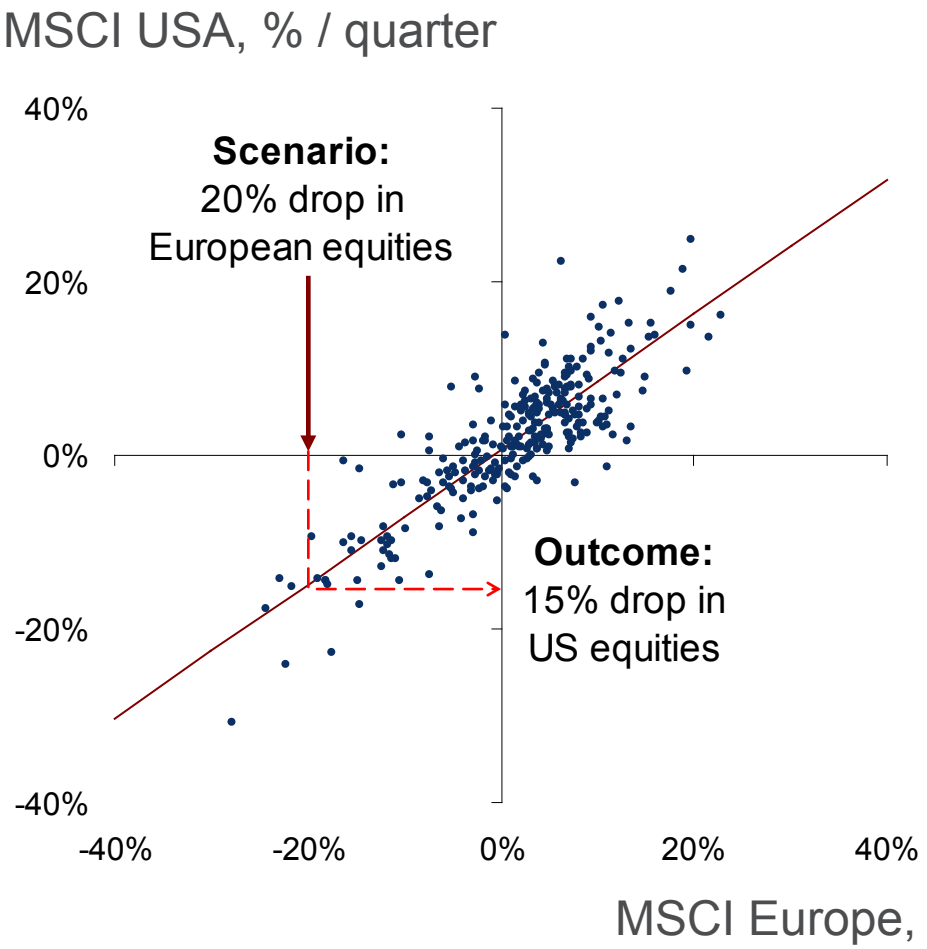
Scenario analysis is a useful tool to complement portfolio risk management

- Scenario analysis usually relies on a few discretionary forecasts
- Historical data help propagate these forecasts to a variety of market factors and provide consistent return projections across a broad investment universe
- We provide a tool that allows:
  - Flexible selection of which asset classes to include in the analysis
  - Ability to specify a scenario in terms of a few selected assets
  - Maximum likelihood analysis is used to extend scenario to all assets
  - Flexibility in determining what data are used to form covariance matrix

Scenario Analysis – Maximum Likelihood Approach

Maximum Likelihood method helps to propagate a partially specified scenario to a broad asset universe

Return Scenario for European Equities Translated into Return for US Equities



- Scenario: -20% return on European equities
- Beta of US equities: 78%
- Use to project US equity expected return
- Similar to OLS regression

Ret US = Const + Beta x Scen Ret EU

- Scenario return of US equities: -15%
- Estimation Period: Jan 1988 to Dec 2011

Source: Barclays Research, Bloomberg

Main screen – Define and propagate scenarios

Selected Scenarios factors	Scenario Units	Factor Category	Factor Volatility (%/yr)	Include?	Scenario Definition (Input)	Propagated Scenario	No Ann Standard Deviations
Gold	TR	Commodity	17.29	0	0.0	4.65	0.27
Base metals	TR	Commodity	14.31	0	0.0	-3.00	-0.21
Copper	TR	Commodity	17.92	0	0.0	-7.41	-0.41
Oil	TR	Commodity	34.85	0	0.0	-27.43	-0.79
US IG	OAS change	CDS Index Spread	42.57	0	0.0	38.65	0.91
Europe IG	OAS change	CDS Index Spread	48.09	0	0.0	38.90	0.81
China equities	TR	Equity	31.60	0	0.0	-26.89	-0.85
UK FTSE	TR	Equity	10.90	0	0.0	-4.27	-0.39
KOSPI	TR	Equity	11.95	0	0.0	-7.38	-0.62
EuroStoxx	TR	Equity	17.94	0	0.0	-8.13	-0.45
DAX	TR	Equity	21.37	0	0.0	-11.22	-0.52
TOPIX	TR	Equity	20.90	0	0.0	-15.26	-0.73
S&P	TR	Equity	14.12	0	0.0	-11.88	-0.84
EURUSD	TR	FX	9.56	0	0.0	-6.37	-0.67
GBPUSD	TR	FX	8.19	1	-10.0	-10.00	-1.22
JPYUSD	TR	FX	10.08	0	0.0	1.87	0.19
CADUSD	TR	FX	10.25	0	0.0	-7.28	-0.71
CHFUSD	TR	FX	9.72	0	0.0	-3.64	-0.37
GBP 10Y	Yield change	Treasury yield	0.76	0	0.0	-0.69	-0.90
EUR 10Y	Yield change	Treasury yield	0.56	0	0.0	-0.34	-0.60
JPY 10Y	Yield change	Treasury yield	0.24	0	0.0	-0.16	-0.66
USD 10y	Yield change	Treasury yield	0.68	0	0.0	-0.50	-0.73
FX vol	Vol change	FX volatility	3.24	0	0.0	2.80	0.86
EuroStoxx vol	Vol change	Equity volatility	21.35	0	0.0	11.45	0.54
Rates vol	Vol change	Rates volatility	33.09	0	0.0	20.28	0.61
VIX	Vol change	Equity volatility	19.22	0	0.0	11.41	0.59
EM equity	TR	Equity	21.72	0	0.0	-19.34	-0.89

Source: Barclays Research

Main screen – Control calibration of covariance matrix

Scenario Period
Recent Past

Include Data
All

Half-Life (month)
6 months

Restore Default Options

Beginning Date:
201001
Ending Date:
201603
+
+
Custom Date
201501

Sample size:
75

Customized Covariance Matrix

	Special 1	Special 2	Special 3	Weight
Total size:	195	195	195	9
200001	1	1	1	0.00000
200002	1	1	1	0.00000
200003	1	1	1	0.00000
200004	1	1	1	0.00000
200005	1	1	1	0.00000
200006	1	1	1	0.00000
200007	1	1	1	0.00000
200008	1	1	1	0.00000
200009	1	1	1	0.00000
200010	1	1	1	0.00000
200011	1	1	1	0.00000
200012	1	1	1	0.00000
200101	1	1	1	0.00000
200102	1	1	1	0.00000
200103	1	1	1	0.00000
200104	1	1	1	0.00000
200105	1	1	1	0.00000
200106	1	1	1	0.00000
200107	1	1	1	0.00000
200108	1	1	1	0.00000
200109	1	1	1	0.00000
200110	1	1	1	0.00000

Source: Barclays Research

Optimal FX Hedging

FX Hedge Optimization: Questions Addressed

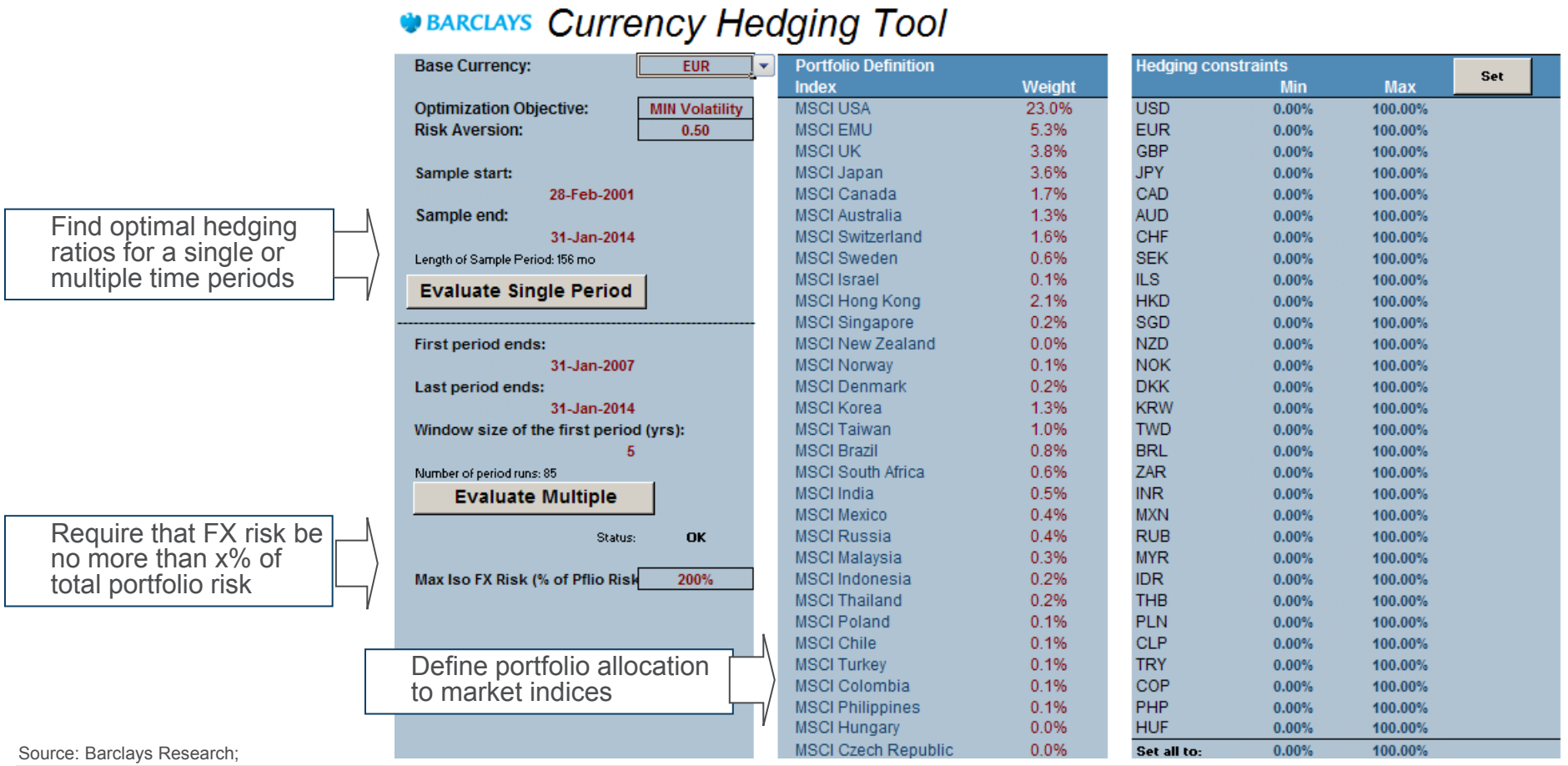
- For my multi-currency portfolio:
  - Should the FX exposure be unhedged? Fully hedged? Partly hedged?
  - Should the hedging policy be different for each currency?
  - How should the hedging policy depend on:
    - Base currency?
    - Asset mix?
    - Current market conditions?
- How would a given approach to hedging my portfolio have performed in different historical periods?

FX Hedge Optimization: Key Inputs and Assumptions

- **Key Inputs:**
  - A multi-currency portfolio, defined in terms of asset allocations
  - Base currency
  - Hedging constraints
  - Optimization criteria
- **Assumptions:**
  - For the purposes of our analysis, current asset allocation is assumed to have been constant over time
  - Hedging is implemented using one-month forwards, excluding transaction costs

Analyzing Hedge Ratios – FX Hedging Tool

- Our analysis is performed in an Excel spreadsheet that we can make available to clients
- It allows for various types of hedge ratio optimizations
  - Minimize volatility
  - Maximize utility, taking current FX carry as a return input
  - Maximize realized Sharpe ratio



Source: Barclays Research;

Analyzing Hedge Ratios – Single Period Output

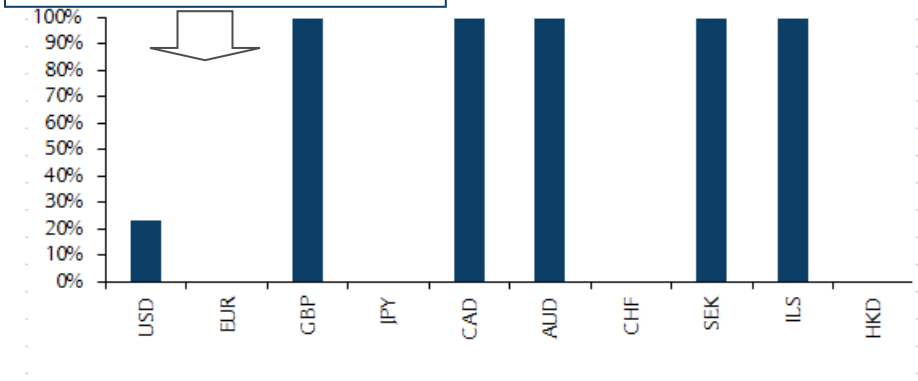
- Single period analysis calculates in-sample optimal FX hedge ratios subject to a set of constraints
- The output of the analysis includes:
  - Portfolio exposures, carry, and hedge ratios by currency
  - Risk and return statistics for hedged and unhedged portfolios

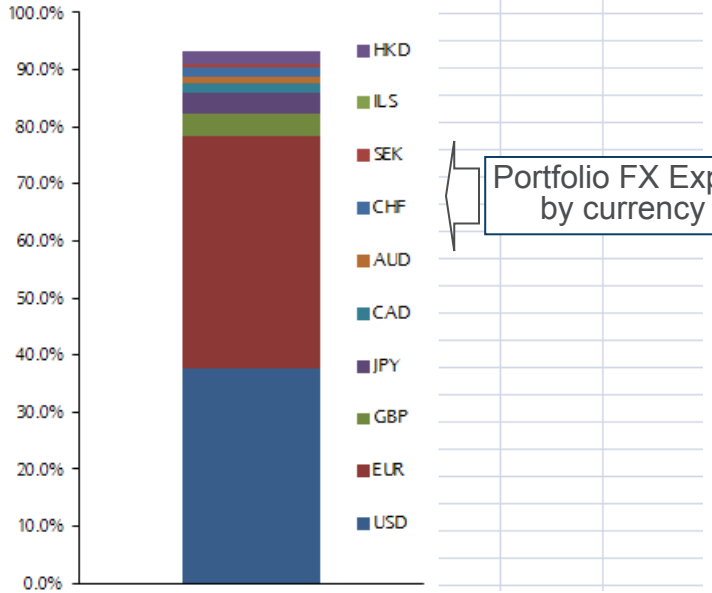
Portfolio risk and return characteristics for different hedging options

Single Period: (as of 01/31/2014)							
Currency	FX Carry bp/mo	UH Asset Portfolio	UH Carry Contr, bp/mo	Opt FX Overlay	FX Hedges %	FX Betas / UNH	Opt Carry Contr, bp/mo
USD	0.1	37.6%	0.0	8.7%	23.2%	0.48	0.0
EUR	0.0	40.8%	0.0				
GBP	2.1	3.8%	0.1	3.8%	100.0%	0.50	0.0
JPY	-1.3	3.6%	0.0	0.0%	0.0%	0.24	0.0
CAD	6.6	1.7%	0.1	1.7%	100.0%	1.27	0.0
AUD	18.8	1.3%	0.2	1.3%	100.0%	1.56	0.0
CHF	-2.1	1.6%	0.0	0.0%	0.0%	0.17	0.0
SEK	4.7	0.6%	0.0	0.6%	100.0%	1.96	0.0
ILS	4.9	0.1%	0.0	0.1%	100.0%	1.09	0.0
HKD	-0.7	2.1%	0.0	0.0%	0.0%	0.16	0.0
Portfolio Total	2.4	100.0%	2.4				-0.1

Single Period: 02/28/2001 - 01/31/2014					
Portfolio	FX Carry, bp/mo	Avg Ret, bp/mo	Volatility, bp/mo	Carry Sharpe Ratio	FX Beta
Unhedged	2.4	25.6	230.8	0.04	0.41
Fully hedged	0.0	33.4	239.0	0.00	-0.59
Opt Uniform	1.4	28.8	222.2	0.02	0.00
Opt Non-Uniform	***-0.1***	***26.5***	***212.2***	***0.00***	***0.10***

Optimal Hedge Ratios





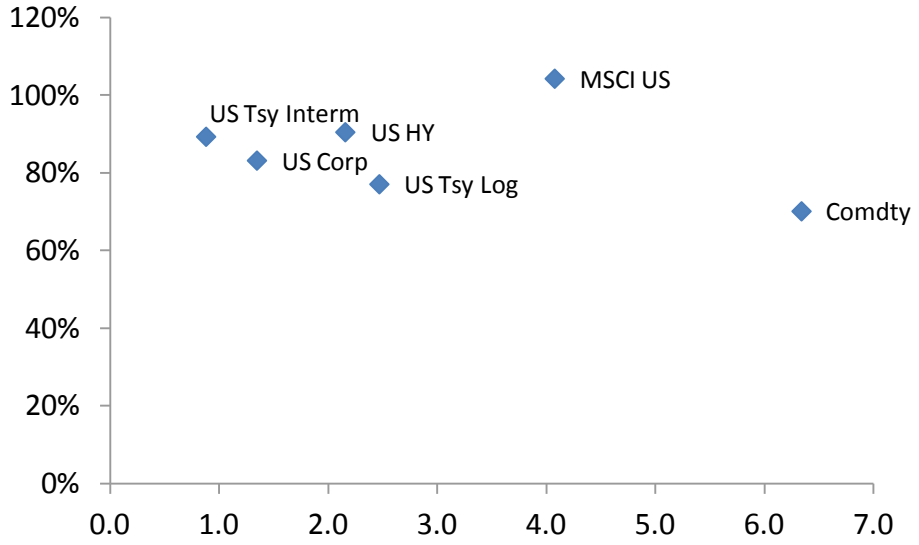
Portfolio FX Exposures by currency

Source: Barclays Research;

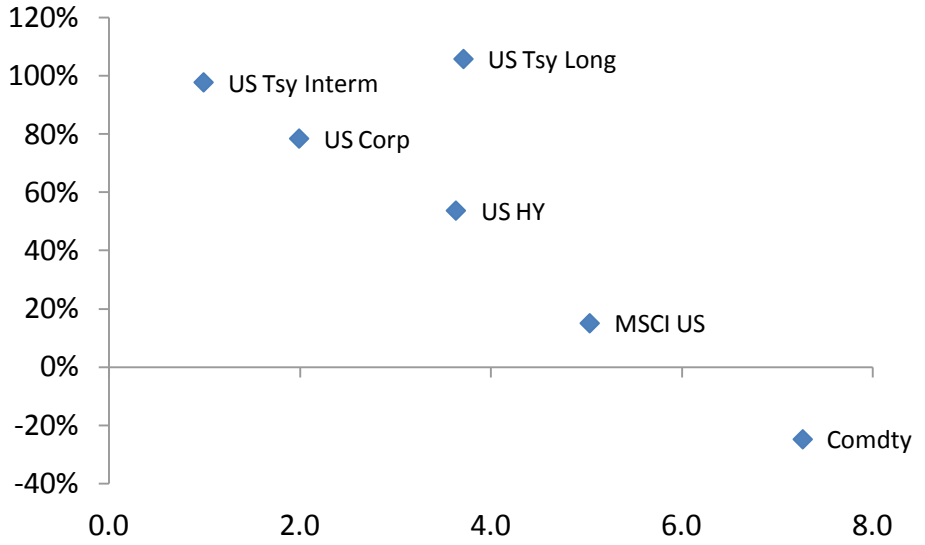
Optimal Hedge Ratios for Different US Asset Classes

- For euro-based investors, volatility-minimizing hedge ratios of USD-denominated assets would have been in a 60-100% range in the period up to July 2007
- The USD recently exhibited safe-haven properties, and this has had the effect of reducing hedge ratios of more volatile asset classes (except treasuries)
  - Recent vol-minimizing hedge ratios for equities and commodities are close to zero or negative
- The hedging decision depends on the currency and the asset class status with regard to systemic market risk

Optimal Hedges for USD Assets (Feb 92 – Jun 07)



Optimal Hedges for USD Assets (Jul 07 – Jan 14)



Source: Barclays Research;

Analyzing Hedge Ratios – Multi-Period Output

- We can consider rolling window analysis to assess the stability of hedge ratios over time
- Using rolling a window helps contrast post-crisis environment (2009-2014) with more stable market conditions

Portfolio avg. statistics and FX exposures

Portfolio FX partition

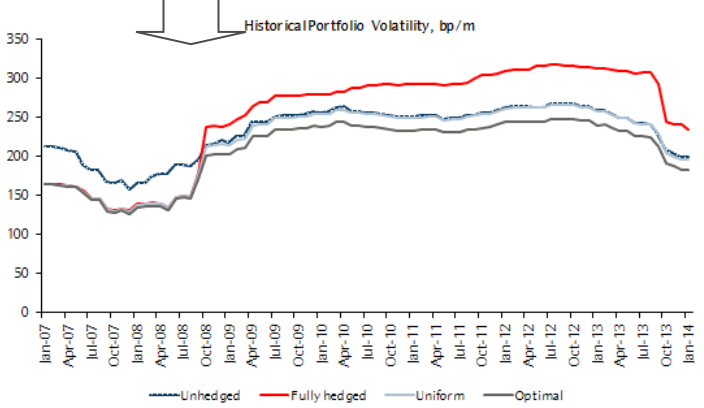
Optimal FX hedges for multiple time periods

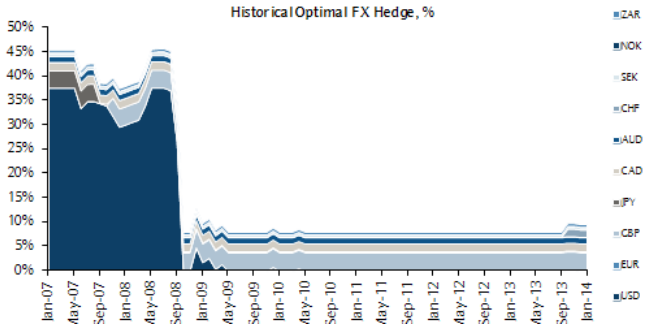
BARCLAYS *Multi-Period Output*

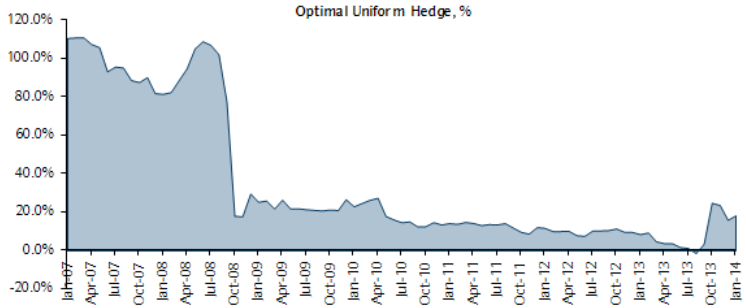
Averages (from 01/31/2007 to 01/31/2014)	Carry,bp/mo	Mo. Ave return, bp	Mo. StDev, bp	Carry Sharpe
Unhedged	1.7	29.0	232.5	0.02
Full hedge	0.0	30.8	253.7	0.00
Opt Uniform	1.2	34.0	222.3	0.02
Opt Non-Uniform	**-0.5**	**32.0**	**209.8**	**-0.01**

Averages (from 01/31/2007 to 01/31/2014)	Portfolio	Opt FX Overlay	FX Hedges %	FX Betas
USD	37.58%	8.65%	23.03%	0.43
EUR	40.82%			
GBP	3.79%	3.35%	88.23%	0.61
JPY	3.65%	0.35%	9.58%	0.27
CAD	1.71%	1.71%	100.00%	1.25
AUD	1.28%	1.28%	100.00%	1.62
CHF	1.58%	0.07%	4.70%	-0.20
SEK	0.56%	0.56%	100.00%	1.63
NOK	0.14%	0.11%	80.01%	1.74
ZAR	0.57%	0.57%	100.00%	1.12
Total	91.7%	32.8%	32.8%	

Realized volatilities of portfolios with different hedging options



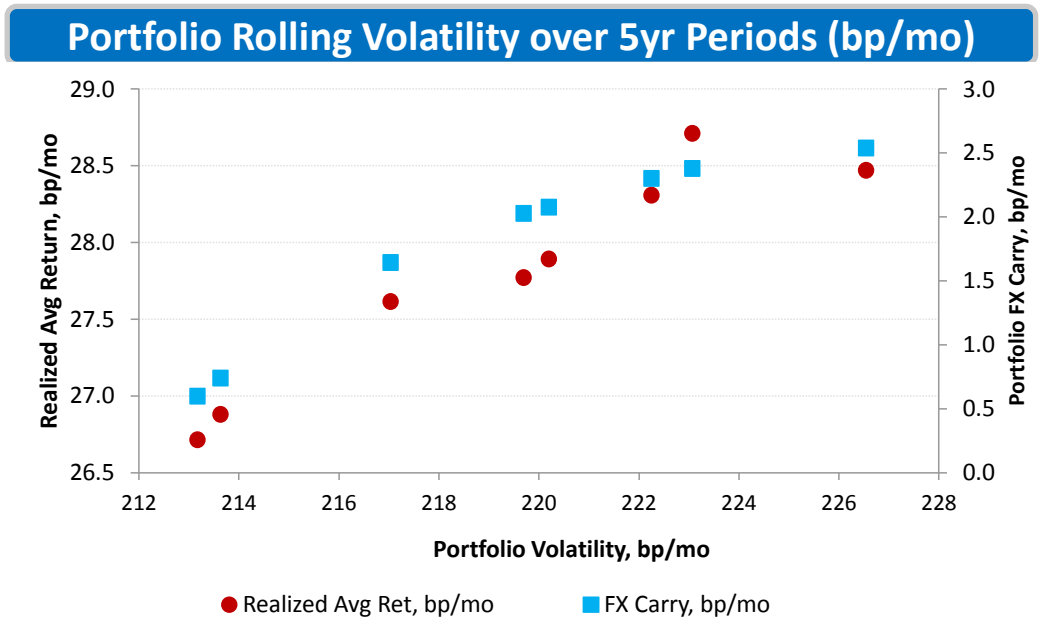




Source: Barclays Research;

Carry Considerations

- FX Exposure is associated with (positive or negative) carry which can be related to realized return
- Carry is measured using one-month forward point, which capture interest rate differentials as well as cross-currency basis
- The FX hedging tool allows for efficient frontier calculations, where the trade-off between current FX carry and realized portfolio volatility is optimized for various degrees of risk aversion
- In the example on the right, a carry-volatility frontier is reported (sample from Feb 2001 to Jan 2014)
  - Carry pick-up is relatively small
  - For this particular window, realized returns have been correlated with current carry
  - Capturing carry requires leaving exposures to most high-yielding currencies unhedged
  - Exposures to safe-haven currencies: USD, JPY, and CHF are left unhedged as well



Source: Barclays Research;

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