

Wiley Finance Series

Hedge Fund modelling and analysis using MATLAB[®]

PAUL DARBYSHIRE
DAVID HAMPTON

WILEY

Hedge Fund Modelling and Analysis Using MATLAB[®]

For other titles in the Wiley Finance series
please see www.wiley.com/finance

Hedge Fund Modelling and
Analysis Using MATLAB[®]

Paul Darbyshire
David Hampton

WILEY

This edition first published 2014

© 2014 John Wiley & Sons, Ltd

Registered office

John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ,
United Kingdom

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at 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 or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

Wiley publishes in a variety of print and electronic formats and by print-on-demand. Some material included with standard print versions of this book may not be included in e-books or in print-on-demand. If this book refers to media such as a CD or DVD that is not included in the version you purchased, you may download this material at <http://booksupport.wiley.com>. For more information about Wiley products, visit www.wiley.com.

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.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with the respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. It is sold on the understanding that the publisher is not engaged in rendering professional services and neither the publisher nor the author shall be liable for damages arising herefrom. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Library of Congress Cataloging-in-Publication Data is available

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

ISBN 978-1-119-96737-8 (hbk) ISBN 978-1-119-96768-2 (ebk)

ISBN 978-1-119-96767-5 (ebk) ISBN 978-1-118-90502-9 (ebk)

Cover images reproduced by permission of Shutterstock.com

Set in 10/12pt Times by Aptara Inc., New Delhi, India

Printed in Great Britain by TJ International Ltd, Padstow, Cornwall, UK

To Mum & Dad

Thank you for all your love and support, as always.

P.D.

To Marie-Christine, Juliette and Antoine,
with my unconditional love.

D.H.

Contents

Preface	xi
1 The Hedge Fund Industry	1
1.1 What are Hedge Funds?	1
1.2 The Structure of a Hedge Fund	4
1.2.1 Fund Administrators	4
1.2.2 Prime Brokers	5
1.2.3 Custodian, Auditors and Legal	6
1.3 The Global Hedge Fund Industry	6
1.3.1 North America	8
1.3.2 Europe	9
1.3.3 Asia	10
1.4 Specialist Investment Techniques	10
1.4.1 Short Selling	10
1.4.2 Leverage	12
1.4.3 Liquidity	13
1.5 New Developments for Hedge Funds	14
1.5.1 UCITS III Hedge Funds	14
1.5.2 The European Passport	17
1.5.3 Restrictions on Short Selling	17
2 Hedge Fund Data Sources	19
2.1 Hedge Fund Databases	19
2.2 Major Hedge Fund Indices	20
2.2.1 Non-Investable and Investable Indices	20
2.2.2 Dow Jones Credit Suisse Hedge Fund Indices	22
2.2.3 Hedge Fund Research	28
2.2.4 FTSE Hedge	32
2.2.5 Greenwich Alternative Investments	33

2.2.6	Morningstar Alternative Investment Center	35
2.2.7	EDHEC Risk and Asset Management Research Centre	39
2.3	Database and Index Biases	39
2.3.1	Survivorship Bias	40
2.3.2	Instant History Bias	41
2.4	Benchmarking	42
2.4.1	Tracking Error	43
3	Statistical Analysis	45
3.1	Basic Performance Plots	45
3.1.1	Value Added Index	45
3.1.2	Histograms	47
3.2	Probability Distributions	49
3.2.1	Populations and Samples	51
3.3	Probability Density Function	52
3.4	Cumulative Distribution Function	53
3.5	The Normal Distribution	54
3.5.1	Standard Normal Distribution	55
3.6	Visual Tests for Normality	56
3.6.1	Inspection	56
3.6.2	Normal Probability Plot	56
3.7	Moments of a Distribution	58
3.7.1	Mean and Standard Deviation	58
3.7.2	Skew	60
3.7.3	Kurtosis	62
3.8	Covariance and Correlation	63
3.9	Linear Regression	67
3.9.1	Coefficient of Determination	69
3.9.2	Residual Plots	69
3.9.3	Jarque-Bera Test	73
4	Mean-Variance Optimisation	77
4.1	Portfolio Theory	77
4.1.1	Mean-Variance Analysis	77
4.1.2	An Optimisation Problem	81
4.1.3	Sharpe Ratio Maximisation	85
4.2	Efficient Portfolios	87
5	Performance Measurement	97
5.1	The Intuition Behind Risk-Adjusted Returns	97
5.1.1	Risk-Adjusted Returns	99

5.2	Absolute Risk-Adjusted Return Metrics	103
5.2.1	The Sharpe Ratio	105
5.2.2	The Modified Sharpe Ratio	106
5.2.3	The Maximum Drawdown Ratio	107
5.3	Market Model Risk-Adjusted Return Metrics	110
5.3.1	The Information Ratio	111
5.3.2	The Treynor Ratio	113
5.3.3	Jensen's Alpha	118
5.3.4	GH1 Metric	119
5.3.5	The M2 Metric	120
5.3.6	The GH2 Metric	123
5.4	MAR and LPM Metrics	125
5.4.1	The Sortino Ratio	125
5.4.2	The Omega Ratio	127
5.4.3	The Upside Potential Ratio and Group Rankings	129
5.5	Multi-Factor Asset Pricing Extensions	131
5.5.1	The Choice of Factors	133
6	Hedge Fund Classification	137
6.1	Financial Instrument Building Blocks and Style Groups	137
6.2	Hedge Fund Clusters and Classification	138
6.2.1	Metric Definitions	140
6.2.2	Creating Dendrograms	140
6.2.3	Interpreting Dendrograms	141
7	Market Risk Management	155
7.1	Value-at-Risk	155
7.2	Traditional VaR Methods	159
7.2.1	Historical Simulation	159
7.2.2	Parametric Method	161
7.2.3	Monte-Carlo Simulation	162
7.3	Modified VaR	165
7.4	Expected Shortfall	166
7.5	Extreme Value Theory	172
7.5.1	Block Maxima	174
7.5.2	Peaks Over Threshold	174
	References	179
	Index	183

Preface

This book is a practical introduction to modelling and analysing hedge funds based on the MATLAB[®] technical computing environment. MATLAB[®] is a high-level language and interactive environment for numerical computation, visualisation and programming. Using MATLAB[®], you can analyse data, develop algorithms and create models and applications. The language, tools and built-in maths functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java. MATLAB[®] is the foundation for all products, including Simulink[®] and can be extended with add-on products for a whole range of applications, including statistics, computational finance and optimisation.

MATLAB[®] and Simulink[®] are registered trademarks of The MathWorks, Inc.

MATHWORKS CONTACT INFORMATION

For MATLAB[®] and Simulink product information, please contact:

The MathWorks, Inc.
3 Apple Hill Drive
Natick, MA, 01760-2098 USA
Tel: 508-647-7000
Fax: 508-647-7001
E-mail: info@mathworks.com
Web: mathworks.com

1. MATLAB[®] SOURCE CODE

This book assumes a working knowledge of MATLAB[®] and an ability to implement built-in functions and have a familiarity with developing basic MATLAB[®] applications.

All MATLAB[®] source code used throughout the book has been tried and tested with the following MATLAB[®] version and Operating System:

MATLAB[®] Version: 8.1.0.604 (R2013a)

Operating System: Microsoft Windows 8 Version 6.2

Java Version: Java 1.6.0_17-b04 with Sun Microsystems Inc.

All MATLAB[®] source code is displayed in the following format.

In addition, the following MATLAB[®] add-on products were included in the installation:

Financial Toolbox Version 5.2

Optimisation Toolbox Version 6.4

Statistics Toolbox Version 8.3

```
%File: barchart.m
import XL data
[~,dates,returns] = getXLData('hfma_matlab_data.xlsx','CTA Index');
n = size(returns,1); %% data points

figure; %create figure
sDate = datenum(dates(1)); %set start date for x-axis
eDate = datenum(dates(end)); %set end date for x-axis
xData = linspace(sDate,eDate,n);

bar(xData, returns); %plot bar chart
xlabel('Date'); %add x label
ylabel('RoR (%)'); %add y label
box off;
ytick = get(gca,'YTick'); %format axes
set(gca,'YTickLabel', sprintf('%0.2f|',ytick))
datetick('x','yyyy','keeplimits');
```

Sample MATLAB[®] source code

If %< > is used at the top of any MATLAB[®] source code it indicates that part of the code has been omitted for simplicity.

```
%File: optimisation.m
%< . . . . >

%target return, linear constraints and bounds
rstar = 9.0; %target return
Aeq = [R';ones(1,N)];
beq = [rstar;1];
lb = zeros(N,1);
ub = ones(N,1)*0.5;
```

Sample MATLAB[®] source code with code omitted

2. MATLAB® USER-DEFINED FUNCTIONS

As well as making use of numerous MATLAB® built-in functions, there are many user-defined MATLAB® functions (prefixed with the letter “f”) that extend functionality where necessary. All MATLAB® user-defined functions are presented in the following format:

```
%File: fStd.m
%STANDARD DEVIATION
function m2 = fStd(x,flag,f)
%-----
%x:      returns
%flag:   0 = sample, 1 = population
%f:      reporting frequency
%m2:     standard deviation (sample or population)
%-----

        m2 = std(x,flag).*sqrt(f);
end
```

Sample MATLAB® user-defined function

Please note that we do not give any warranty for completeness, nor do we guarantee that the code is error free. Any damage or loss incurred in the application of the MATLAB® source code, functions and concepts discussed in the book are entirely the reader’s responsibility.

If you notice any errors in the MATLAB® source code or you wish to submit a new method as a user-defined MATLAB® function, algorithm, model, or some improvement to a method illustrated in the book, you are more than welcome.

3. HYPOTHETICAL HEDGE FUND DATA

Throughout the book there is constant reference to many hedge fund return series and factors. The 10 hedge funds and 15 factors used are all *hypothetical* and have been simulated by the authors as a unique data set for demonstration purposes only. The techniques and models used in the book can therefore be tested on the hypothetical data before being applied to real-life situations by the reader. The hypothetical data are nonetheless close to what would be expected in reality. The 10 funds are a mixture of several major hedge fund strategies, i.e. Commodity Trading Adviser (CTA), Long-Short Equity (LS),

Global Macro (GM) and Market Neutral (MN) strategies as described in the table below:

10 hypothetical hedge funds

Hedge Fund	Abbreviation
Commodity Trading Advisor	CTA1, CTA2, CTA3
Long-Short Equity	LS1, LS2, LS3
Global Macro	GM1, GM2
Market Neutral	MN1, MN2

The 15 factors are a mixture of both passive and active indices as described in the table below:

15 hypothetical hedge fund factors

#	Beta Factors	Abbreviation
1	Passive Global Stock Index	PSDX
2	S&P 500 Equity Index	S&P 500 Index
3	Passive Global Bond Index	PBond DX
4	Passive Long Global Commodity Index	PCom DX
5	Passive Long US\$ Index	PUSD DX
6	Risk-Free Rate	Rf
Industry Reference Alternative Beta Factors		
7	Commodity Trading Advisor Index	CTA Index
8	Long-Short Equity Index	LS Index
Fama French Carhart Factors		
9	Value minus Growth	Val - Gr
10	Small Cap minus Large Cap	SC - LC
11	Momentum	Mom
Active Alternative Beta Factors		
12	Active Global Stock Futures Index	ASDX
13	Active Global Bond Futures Index	ABDX
14	Active Global Commodity Futures Index	ACDX
15	Active Global Foreign Exchange Futures Index	AFDX

4. BOOK WEBSITE

The official website for the book is located at:

www.darbyshirehampton.com

The website provides free downloads to all of the hypothetical data and MATLAB® source code as well as many other useful resources.

The authors can be contacted on any matter relating to the book, or in a professional capacity, at the following email addresses:

Paul Darbyshire: pd@darbyshirehampton.com

David Hampton: dh@darbyshirehampton.com

The Hedge Fund Industry

The global credit crisis originated from a growing bubble in the US real estate market which eventually burst in 2008. This led to an overwhelming default of mortgages linked to subprime debt to which financial institutions reacted by tightening credit facilities, selling off bad debts at huge losses and pursuing fast foreclosures on delinquent mortgages. A liquidity crisis followed in the credit markets and banks became increasingly reluctant to lend to one another causing risk premiums on debt to soar and credit to become ever scarcer and more costly. The global financial markets went into meltdown as a continuing spiral of worsening liquidity ensued. When the credit markets froze, hedge fund managers were unable to get their hands on enough capital to meet investor redemption requirements. Not until the early part of 2009 did the industry start to experience a marked resurgence in activity realising strong capital inflows and growing investor confidence. Nevertheless, this positive growth has since been slowed as a result of the on-going European sovereign debt crisis affecting the global economy.

The aftermath of the financial crisis has clearly highlighted many of the shortcomings of the hedge fund industry and heightened the debate over the need for increased regulation and monitoring. Nevertheless, it has since been widely accepted that hedge funds played only a small part in the global financial collapse and suffered at the hands of a highly regulated banking system.

Chapter 1 introduces the concept of a hedge fund and a description of how they are structured and managed as well as a discussion of the current state of the global hedge fund industry in the light of past and more recent financial crises. Several key investment techniques that are used in managing hedge fund strategies are also discussed. Chapter 1 aims to build a basic working knowledge of hedge funds, and along with an overview of hedge fund data sources in Chapter 2, arm the reader with the information required in order to approach and understand the more quantitative and theoretical aspects of modelling and analysis developed in later chapters.

1.1 WHAT ARE HEDGE FUNDS?

Whilst working for *Fortune* magazine in 1949, Alfred Winslow Jones began researching an article on various fashions in stock market forecasting and soon

realised that it was possible to neutralise *market risk*¹ by buying undervalued securities and *short selling*² overvalued ones. Such an investment scheme was the first to employ a *hedge* to eliminate the potential for losses by cancelling out adverse market moves, and the technique of *leverage*³ to greatly improve profits. Jones generated an exceptional amount of wealth through his *hedge fund* over the 1950s and 1960s and continually outperformed traditional money managers. Jones refused to register the hedge fund with the Securities Act of 1933, the Investment Advisers Act of 1940, or the Investment Company Act of 1940, the main argument being that the fund was a *private* entity and none of the laws associated with the three Acts applied to this type of investment. It was essential that such funds were treated separately to other regulated markets since the use of specialised investment techniques, such as short selling and leverage, was not permitted under these Acts, neither was the ability to charge performance fees to investors.

So that the funds maintained their *private* status, Jones would never publicly advertise or market the funds but only sought investors through word of mouth, keeping everything as secretive as possible. It was not until 1966, through the publication of a news article about Jones' exceptional profit-making ability, that Wall Street and *High Net Worth*⁴ (HNW) individuals finally caught on and within a couple of years there were over 200 active hedge funds in the market. However, many of these hedge funds began straying from the original *market neutral* strategy used by Jones and employed other seemingly more volatile strategies. The losses investors associated with highly volatile investments discouraged them from investing in hedge funds. Moreover, the onset of the turbulent financial markets experienced in the 1970s practically wiped out the hedge fund industry altogether. Despite improving market conditions in the 1980s, only a handful of hedge funds remained active over this period. Indeed, the lack of hedge funds around in the market during this time changed the regulators' views on enforcing stricter regulation on the industry altogether. Not until the 1990s did the hedge fund industry begin to rise to prominence again and attract renewed investor confidence.

Nowadays, hedge funds are still considered private investment schemes (or vehicles) with a collective pool of capital only open to a small range of institutional investors and/or wealthy individuals and having minimal regulation. They can be as diverse as the manager in control of the capital wants to be in

¹ *Market risk* (or *systematic risk*) is the risk that the value of an investment will decrease due to the impact of various market factors, for example changes in interest and foreign currency rates.

² See Section 1.4.1.

³ *Leverage* is the use of a range of financial instruments or borrowed capital to increase the potential return of an investment (see Section 1.4.2).

⁴ A *High Net Worth* (HNW) individual (or family) is generally assumed to have investable assets in excess of \$1 million, excluding any primary residence.