MSCI A Clear View of Risk and Return

Barra

The Alpha and Beta of Risk Attribution

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Outline

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Davis and Menchero, *The Alpha and Beta of Risk Attribution*, Journal of Portfolio Management, Winter 2012, pp. 99-107

Portfolio Analytics Overview

Three Basic Questions of Portfolio Management

Portfolio Managers are concerned with three basic questions:

1. How much does an investment decision contribute to return?
2. How much does an investment decision contribute to risk?
3. How much does an investment decision contribute to risk-adjusted return?

Segmenting the Portfolio Analytics Space

Return	Risk	Risk/Return	
Alpha Modeling	Risk Forecasting Risk Attribution	Portfolio Construction	Future
Performance Attribution	Risk Measurement Risk Attribution	Risk-adjusted Attribution	Past

Risk and Performance Attribution (*Ex Post*)

$$R_t = \sum_m Q_{mt} \qquad Q_m = \sum_t \beta_t \, Q_{mt} \longrightarrow \boxed{R = \sum_m Q_m}$$

Return Attribution

Multi-period linking coefficient (a)

$$\boxed{\sigma(R) = \sum_m \sigma(Q_m)\, \rho(Q_m, R)}$$

Risk Attribution (b)

- Volatilities and correlations computed using standard time-series methods

(a) Menchero, *Multi-period Arithmetic Attribution*, Financial Analysts Journal, July/Aug 2004, pp 76-91

(b) Menchero and Hu, *Portfolio Risk Attribution*, J. of Performance Measurement, Spring 2006, pp 22-33

Risk-Adjusted Attribution (*Ex Post*)

$$\boxed{\frac{R}{\sigma(R)} = \sum_{m} \underbrace{\left(\frac{\sigma(Q_m)\,\rho(Q_m,R)}{\sigma(R)}\right)}_{\text{“Risk Weight”}} \underbrace{\left(\frac{Q_m}{\sigma(Q_m)\,\rho(Q_m,R)}\right)}_{\text{“Component IR”}}}$$

Information
Ratio
Attribution

- Analyzes each return source on a risk-adjusted basis
- Ideally, every source has the same component Information Ratio
- Answers how efficiently the risk budget was allocated in practice

Menchero, *Risk-adjusted Performance Attribution*, Journal of Performance Measurement, Winter 2006/2007, pp. 22-28

Performance Attribution (*Ex Ante*)

$$\boxed{R=\sum_m x_m g_m}$$

x_m = Source Exposure

g_m = Source Return

Specific Examples:

$$R_A=\sum_n (w_n^P - w_n^B)(r_n - R_B)$$

Security Level

$$R_A=\sum_i (w_i^P - w_i^B)(R_i^B - R_B)+\sum_i w_i^P (R_i^P - R_i^B)$$

Brinson Model

$$R_A=\sum_k X_k^A f_k + \sum_n w_n^A u_n$$

Factor Approach

Risk Attribution (*Ex Ante*)

$$\boxed{\sigma(R) = \sum_m x_m \sigma(g_m)\, \rho(g_m, R)}$$

Risk Attribution

- Align risk and return attribution variables
- Risk contributions are additive and intuitive
- Identifies three drivers of portfolio risk:
  - Sizes of the exposures x_m
  - Stand-alone volatilities of the return sources $\sigma(g_m)$
  - Correlation of return sources with portfolio $\rho(g_m, R)$
- Volatility and correlation forecasts obtained from risk model

Menchero and Davis, "*Risk Contribution is Exposure Times Volatility Times Correlation: Decomposing Risk Using the X-Sigma-Rho Formula*," Journal of Portfolio Management, Winter 2011, pp. 97-106

Information Ratio Attribution (*Ex Ante*)

$$IR=\frac{R}{\sigma(R)}; \quad R=\sum_m x_m g_m; \quad \sigma(R)=\sum_m x_m\sigma(g_m)\,\rho(g_m,R)$$

$$\boxed{IR=\sum_m \left(\frac{x_m\sigma(g_m)\,\rho(g_m,R)}{\sigma(R)}\right)\left(\frac{x_m g_m}{x_m\sigma(g_m)\,\rho(g_m,R)}\right)}$$

$$\underbrace{\qquad\qquad\qquad\qquad}_{\text{“Risk Weight”}}\qquad\underbrace{\qquad\qquad\qquad\qquad}_{\text{“Component IR”}}$$

- Portfolio *IR* is the risk-weighted average of component *IR*
- Component *IR* is the stand-alone *IR* of return source, but magnified by ρ^{-1}. This represents a diversification benefit.

Implied Returns

- For an unconstrained optimal portfolio, each component *IR* must equal the portfolio *IR*:

$$IR_m = \frac{g_m}{\sigma(g_m)\,\rho(g_m, R)} = IR$$

- The expected return of any asset can be "reverse engineered" by computing its volatility and correlation with the optimal portfolio

$$\boxed{E\left[g_m\right] = IR \cdot \sigma(g_m) \cdot \rho(g_m, R) = \beta_m \cdot E\left[R\right]}$$

Implied Returns

- Result reduces to CAPM when the efficient portfolio is the Market
- Constraints reduce the portfolio *IR* by forcing part of the risk budget to be allocated to low *IR* positions

Residual Volatility and Transfer Coefficient

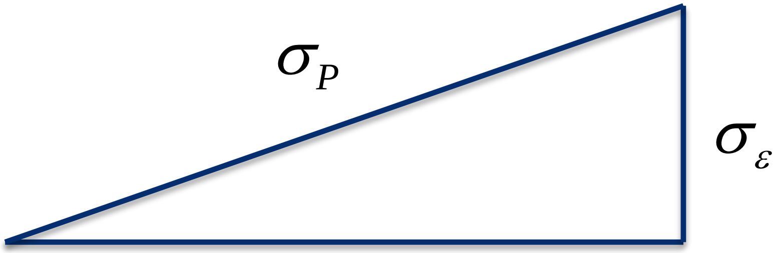
- Investment constraints force the *actual* portfolio *P* to deviate from the *ideal* portfolio *Q*

$$R_P = \beta_P R_Q + R_\varepsilon$$

Portfolio you own

Portfolio you want

Residual Portfolio



$$\beta_P \sigma_Q = \rho \sigma_P$$

- Residual portfolio contributes to risk, but *not* to expected return
- Compute betas and correlations relative to ideal portfolio *Q*

$$IR_P = \frac{\beta_P R_Q}{\sigma_P}\left(\frac{\sigma_Q}{\sigma_Q}\right)$$

$$\boxed{\sigma_\varepsilon = \sigma_P \sqrt{1-\rho^2}}$$

Residual Volatility

$$\boxed{IR_P = \rho \cdot IR_Q}$$

Transfer Coefficient

Portfolio Optimization

Unconstrained Optimal Portfolios

Minimize tracking error: $\sum_{mn} w_m^A V_{mn} w_n^A$

Subject to fixed return constraint: $\sum_{n} w_n^A r_n = 1$

where: $r_n = \alpha_n + \beta_n R_B$

Solution: $\boxed{\mathbf{w_A} = \dfrac{\mathbf{V^{-1}r}}{\mathbf{r'V^{-1}r}}}$

Optimal Portfolio $w_n^A = \dfrac{\sum_m r_m V_{mn}^{-1}}{\sum_{mn} r_m V_{mn}^{-1} r_n}$

- Optimal portfolio has maximum Information Ratio
- Fixed return constraint determines leverage, does not impact IR
- In general, active weights do not sum to zero
- In general, active beta is non-zero

Optimal Portfolios with Constraints

Fixed return constraint:

Full investment constraint:

Zero beta constraint:

$$\begin{pmatrix} r_1 & r_2 & r_3 & \cdots & r_N \\ 1 & 1 & 1 & \cdots & 1 \\ \beta_1 & \beta_2 & \beta_3 & \cdots & \beta_N \end{pmatrix} \begin{pmatrix} w_1^A \\ w_2^A \\ \vdots \\ w_N^A \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$$

Minimize tracking error: $\mathbf{w}_\mathbf{A}' \mathbf{V} \mathbf{w}_\mathbf{A}$

Subject to constraint equation: $\mathbf{Q}\mathbf{w}_\mathbf{A} = \mathbf{c}$

Analytic Solution: $\boxed{\mathbf{w}_\mathbf{A} = \mathbf{V}^{-1}\mathbf{Q}'\left(\mathbf{Q}\mathbf{V}^{-1}\mathbf{Q}'\right)^{-1}\mathbf{c}}$ Optimal Portfolio

- More complex constraints require numerical solution

Attributing Risk to Alpha and Beta

Segmenting Source Returns into Alpha and Beta

$$\boxed{g_m = g_m^{\alpha} + g_m^{\beta}}$$

Decompose Return Source into Alpha and Beta

$$g_m^{\beta} = \beta_m \cdot R_B$$

Beta component is perfectly correlated with the benchmark

$$g_m^{\alpha} = g_m - g_m^{\beta}$$

Alpha component is uncorrelated with the benchmark

$$\sigma(R_A) = \sum_m x_m \sigma(g_m^{\alpha}) \rho(g_m^{\alpha}, R_A)$$

Alpha Risk

$$+ \sum_m x_m \sigma(g_m^{\beta}) \rho(g_m^{\beta}, R_A)$$

Beta Risk

- Now compute betas relative to *benchmark*
- Note: active strategy presupposes benchmark is *not* optimal

Example

- Portfolio: 95% MSCI World Value Index, with 5% cash (USD)
- Benchmark: MSCI World Growth Index
- Risk Model: Barra Global Equity Model GEM2L
- Analysis Date: September 30, 2009
- Portfolio Beta: 1.08
- Tracking Error: 4.81%

$$\boxed{R_A = \alpha_P + \beta_A R_B}$$

Source	**Volatility**	**Correlation**	**TE Contrib**
Alpha	**4.32%**	**0.90**	**3.89%**
Beta	**2.10%**	**0.44**	**0.92%**
Total	**4.81%**	**1.00**	**4.81%**

- Assuming optimality and *IR*=1: $E\left[R_B\right] = \left(0.92/0.08\right) = 11.8\%$

Security Level

- Consider bottom-up investment process:

$$R_A = \sum_n \underbrace{w_n^A}_{\text{Active Weight}} \underbrace{\left(r_n - R_B\right)}_{\text{Relative Return}}$$

- Relative returns are more appropriate than absolute returns
- Intuitively, we want to overweight the outperformers, but sometimes it is optimal to *underweight* outperformers (hedging purposes)
- The benchmark represents the risk-free asset (zero relative volatility)
- Cash has relative volatility σ_B
- Relative return of Cash has correlation of -1.0 to the benchmark

Example: Security Level

					Alpha Component			Beta Component		
Asset Name	**Active Weight**	**Relative Volatility**	**Relative Corr**	**TE Contrib**	**Relative Volatility**	**Relative Corr**	**TE Contrib**	**Relative Volatility**	**Relative Corr**	**TE Contrib**
BANK OF AMERICA	1.31%	61.77%	0.44	0.35%	57.12%	0.29	0.22%	23.52%	0.44	0.13%
CITIGROUP	0.69%	82.99%	0.41	0.24%	75.48%	0.25	0.13%	34.49%	0.44	0.10%
GENERAL ELECTRIC	1.56%	35.56%	0.38	0.21%	33.29%	0.25	0.13%	12.48%	0.44	0.08%
JPMORGAN CHASE	1.47%	40.66%	0.37	0.22%	39.32%	0.26	0.15%	10.36%	0.44	0.07%
NESTLE	-1.52%	24.41%	-0.22	0.08%	22.60%	-0.06	0.02%	9.23%	-0.44	0.06%
…										
UBS	-0.64%	41.47%	0.26	-0.07%	38.49%	0.11	-0.03%	15.44%	0.44	-0.04%
RIO TINTO	-0.57%	47.90%	0.07	-0.02%	43.69%	-0.12	0.03%	19.65%	0.44	-0.05%
EXXON MOBIL	3.00%	23.64%	0.06	0.04%	23.16%	0.15	0.10%	4.72%	-0.44	-0.06%
BHP BILLITON	-1.10%	39.76%	0.01	-0.01%	36.70%	-0.17	0.07%	15.31%	0.44	-0.07%
US Dollar	5.00%	26.78%	-0.44	-0.59%	0.00%	0.00	0.00%	26.78%	-0.44	-0.59%
Total				4.81%			3.89%			0.92%

- Assuming optimality and *IR*=1, expected return of benchmark is (26.78)(0.44), or 11.8 percent
- GE is expected to outperform benchmark by (35.56)x(0.38), or 13.5 percent
- Portfolio is underweight UBS, although it has a positive expected return
- US Dollar is the greatest diversifier and contributes zero to Alpha risk

Example: Sector-Based Approach

Brinson Model:

$$R = \sum_i (w_i^P - w_i^B)(R_i^B - R_B) + \sum_i w_i^P (R_i^P - R_i^B)$$

Sector Name	Portfolio Weight	Bench Weight	Active Weight	Relative Volatility	Relative Corr	Allocation TE Contrib	Active Volatility	Active Corr	Selection TE Contrib	Total TE Contrib
Energy	13.09%	7.77%	5.32%	18.04%	0.13	0.12%	12.64%	-0.02	-0.03%	0.09%
Materials	4.98%	8.80%	-3.82%	17.09%	0.02	-0.01%	12.09%	0.41	0.25%	0.23%
Industrials	10.55%	9.85%	0.70%	5.80%	0.32	0.01%	7.84%	0.45	0.38%	0.39%
Cons Disc	6.97%	11.27%	-4.31%	7.50%	0.30	-0.10%	6.44%	0.25	0.11%	0.01%
Cons Stpls	4.39%	15.65%	-11.25%	10.21%	-0.25	0.29%	6.86%	0.24	0.07%	0.36%
Health Care	6.53%	13.49%	-6.96%	11.02%	-0.32	0.25%	8.15%	0.26	0.14%	0.38%
Financials	32.57%	8.39%	24.19%	12.30%	0.58	1.73%	9.61%	0.57	1.78%	3.50%
IT	3.25%	19.95%	-16.70%	9.22%	-0.16	0.25%	10.34%	0.08	0.03%	0.28%
Telecom	5.95%	2.58%	3.36%	14.16%	-0.02	-0.01%	14.39%	0.10	0.09%	0.08%
Utilities	6.72%	2.26%	4.47%	13.92%	-0.17	-0.10%	9.28%	0.25	0.16%	0.05%
Cash	5.00%	0.00%	5.00%	26.78%	-0.44	-0.59%	0.00%	0.00	0.00%	-0.59%
Total	100.00%	100.00%	0.00%	3.94%	0.47	1.84%	4.57%	0.65	2.96%	4.81%

- Financial sector contributes 350 bps to TE; 173 bps due to Allocation
- Each attribution effect can be subdivided into Alpha and Beta components

Alpha Decomposition for Brinson Model

Sector Name	Portfolio Weight	Bench Weight	Active Weight	Alpha (Residual) Component						
				Relative Volatility	Relative Corr	Allocation TE Contrib	Active Volatility	Active Corr	Selection TE Contrib	Total TE Contrib
Energy	13.09%	7.77%	5.32%	15.95%	-0.09	-0.07%	10.77%	0.25	0.35%	0.28%
Materials	4.98%	8.80%	-3.82%	15.11%	-0.21	0.12%	11.89%	0.34	0.20%	0.32%
Industrials	10.55%	9.85%	0.70%	5.61%	0.22	0.01%	6.93%	0.28	0.21%	0.22%
Cons Disc	6.97%	11.27%	-4.31%	7.29%	0.20	-0.06%	6.18%	0.13	0.06%	-0.01%
Cons Stpls	4.39%	15.65%	-11.25%	7.48%	0.06	-0.05%	6.83%	0.20	0.06%	0.01%
Health Care	6.53%	13.49%	-6.96%	8.95%	-0.08	0.05%	8.11%	0.30	0.16%	0.21%
Financials	32.57%	8.39%	24.19%	10.69%	0.42	1.08%	8.64%	0.42	1.18%	2.26%
IT	3.25%	19.95%	-16.70%	9.22%	-0.16	0.25%	10.34%	0.07	0.02%	0.27%
Telecom	5.95%	2.58%	3.36%	13.78%	0.08	0.04%	14.26%	0.16	0.14%	0.18%
Utilities	6.72%	2.26%	4.47%	11.73%	0.08	0.04%	9.13%	0.17	0.11%	0.15%
Cash	5.00%	0.00%	5.00%	0.00%	-0.31	0.00%	0.00%	0.00	0.00%	0.00%
Total	100.00%	100.00%	0.00%	3.81%	0.37	1.41%	4.43%	0.56	2.48%	3.89%

- Alpha component contributes 108 bps (of 173 bps total) to Financials Allocation

Beta Decomposition for Brinson Model

Sector Name	Portfolio Weight	Bench Weight	Active Weight	Beta (Market Timing) Component						
				Relative Volatility	Relative Corr	Allocation TE Contrib	Active Volatility	Active Corr	Selection TE Contrib	Total TE Contrib
Energy	13.09%	7.77%	5.32%	8.44%	0.44	0.20%	6.61%	-0.44	-0.38%	-0.18%
Materials	4.98%	8.80%	-3.82%	7.98%	0.44	-0.13%	2.15%	0.44	0.05%	-0.09%
Industrials	10.55%	9.85%	0.70%	1.46%	0.44	0.00%	3.66%	0.44	0.17%	0.17%
Cons Disc	6.97%	11.27%	-4.31%	1.78%	0.44	-0.03%	1.81%	0.44	0.06%	0.02%
Cons Stpls	4.39%	15.65%	-11.25%	6.94%	-0.44	0.34%	0.55%	0.44	0.01%	0.35%
Health Care	6.53%	13.49%	-6.96%	6.42%	-0.44	0.20%	0.75%	-0.44	-0.02%	0.17%
Financials	32.57%	8.39%	24.19%	6.08%	0.44	0.64%	4.20%	0.44	0.60%	1.24%
IT	3.25%	19.95%	-16.70%	0.03%	-0.44	0.00%	0.22%	0.44	0.00%	0.01%
Telecom	5.95%	2.58%	3.36%	3.29%	-0.44	-0.05%	1.88%	-0.44	-0.05%	-0.10%
Utilities	6.72%	2.26%	4.47%	7.50%	-0.44	-0.15%	1.69%	0.44	0.05%	-0.10%
Cash	5.00%	0.00%	5.00%	26.78%	-0.44	-0.59%	0.00%	0.00	0.00%	-0.59%
Total	100.00%	100.00%	0.00%	1.00%	0.44	0.44%	1.11%	0.44	0.48%	0.92%

- Beta component contributes 64 bps (of 173 bps total) to Financials Allocation
- Correlation between benchmark and active portfolio is 0.44

Factor-Based Approach

$$R = \sum_k X_k^P f_k + \sum_n w_n u_n$$

- Attribute risk to a set of custom factors:
  - World factor
  - 10 GICS Economic Sectors
  - Use *Predicted Beta* as a style factor, together with Value, Size, and Momentum
  - Style factors are cap-weighted mean zero
  - Use benchmark as estimation universe
  - Use benchmark cap-weights as regression weights
- All factor portfolios (except Beta and World) have zero beta
- World factor portfolio becomes the benchmark (beta=1)
- Beta factor portfolio is dollar neutral (also with beta=1)

Menchero and Poduri, *Custom Factor Attribution*, Financial Analysts Journal, March/April 2008, pp. 81-92

Example: Factor-Based Approach

					Alpha Component			Beta Component		
Source	**Active Exposure**	**Volatility**	**Corr**	**TE Contrib**	**Volatility**	**Corr**	**TE Contrib**	**Volatility**	**Corr**	**TE Contrib**
World	-0.05	26.78%	0.44	-0.59%	0.00%	-0.28	0.00%	26.78%	0.44	-0.59%
Energy	0.05	16.20%	-0.08	-0.07%	16.20%	-0.08	-0.07%	0.00%	-0.44	0.00%
Materials	-0.04	14.59%	-0.20	0.11%	14.59%	-0.20	0.11%	0.00%	0.44	0.00%
Industrials	0.01	5.34%	0.20	0.01%	5.34%	0.20	0.01%	0.00%	0.44	0.00%
ConsDscr	-0.04	7.30%	0.22	-0.07%	7.30%	0.22	-0.07%	0.00%	-0.44	0.00%
ConsStpls	-0.11	7.17%	0.03	-0.03%	7.17%	0.03	-0.03%	0.00%	-0.44	0.00%
HealthCare	-0.07	8.89%	-0.12	0.07%	8.89%	-0.12	0.07%	0.00%	-0.44	0.00%
Financials	0.24	11.92%	0.40	1.15%	11.92%	0.40	1.15%	0.00%	0.44	0.00%
IT	-0.17	9.12%	-0.13	0.20%	9.12%	-0.13	0.20%	0.00%	0.44	0.00%
Telecom	0.03	14.07%	0.06	0.03%	14.07%	0.06	0.03%	0.00%	0.44	0.00%
Utilities	0.04	10.62%	0.00	0.00%	10.62%	0.00	0.00%	0.00%	0.44	0.00%
Momentum	0.05	6.28%	-0.12	-0.04%	6.28%	-0.12	-0.04%	0.00%	-0.44	0.00%
Beta	0.13	31.57%	0.36	1.48%	16.72%	-0.01	-0.03%	26.78%	0.44	1.51%
Value	0.48	4.74%	0.14	0.32%	4.74%	0.14	0.32%	0.00%	0.44	0.00%
Size	0.07	3.05%	-0.13	-0.03%	3.05%	-0.13	-0.03%	0.00%	-0.44	0.00%
Specific	1.00	4.02%	0.56	2.27%	4.02%	0.56	2.27%	0.00%	-0.44	0.00%
Total				4.81%			3.89%			0.92%

- Beta risk is fully explained by Beta and World factors
- World factor accounts for hedging due to cash position (-59 bps)
- Beta factor portfolio contains some residual risk

Residual Weights versus Residual Returns

Alpha Analysis: Residual Weights or Residual Returns?

- Our approach is based on active weights and residual returns
    - Active weights are intuitive
    - Residual returns are uncorrelated with the benchmark
- Alternative approach: use *residual weights* with *total returns*
- This adds up to the total portfolio alpha:

$$\sum_n \underbrace{\left(w_n^P - \beta_P w_n^B\right)}_{\text{Residual Weight}} \underbrace{\left(\alpha_n + \beta_n R_B\right)}_{\text{Total Return}} = \alpha_P$$

Residual Weights Approach

- Shortcomings:
    - Residual weights are less intuitive
    - Total returns are *correlated* with the benchmark
    - Inconsistent with notion of Alpha as an uncorrelated return source

Example: Residual Exposures

Source	Residual Exposure	Factor Volatility	Corr	TE Contrib
World	-0.13	26.78%	0.44	-1.51%
Energy	0.05	16.20%	-0.08	-0.06%
Materials	-0.05	14.59%	-0.20	0.13%
Industrials	0.00	5.34%	0.20	0.00%
ConsDscr	-0.05	7.30%	0.22	-0.08%
ConsStpls	-0.12	7.17%	0.03	-0.03%
HealthCare	-0.08	8.89%	-0.12	0.08%
Financials	0.24	11.92%	0.40	1.12%
IT	-0.18	9.12%	-0.13	0.22%
Telecom	0.03	14.07%	0.06	0.03%
Utilities	0.04	10.62%	0.00	0.00%
Momentum	0.05	6.28%	-0.12	-0.04%
Beta	0.13	31.57%	0.36	1.48%
Value	0.48	4.74%	0.14	0.32%
Size	0.07	3.05%	-0.13	-0.03%
Specific	1.00	4.02%	0.56	2.27%
Total				3.89%

- Factor exposures are quoted on a residual basis
- World and Beta factors make non-intuitive contribution to Alpha risk

$$X_k^R = \sum_n w_n^R X_{nk}$$

Residual Exposures

Summary

- Portfolio returns can always be segmented into Alpha and Beta:
  - Alpha component is uncorrelated with the benchmark
  - Beta component is perfectly correlated with the benchmark
- Portfolio risk can always be segmented into Alpha and Beta sources
- Three examples:
  - Security Level
  - Brinson Model
  - Factor Approach
- Alternative formulation based on residual weights leads to non-intuitive results

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