Practical Portfolio Performance Measurement and Attribution

Carl R. Bacon

John Wiley & Sons, Ltd

Practical Portfolio Performance Measurement and Attribution

Wiley Finance Series

Hedge Funds: Quantitative Insights
François-Serge Lhabitant
A Currency Options Primer
Shani Shamah
New Risk Measures in Investment and Regulation
Giorgio Szegö (Editor)
Modelling Prices in Competitive Electricity Markets
Derek Bunn (Editor)
Inflation-indexed Securities: Bonds, Swaps and Other Derivatives, 2nd Edition
Mark Deacon, Andrew Derry and Dariush Mirfendereski
European Fixed Income Markets: Money, Bond and Interest Rates
Jonathan Batten, Thomas Fetherston and Peter Szilagyi (Editors)
Global Securitisation and CDOs
John Deacon
Applied Quantitative Methods for Trading and Investment
Christian L. Dunis, Jason Laws and Patrick Naim (Editors)
Country Risk Assessment: A Guide to Global Investment Strategy
Michel Henry Bouchet, Ephraim Clark and Bertrand Groslambert
Credit Derivatives Pricing Models: Models, Pricing and Implementation
Philipp J. Schönbucher
Hedge Funds: A Resource for Investors
Simone Borla
A Foreign Exchange Primer
Shani Shamah
The Simple Rules: Revisiting the Art of Financial Risk Management
Erik Banks
Option Theory
Peter James
Risk-adjusted Lending Conditions
Werner Rosenberger
Measuring Market Risk
Kevin Dowd
An Introduction to Market Risk Management
Kevin Dowd
Behavioural Finance
James Montier
Asset Management: Equities Demystified
Shanta Acharya
An Introduction to Capital Markets: Products, Strategies, Participants
Andrew M. Chisholm
Hedge Funds: Myths and Limits
François-Serge Lhabitant
The Manager's Concise Guide to Risk
Jihad S. Nader
Securities Operations: A Guide to Trade and Position Management
Michael Simmons
Modeling, Measuring and Hedging Operational Risk
Marcelo Cruz
Monte Carlo Methods in Finance
Peter Jäckel
Building and Using Dynamic Interest Rate Models
Ken Kortanek and Vladimir Medvedev
Structured Equity Derivatives: The Definitive Guide to Exotic Options and Structured Notes
Harry Kat
Advanced Modelling in Finance Using Excel and VBA
Mary Jackson and Mike Staunton
Operational Risk: Measurement and Modelling
Jack King
Interest Rate Modelling
Jessica James and Nick Webber

Practical Portfolio Performance Measurement and Attribution

Carl R. Bacon

John Wiley & Sons, Ltd

Copyright © 2004 John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester,
West Sussex PO19 8SQ, England

Telephone (+44) 1243 779777

Email (for orders and customer service enquiries): cs-books@wiley.co.uk
Visit our Home Page on www.wileyeurope.com or www.wiley.com

All Rights Reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except under the terms of the Copyright, Designs and Patents Act 1988 or under the terms of a licence issued by the Copyright Licensing Agency Ltd, 90 Tottenham Court Road, London W1T 4LP, UK, without the permission in writing of the Publisher. Requests to the Publisher should be addressed to the Permissions Department, John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England, or emailed to permreq@wiley.co.uk, or faxed to (+44) 1243 770620.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The Publisher is not associated with any product or vendor mentioned in this book.

This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the Publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Other Wiley Editorial Offices

John Wiley & Sons Inc., 111 River Street, Hoboken, NJ 07030, USA

Jossey-Bass, 989 Market Street, San Francisco, CA 94103-1741, USA

Wiley-VCH Verlag GmbH, Boschstr. 12, D-69469 Weinheim, Germany

John Wiley & Sons Australia Ltd, 33 Park Road, Milton, Queensland 4064, Australia

John Wiley & Sons (Asia) Pte Ltd, 2 Clementi Loop #02-01, Jin Xing Distripark, Singapore 129809

John Wiley & Sons Canada Ltd, 22 Worcester Road, Etobicoke, Ontario, Canada M9W 1L1

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN 0-470-85679-3

Project management by Originator, Gt Yarmouth, Norfolk (typeset in 10/12pt Times)
Printed and bound in Great Britain by Antony Rowe Ltd, Chippenham, Wiltshire
This book is printed on acid-free paper responsibly manufactured from sustainable forestry in which at least two trees are planted for each one used for paper production.

This book is dedicated to Alex and Matt

Thanks for the support, black coffee and
suffering in silence the temporary suspension of
normal family life

Contents

About the Author		xii
Acknowledgements		xiii
1	**Introduction**	1
	Why measure portfolio performance?	1
	The purpose of this book	2
	Reference	3
2	**The Mathematics of Portfolio Return**	5
	Simple return	5
	Money-weighted returns	7
	Internal rate of return (IRR)	7
	Simple internal rate of return	7
	Modified internal rate of return	8
	Simple Dietz	9
	ICAA method	11
	Modified Dietz	12
	Time-weighted returns	13
	True time-weighted	13
	Unit price method	15
	Time-weighted versus money-weighted rates of return	16
	Approximations to the time-weighted return	18
	Index substitution	18
	Regression method (or β method)	19
	Analyst's test	20
	Hybrid methodologies	21
	Linked modified Dietz	21
	BAI method	22
	Which method to use?	22
	Self-selection	23
	Annualized returns	25
	Continuously compounded returns	28

Gross- and net-of-fee calculations 29
Estimating gross- and net-of-fee returns 30
Performance fees 30
Portfolio component returns 32
Component weight 33
Carve-outs 34
Multi-period component returns 34
Base currency and local returns 35
References 36

3 Benchmarks 39
Benchmarks 39
Benchmark attributes 39
Commercial indexes 40
Calculation methodologies 40
Index turnover 40
Hedged indexes 41
Customized (or composite) indexes 41
Fixed weight and dynamized benchmarks 42
Capped indexes 44
Blended (or spliced) indexes 44
Peer groups and universes 45
Percentile rank 45
Notional funds 46
Normal portfolio 47
Growth and value 47
Excess return 47
Arithmetic excess return 48
Geometric excess return 48

4 Risk 53
Definition of risk 53
Risk management versus risk control 54
Risk aversion 54
Risk measures 54
Ex post and *ex ante* risk 54
Variability 54
Mean absolute deviation 54
Variance 55
Standard deviation 55
Sharpe ratio (reward to variability) 56
Risk-adjusted return: M^2 58
M^2 excess return 59
Differential return 60
Regression analysis 61
Regression equation 62
Regression alpha (α_R) 62

- Regression beta (β_R) 62
- Regression epsilon (ε_R) 62
- Capital Asset Pricing Model (CAPM) 62
- Beta (β) (systematic risk or volatility) 62
- Jensen's alpha (or Jensen's measure or Jensen's differential return) 63
- Bull beta (β^+) 63
- Bear beta (β^-) 63
- Beta timing ratio 63
- Covariance 64
- Correlation (ρ) 64
- R^2 (or coefficient of determination) 66
- Systematic risk 66
- Specific or residual risk 66
- Treynor ratio (reward to volatility) 66
- Modified Treynor ratio 68
- M^2 for beta 68
- Appraisal ratio (Sharpe ratio adjusted for systematic risk) 68
- Modified Jensen 69
- Fama decomposition 69
- Selectivity 69
- Diversification 69
- Net selectivity 70

Relative risk 70
- Tracking error 71
- Information ratio (or modified Sharpe ratio) 71

Return distributions 74
- Normal distribution 74
- Skewness 74
- Kurtosis 74
- d ratio 75

Downside risk 75
- Sortino ratio 76
- M^2 for Sortino 76
- Upside potential ratio 77
- Omega excess return 77
- Volatility skewness 77
- Value at Risk (VaR) 78
- VaR ratio 78
- Hurst index 80

Fixed income risk 80
- Duration 80
- Macaulay duration 81
- Modified duration 81
- Effective duration 81
- Convexity 82
- Modified convexity 82
- Effective convexity 82

Duration beta 82
Which risk measures to use? 82
Risk efficiency ratio 83
Risk control structure 83
References 85

5 Performance Attribution 87
Arithmetic attribution 88
Brinson, Hood and Beebower 88
Asset allocation 89
Security (or stock) selection 89
Interaction 90
Brinson and Fachler 94
Interaction 96
Geometric excess return attribution 98
Asset allocation 99
Stock selection 100
Sector weights 101
Buy-and-hold (or holding-based) attribution 104
Security-level attribution 105
Multi-period attribution 105
Smoothing algorithms 105
Carino 105
Menchero 108
GRAP method 112
Frongello 113
Davies and Laker 115
Multi-period geometric attribution 119
Risk-adjusted attribution 121
Selectivity 122
Multi-currency attribution 125
Ankrim and Hensel 125
Karnosky and Singer 131
Geometric multi-currency attribution 135
Naive currency attribution 135
Compounding effects 139
Interest-rate differentials 141
Currency allocation 142
Cost of hedging 144
Currency timing (or currency selection) 146
Summarizing 149
Other currency issues 149
Fixed income attribution 150
Weighted duration attribution 151
Attribution standards 158
Evolution of performance attribution methodologies 159
References 160

6 Performance Presentation Standards 163
Why do we need performance presentation standards? 163
Advantages for asset managers 164
The standards 165
Verification 167
Investment Performance Council 167
Country Standards Subcommittee (CSSC) 168
Verification Subcommittee 169
Interpretation Subcommittee 169
Guidance statements 170
Definition of firm 170
Carve-outs 170
Portability 171
Supplemental information 172
Achieving compliance 172
Maintaining compliance 173
Reference 174

Appendix A Simple Attribution 175

Appendix B Multi-currency Attribution Methodology 178

Appendix C EIPC Guidance for Users of Attribution Analysis 186

Appendix D European Investment Performance Committee – Guidance on Performance Attribution Presentation 191

Appendix E The Global Investment Performance Standards 204

Bibliography 215

Index 219

About the Author

Carl Bacon joined StatPro Group plc as Chairman in April 2000. StatPro develops and markets specialist middle-office reporting software to the asset management industry. Carl also runs his own consultancy business providing advice to asset managers on various risk and performance measurement issues.

Prior to joining StatPro Carl was Director of Risk Control and Performance at Foreign & Colonial Management Ltd, Vice President Head of Performance (Europe) for J P Morgan Investment Management Inc., and Head of Performance for Royal Insurance Asset Management.

Carl holds a B.Sc. Hons. in Mathematics from Manchester University and is a member of the UK Investment Performance Committee (UKIPC), the European Investment Performance Committee (EIPC) and the Investment Performance Council (IPC). An original GIPS committee member, Carl also chairs the IPC Interpretations Sub-Committee, is ex-chair of the IPC Verification Sub-committee and is a member of the Advisory Board of the *Journal of Performance Measurement*.

Acknowledgements

This book developed from the series of performance measurement trainings courses I have had the pleasure of running around the world since the mid-1990s. I have learned so much and continue to learn from the questions and observations of the participants over the years, all of whom must be thanked.

I should also like to thank the many individuals at work, at conferences and in various IPC committee meetings who have influenced my views over the years and are not mentioned specifically.

Naturally from the practitioner's perspective, I've favoured certain methodologies over others – apologies to those who may feel their methods have been unfairly treated.

I am particularly grateful to Stefan Illmer for his useful corrections and suggestions for additional sections.

Of course, all errors and omissions are my own.

Carl R. Bacon
Deeping St James
September 2004

1 Introduction

The more precisely the position is determined, the less precisely the momentum is known in this instant, and vice versa.

Heisenberg, *The Uncertainty Principle* (1927)

WHY MEASURE PORTFOLIO PERFORMANCE?

Whether we manage our own investment assets or choose to hire others to manage the assets on our behalf we are keen to know "how well" our collection, or portfolio of assets are performing.

The process of adding value via benchmarking, asset allocation, security analysis, portfolio construction and executing transactions is collectively described as the investment decision process. The measurement of portfolio performance should be part of the investment decision process, not external to it.

Clearly there are many stakeholders in the investment decision process; this book focuses on the investors or owners of capital and the firms managing their assets (asset managers or individual portfolio managers). Other stakeholders in the investment decision process include independent consultants tasked with providing advice to clients, custodians, independent performance measurers and audit firms.

Portfolio performance measurement answers the three basic questions central to the relationship between asset managers and the owners of capital:

(1) *What* is the return on assets?
(2) *Why* has the portfolio performed that way?
(3) *How* can we improve performance?

Portfolio performance measurement is the quality control of the investment decision process and provides the necessary information to enable asset managers and clients to assess exactly how the money has been invested and the results of the process. The US Bank Administration Institute (BAI) laid down the foundations of the performance measurement process as early as 1968. The main conclusions of their study hold today:

(1) Performance measurement returns should be based on asset values measured at market value not at cost.

(2) Returns should be "total" returns (i.e., they should include both income and changes in market value – realized and unrealized capital appreciation).
(3) Returns should be time-weighted.
(4) Measurement should include risk as well as return.

THE PURPOSE OF THIS BOOK

The vocabulary of performance measurement and the multiple methodologies open to performance analysts worldwide are extremely varied and complex.

My purpose in writing this book is an attempt to provide a reference of the available methodologies and to hopefully provide some consistency in their definition.

Despite the development and global success of performance measurement standards there are considerable differences in terminology, methodology and attitude to performance measurement throughout the world.

Few books are dedicated to portfolio performance measurement; the aim of this one is to promote the role of performance measurers and to provide some insights into the tools at their disposal.

With its practical examples this book should meet the needs of performance analysts, portfolio managers, senior management within asset management firms, custodians, verifiers and ultimately the clients.

Performance measurement is a key function in an asset management firm, it deserves better than being grouped with the back office. Performance measurers provide real added value, with feedback into the investment decision process and analysis of structural issues. Since their role is to understand in full and communicate the sources of return within portfolios they are often the only independent source equipped to understand the performance of all the portfolios and strategies operating within the asset management firm.

Performance measurers are in effect alternative risk controllers able to protect the firm from rogue managers and the unfortunate impact of failing to meet client expectations.

The chapters of this book are structured in the same order as the performance measurement process itself, namely:

(1) Calculation of portfolio returns.
(2) Comparison against a benchmark.
(3) Proper assessment of the reward received for the risk taken.
(4) Attribution of the sources of return.
(5) Presentation and communicating the results.

First, we must establish what has been the return on assets and to make some assessment of that return compared with a benchmark or the available competition.

In Chapter 2 the "what" of performance measurement is introduced describing the many forms of return calculation, including the relative merits of each method together with calculation examples.

Performance returns in isolation add little value; we must compare these returns

against a suitable benchmark. Chapter 3 discusses the merits of good and bad benchmarks and examines the detailed calculation of commercial and customized indexes.

Clients should be aware of the increased risk taken in order to achieve higher rates of return; Chapter 4 discusses the multiple risk measures available to enhance understanding about the quality of return and to facilitate the assessment of the reward achieved for risk taken.

Chapter 5 examines the sources of excess return with the help of a number of performance attribution techniques.

Finally, in Chapter 6 we turn to the presentation of performance and consider the global development of performance presentation standards.

REFERENCE

BAI (1968) *Measuring the Investment Performance of Pension Funds for the purpose of Inter Fund Comparison*. Bank Administration Institute.

2
The Mathematics of Portfolio Return

Mathematics has given economics rigour, alas also mortis.

Robert Helibroner

SIMPLE RETURN

In measuring the performance of a "portfolio" or collection of investment assets we are concerned with the increase or decrease in the value of those assets over a specific time period – in other words, the change in "wealth".

This change in wealth can be expressed either as a "wealth ratio" or a "rate of return".

The wealth ratio describes the ratio of the end value of the portfolio relative to the start value, mathematically:

$$\frac{V_E}{V_S} \tag{2.1}$$

where: V_E = the end value of the portfolio

V_S = the start value of the portfolio.

A wealth ratio greater than one indicates an increase in value, a ratio less than one a decrease in value.

Starting with a simple example, take a portfolio valued at £100m initially and valued at £112m at the end of the period. The wealth ratio is calculated as follows:

Exhibit 2.1 Wealth ratio

$$\frac{112}{100} = 1.12$$

The value of a portfolio of assets is not always easy to obtain, but should represent a reasonable estimate of the current economic value of the assets. Firms should ensure internal valuation policies are in place and consistently applied over time. A change in valuation policy may generate spurious performance over a specific time period.

Economic value implies that the traded market value, rather than the settlement value of the portfolio should be used. For example, if an individual security has been

bought but the trade has not been settled (i.e., paid for) then the portfolio is economically exposed to any change in price of that security. Similarly, any dividend declared and not yet paid or interest accrued on a fixed income asset is an entitlement of the portfolio and should be included in the valuation.

The rate of return, denoted r, describes the gain (or loss) in value of the portfolio relative to the starting value, mathematically:

$$r = \frac{V_E - V_S}{V_S} \tag{2.2}$$

Rewriting Equation (2.2):

$$r = \frac{V_E}{V_S} - \frac{V_S}{V_S} = \frac{V_E}{V_S} - 1 \tag{2.3}$$

Using the previous example the rate of return is:

Exhibit 2.2 Rate of return

$$\frac{112}{100} - 1 = 12\%$$

Equation (2.3) can be conveniently rewritten as:

$$1 + r = \frac{V_E}{V_S} \tag{2.4}$$

Hence, the wealth ratio is actually the rate of return plus one.

Where there are no "external cash flows" it is easy to show that the rate of return for the entire period is the "compounded return" over multiple sub-periods.

Let V_t equal the value of the portfolio after the end of period t then:

$$\frac{V_1}{V_S} \times \frac{V_2}{V_1} \times \frac{V_3}{V_2} \times \cdots \times \frac{V_{n-1}}{V_{n-2}} \times \frac{V_E}{V_{n-1}} = \frac{V_E}{V_S} = 1 + r \tag{2.5}$$

External cash flow is defined as any new money added to or taken from the portfolio, whether in the form of cash or other assets. Dividend and coupon payments, purchases and sales, and corporate transactions funded from within the portfolio are not considered external cash flows.

Substituting Equation (2.4) into Equation (2.5) we establish Equation (2.6):

$$(1 + r_1) \times (1 + r_2) \times (1 + r_3) \times \cdots \times (1 + r_{n-1}) \times (1 + r_n) = (1 + r) \tag{2.6}$$

This process (demonstrated in Exhibit 2.3) of compounding a series of sub-period returns to calculate the entire period return is called "geometric" or "chain" linking.

Exhibit 2.3 Chain linking

		Market value (£m)	Return (%)
Start value	V_S	100	
End of period 1	V_1	112	12.0
End of period 2	V_2	95	−15.18
End of period 3	V_3	99	4.21
End of period 4	V_4	107	8.08
End value	V_E	115	7.48

$$\frac{112}{100} \times \frac{95}{112} \times \frac{99}{95} \times \frac{107}{99} \times \frac{115}{107} = \frac{115}{100} = 1.15 \quad or \quad 15.0\%$$

$$1.12 \times 0.8482 \times 1.0421 \times 1.0808 \times 1.0748 = 1.15 \quad or \quad 15.0\%$$

MONEY-WEIGHTED RETURNS

Unfortunately, in the event of external cash flows we cannot continue to use the ratio of market values to calculate wealth ratios and hence rates of return. The cash flow itself will make a contribution to the valuation. Therefore, we must develop alternative methodologies that adjust for external cash flow.

Internal rate of return (IRR)

To make allowance for external cash flow we can borrow a methodology from economics and accountancy, the "internal rate of return" or IRR.

The internal rate of return has been used for many decades to assess the value of capital investment or other business ventures over the future lifetime of a project. Normally, the initial outlay, estimated costs and expected returns are well known and the internal rate of return of the project can be calculated to determine if the investment is worth undertaking. The IRR is often used to calculate the future rate of return on a bond and called the yield to redemption.

Simple internal rate of return

In the context of the measurement of investment assets for a single period the IRR method in its most simple form requires that a return r be found that satisfies the following equation:

$$V_E = V_S \times (1 + r) + C \times (1 + r)^{0.5} \tag{2.7}$$

where: C = external cash flow.

In this form we are making an assumption that all cash flows are received at the mid-point of the period under analysis. To calculate the simple IRR we need only the start and end market values, and the total external cash flow as shown in Exhibit 2.4:

Exhibit 2.4 Simple IRR

Market start value	\$74.2m
Market end value	\$104.4m
External cash flow	\$37.1m

$$104.4 = 74.2 \times (1 + r) + 37.1 \times (1 + r)^{0.5}$$

We can see $r = -7.41\%$ satisfies the above equation:

$$74.2 \times (0.9259) + 37.1 \times (0.9259)^{0.5} = 104.4$$

Modified internal rate of return

Making the assumption that all cash flows are received midway through the period of analysis is a fairly crude estimate. The midpoint assumption can be modified for all cash flows to adjust for the fraction of the period of measurement that the cash flow is available for investment as follows:

$$V_E = V_S \times (1 + r) + \sum_{t=1}^{t=T} C_t \times (1 + r)^{W_t} \tag{2.8}$$

where: C_t = the external cash flow on day t

W_t = weighting ratio to be applied on day t.

Obviously, there will be no external cash flow for most days:

$$W_t = \frac{TD - D_t}{TD} \tag{2.9}$$

where: TD = total number of days within the period of measurement

D_t = number of days since the beginning of the period including weekends and public holidays.

In addition to the information in Exhibit 2.4 to calculate the modified internal rate of return shown in Exhibit 2.5 we need to know the date of the cash flow and the length of the period of analysis:

Exhibit 2.5 Modified IRR

Market start value	31 December	\$74.2m
Market end value	31 January	\$104.4m
External cash flow	14 January	\$37.1m