## Contents

### Acknowledgements

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>xv</td>
</tr>
</tbody>
</table>

### 1 Introduction

<table>
<thead>
<tr>
<th>Why measure portfolio performance?</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>The performance measurement process</td>
<td>2</td>
</tr>
<tr>
<td>The purpose of this book</td>
<td>2</td>
</tr>
<tr>
<td>Role of performance measurers</td>
<td>2</td>
</tr>
<tr>
<td>Book structure</td>
<td>3</td>
</tr>
</tbody>
</table>

### 2 The Mathematics of Portfolio Return

<table>
<thead>
<tr>
<th>Simple return</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money-weighted returns</td>
<td>7</td>
</tr>
<tr>
<td>Internal rate of return (IRR)</td>
<td>7</td>
</tr>
<tr>
<td>Simple internal rate of return</td>
<td>7</td>
</tr>
<tr>
<td>Modified internal rate of return</td>
<td>8</td>
</tr>
<tr>
<td>Simple Dietz</td>
<td>10</td>
</tr>
<tr>
<td>ICAA method</td>
<td>11</td>
</tr>
<tr>
<td>Modified Dietz</td>
<td>12</td>
</tr>
<tr>
<td>Time-weighted returns</td>
<td>13</td>
</tr>
<tr>
<td>True time-weighted</td>
<td>13</td>
</tr>
<tr>
<td>Unit price method</td>
<td>14</td>
</tr>
<tr>
<td>Time-weighted versus money-weighted rates of return</td>
<td>16</td>
</tr>
<tr>
<td>Approximations to the time-weighted return</td>
<td>18</td>
</tr>
<tr>
<td>Index substitution</td>
<td>18</td>
</tr>
<tr>
<td>Regression method (or β method)</td>
<td>19</td>
</tr>
<tr>
<td>Analyst’s test</td>
<td>19</td>
</tr>
<tr>
<td>Hybrid methodologies</td>
<td>20</td>
</tr>
<tr>
<td>Linked modified Dietz</td>
<td>21</td>
</tr>
<tr>
<td>BAI method (or linked IRR)</td>
<td>21</td>
</tr>
<tr>
<td>Which method to use?</td>
<td>21</td>
</tr>
<tr>
<td>Self-selection</td>
<td>22</td>
</tr>
<tr>
<td>Annualised returns</td>
<td>27</td>
</tr>
<tr>
<td>Return hiatus</td>
<td>28</td>
</tr>
</tbody>
</table>
Contents

Continuously compounded returns 28
Gross- and net-of-fee calculations 29
   Estimating gross- and net-of-fee returns 30
   Initial fees 32
Portfolio component returns 32
   Component weight 32
   Short positions 34
   Overlay strategies 34
   Carve-outs 34
   Multi-period component returns 35
Base currency and local returns 35

3 Benchmarks 39

Benchmarks 39
   Benchmark attributes 39
   Commercial indexes 39
   Calculation methodologies 40
      Aggregate price index (price-weighted index) 40
      Geometric (or Jevons-type) index 41
      Market capitalisation index 41
      Laspeyres index 41
      Paasche index 42
      Marshall–edgeworth index 42
      Fisher index 42
      Equal-weighted indexes 42
      Fundamental indexes 43
      Currency effects in benchmark 43
      Hedged indexes 43
      Customised (or composite) indexes 44
      Fixed weight and dynamised benchmarks 45
      Capped indexes 45
      Blended (or spliced) indexes 46
      Money-weighted benchmarks 47

Benchmark statistics 47
   Index turnover 47
   Up capture indicator 47
   Down capture indicator 47
   Up number ratio 48
   Down number ratio 48
   Up percentage ratio 48
   Down percentage ratio 48
   Percentage gain ratio 48

Peer groups and universes 48
   Percentile rank 49

Random portfolios 50

Notional funds 50
   Normal portfolio 51
   Growth and value 51
Contents ix

Excess return 51
  Arithmetic excess return 51
  Geometric excess return 52
Performance fees 55
  Symmetrical performance fees (or fulcrum fees) 55
  Asymmetrical performance fees 56
Performance fee structures 57
  Sliding scale 57
  Performance fee caps 57
  Hurdle rate 58
  Crystallisation 58
  High water mark 58
  Equalisation 58

4 Risk 61
Definition of risk 61
  Risk management versus risk control 61
  Risk aversion 62
Risk measures 62
  Ex post and ex ante 62
  Variability 62
  Mean absolute deviation 62
  Variance 63
  Standard deviation 63
  Frequency and number of data points 64
  Sharpe ratio (reward to variability) 64
  Risk-adjusted return: $M^2$ 67
  $M^2$ excess return 68
  Differential return 68
  GH1 (Graham and Harvey 1) 69
  GH2 (Graham and Harvey 2) 70
Regression analysis 70
  Regression equation 71
  Regression alpha ($\alpha_R$) 71
  Regression beta ($\beta_R$) 71
  Regression epsilon ($\epsilon_R$) 71
  Capital asset pricing model (CAPM) 72
  Beta ($\beta$) (systematic risk or volatility) 72
  Jensen's alpha (or Jensen's measure or Jensen's differential return or ex post alpha) 72
  Bull beta ($\beta^+$) 72
  Bear beta ($\beta^-$) 73
  Beta timing ratio 73
  Covariance 73
  Correlation ($\rho$) 73
  Correlation and risk-adjusted return: $M^3$ 74
  $R^2$ (or coefficient of determination) 75
  Systematic risk 75
Specific or residual risk 75
Treynor ratio (reward to volatility) 75
Modified Treynor ratio 77
Appraisal ratio (or Treynor–Black ratio) 77
Modified Jensen 77
Fama decomposition 77
Selectivity 78
Diversification 78
Net selectivity 78
Relative risk 78
Tracking error 78
Information ratio 80
Return distributions 81
Normal (or Gaussian) distribution 81
The central limit theorem 81
Skewness (Fisher's or moment skewness) 83
Sample skewness 84
Kurtosis (Pearson’s kurtosis) 84
Sample kurtosis 84
Bera–Jarque statistic 85
Risk-adjusted performance measures for hedge funds 85
Drawdown 87
Average drawdown 87
Maximum drawdown 87
Largest individual drawdown 87
Recovery time (or drawdown duration) 87
Drawdown deviation 88
Ulcer index 88
Pain index 89
Calmar ratio 89
Sterling ratio 89
Sterling–Calmar ratio 90
Burke ratio 90
Modified Burke ratio 91
Martin ratio (or ulcer performance index) 91
Pain ratio 91
Lake ratio 91
Peak ratio 92
Downside risk (or semi-standard deviation) 92
Upside risk 92
Shortfall risk (or downside frequency) 94
Omega ratio (Ω) 94
Bernardo and Ledoit (or gain–loss) ratio 95
d' ratio 95
Omega–Sharpe ratio 95
Sortino ratio 96
Kappa (κ) 96
Upside potential ratio 97
Volatility skewness 97
Variability skewness 98
Adjusted Sharpe ratio 99
Skewness–kurtosis ratio 99
Prospect ratio 100
Value at risk (VaR) 100
  Variance–covariance (or parametric) 100
  Historical simulation (or non-parametric) 100
  Monte Carlo simulation 101
  VaR ratio 101
  Reward to VaR ratio 101
  Conditional VaR (or expected shortfall) 101
  Conditional Sharpe ratio 101
  Modified VaR 102
  Modified Sharpe ratio 102
Return adjusted for downside risk 102
  $M^2$ for Sortino 102
  Omega excess return 103
  Hurst index 104
Fixed Income Risk 104
  Duration (or volatility) 104
  Macaulay duration 104
  Modified duration 105
  Macaulay–Weil duration 105
  Portfolio duration 105
  Effective duration (or option-adjusted duration) 107
  Duration to worst 107
  Convexity 108
  Modified convexity 108
  Effective convexity 108
  Duration beta 108
  Reward to duration 108
Which risk measures to use? 108
  Risk efficiency ratio 109
  Fund rating systems 109
Risk control structure 114

5 Performance Attribution 117
Arithmetic attribution 117
  Brinson, Hood and Beebower 118
Asset allocation 118
Security (or stock) selection 119
Interaction 120
Brinson and Fachler 125
Interaction 126
9 Further Attribution Issues

Attribution variations
- Contribution analysis (or absolute return attribution)
- Return (or regression)-based attribution
- Holding-based (or buy/hold) attribution
- Transaction-based attribution
- Security-level attribution
- Transaction costs
- Off-benchmark (or zero-weight sector) attribution

Multi-level attribution
- Balanced attribution
- Lookthrough attribution (or fund of funds attribution)

Attribution standards

Evolution of performance attribution methodologies

Risk-adjusted attribution

Selectivity

10 Performance Measurement for Derivatives

Futures
- Equity index future
- Libor (London interbank offered rate)
- Attribution including equity index futures
- Leverage (or gearing)

Forward foreign exchange (FFX) contract (or currency forward)

Swaps
- Interest rate swaps
- Total return swap
- Credit default swap
- Equity index swaps
- Contracts for difference (CFD)

Options
- Option price sensitivity (the Greeks)

Warrants
- Convertible bonds
- Attribution analysis using options, warrants and convertible bonds

Market neutral attribution
- Attribution for 130/30 funds (or extended short funds)

11 Performance Presentation Standards

Why do we need performance presentation standards?

Global Investment Performance Standards (GIPS®)

Advantages for asset managers

The standards
- Composites
- Presentation
- Calculation
- Claim of compliance
- Structure of the standards
<table>
<thead>
<tr>
<th>Contents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification</td>
<td>253</td>
</tr>
<tr>
<td>Verification/practitioners subcommittee</td>
<td>254</td>
</tr>
<tr>
<td>Interpretations subcommittee</td>
<td>254</td>
</tr>
<tr>
<td>Guidance statements</td>
<td>254</td>
</tr>
<tr>
<td>Definition of firm</td>
<td>255</td>
</tr>
<tr>
<td>Carve-outs</td>
<td>255</td>
</tr>
<tr>
<td>Significant cash flows</td>
<td>256</td>
</tr>
<tr>
<td>Portability</td>
<td>256</td>
</tr>
<tr>
<td>Supplemental information</td>
<td>257</td>
</tr>
<tr>
<td>Error correction</td>
<td>257</td>
</tr>
<tr>
<td>Measures of dispersion</td>
<td>258</td>
</tr>
<tr>
<td>Equal-weighted standard deviation</td>
<td>258</td>
</tr>
<tr>
<td>Asset-weighted dispersion</td>
<td>258</td>
</tr>
<tr>
<td>High–low</td>
<td>258</td>
</tr>
<tr>
<td>Interquartile range</td>
<td>258</td>
</tr>
<tr>
<td>Achieving compliance</td>
<td>259</td>
</tr>
<tr>
<td>Maintaining compliance</td>
<td>259</td>
</tr>
<tr>
<td>Appendix A Simple Attribution</td>
<td>261</td>
</tr>
<tr>
<td>Appendix B Multi-currency Attribution Methodology</td>
<td>264</td>
</tr>
<tr>
<td>Appendix C EIPC Guidance for Users of Attribution Analysis</td>
<td>271</td>
</tr>
<tr>
<td>Appendix D European Investment Performance Committee – Guidance on Performance Attribution Presentation</td>
<td>275</td>
</tr>
<tr>
<td>Appendix E The Global Investment Performance Standards</td>
<td>287</td>
</tr>
<tr>
<td>Appendix F Guidance Statement on Composite Definition</td>
<td>324</td>
</tr>
<tr>
<td>Appendix G Sample Global Investment Performance Standards Presentation</td>
<td>334</td>
</tr>
<tr>
<td>Appendix H Calculation Methodology Guidance Statement</td>
<td>336</td>
</tr>
<tr>
<td>Appendix I Definition of Firm Guidance Statements</td>
<td>345</td>
</tr>
<tr>
<td>Appendix J Treatment of Carve-outs Guidance Statement</td>
<td>351</td>
</tr>
<tr>
<td>Appendix K Significant Cash Flow Guidance Statement</td>
<td>356</td>
</tr>
<tr>
<td>Appendix L Guidance Statement on Performance Record Portability</td>
<td>361</td>
</tr>
<tr>
<td>Appendix M Guidance Statement on the Use of Supplemental Information</td>
<td>365</td>
</tr>
<tr>
<td>Appendix N Guidance Statement on Recordkeeping Requirements of the GIPS Standards</td>
<td>369</td>
</tr>
<tr>
<td>Appendix O Useful Websites</td>
<td>376</td>
</tr>
<tr>
<td>Bibliography</td>
<td>377</td>
</tr>
<tr>
<td>Index</td>
<td>381</td>
</tr>
</tbody>
</table>