

**Building
Quantitative Finance
Applications with R**

**Quantitative Finance
Materials**

Robert Brooks

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December 2023

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Library of Congress Cataloging-in-Publication Data

Brooks, Robert, 1960-

Building Quantitative Finance Applications with R/Robert Brooks.

p. cm.

ISBN-13: XXX-XXXXXXXXXX (paper)

ISBN-10: XXXXXXXXXXX

1. Quantitative Finance. 2. R. 3. Financial Valuation. 4. Financial Risk Management

Printed in the United States of America

To my wife Ann,
as well as our children,
and our many grandchildren.

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Part 1: Foundation of Quantitative Finance

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Opening Quote

“The real trouble with this world of ours is not that it is an unreasonable world, nor even that it is a reasonable one. The commonest kind of trouble is that it is nearly reasonable, but not quite. Life is not an illogicality; yet it is a trap for logicians. It looks just a little more mathematical and regular than it is; its exactitude is obvious, but its inexactitude is hidden; its wildness lies in wait.”

G. K. Chesterton, *Orthodoxy*, 1908.

Preface

Two driving forces that make books of this nature possible: First, developing computer programs using the interactive R language is easily within reach of the financial analyst. Every effort is made here to keep the R programming elementary. One objective is for financial analysts to quickly learn to express their ideas in the R computer language. Second, quantitative finance is now widely applied in a variety of career fields. Quantitative financial analysts are now needed in a variety of different arenas. The ability for these analysts to express their own ideas in R is a highly valued skill.

Finance is a social science. Thus, as ideas about how certain financial products should be valued and managed evolve, the actual value and risk properties also change. Therefore, there will never be a “theory of everything” in finance. More likely, we should be surprised if there ever appears a “theory of anything” that endures for very long. Because of the dynamic nature of financial markets, financial analysts need to be able to rapidly adapt their valuation and risk management models to changing times. Rather than rely on faulty communication between analysts and professional programmers, financial analysts can express their ideas in prototype R code. Prototype code is not designed to be the final implementation within an enterprise computer system, rather it is a template that can be used by professional programmers to develop enterprise application enhancements. This ability dramatically reduces errors and allows financial analysts greater precision in expressing their ideas.

Building Quantitative Finance Applications with R is written for college students and entry-level financial analysts. No prior knowledge of programming is assumed. As with any language, having access to multiple sources when learning technical material is highly recommended. Therefore, it is assumed that you have access to several introductory R books or similar web-based materials. In 2000, when *Building Financial Derivatives Applications with C++* was first published, the combination of financial analysis with C++ was unique. Today, there are several other books linking quantitative finance with computer programming. The approach taken here, like my prior books, is distinctly different. Rather than present state-of-the-art programming techniques, we use only elementary R. Rarely do financial analysts want to become professional programmers. Rather, they want to rapidly learn how to express their unique analytical ideas in a form that the computer can run. Therefore, we focus on the minimal set of computer programming tools necessary to perform this task.

This book is a natural extension of *Building Financial Derivatives Applications with C++* published in 2000 and *Building Financial Risk Management Applications with C++* published in 2013. The focus of those books was financial derivatives valuation and financial risk management, respectively. With the rapid advance of the open-source and free R programming language as well as the ease of integrating the C++ programming language there is a need for an additional book. Though not covered in this book, pairing R with C++ using the RCpp package is a natural extension for financial analysts. The focus in this book is on quantitative finance, including both financial derivatives valuation as well as financial risk management.

This book contains the following features:

- 1) Elementary R programming techniques and modern quantitative finance methodologies are brought together. For ease of exposition, the R commentaries are separated from the quantitative finance materials.
- 2) We use the modular approach starting in Chapter 4 to make learning specific content easier. The modular approach allows for the independent study of that particular implementation

instead of each subsequent concept requiring a thorough knowledge of the preceding concepts. Many modules, however, incorporate prior material.

- 3) Clear development of a repository allows for efficient code reuse. Throughout this book, the repository is assumed to be the directory “/QFRpository/”. Every module is in a separate subdirectory affording the ability to jump around depending on your needs. For example, the corporate bond valuation code covered in Chapter 4 will be found in “/QFRpository/Ch 4 Valuation Bonds and Stocks/Ch 4.2 Valuation Corporate Bonds/”. Thus, bond valuation is covered in the second module of Chapter 4.
- 4) Source code, numerous supplements, and other materials are provided at www.robtebrooks.org.

All the source code illustrated in this book, as well as many more materials on this subject, can be found at www.robtebrooks.org.

Any book of this length addressing a technical topic of this nature will contain errors. An errata sheet will also be available at www.robtebrooks.org. I would be deeply grateful if you could help me locate more of them. Please provide your feedback at the Contact tab at www.robtebrooks.org.

Robert Brooks

Tuscaloosa, Alabama
December 2023

Acknowledgements

This work is based on more than thirty five years of quantitative finance (mostly financial derivatives and financial risk management) training for college students in Alabama. Many students provided insights that have helped improve communicating complex quantitative finance concepts. Alumni that have stayed in touch assist in providing color on what does and does not work in practice.

Over these decades, I have learned the most from this experience. The style of presentation here has been heavily influenced by many attempts to explain the nexus between financial theory, quantitative finance practice, and computer programming. The work has also been impacted by numerous consulting engagements related to financial derivatives, financial risk management, and financial litigation.

Three of my sons, Joshua, Stephen, and Phillips, are now finance professionals. They have further provided an enormous amount of insights on finance practice for which I am grateful.

Back Cover

There are many good books related to financial valuation, financial risk management, as well as quantitative finance. The goal here is to integrate financial valuation, financial risk management, quantitative finance, and R implementation issues. We do not attempt to provide state-of-the-art quantitative techniques often found in quantitative finance books oriented primarily toward advanced mathematics or physics. Rather we provide simple insights into actually deploying these models *yourself* in R. Because of the unique nature of financial valuation, such as determining the value of some derivative instrument, many useful concepts are available that will improve financial decision-making. Hence, we seek to help you make better financial decisions with insights gleaned through implementing quantitative finance models in R.

Biographical Sketch

Robert E. Brooks, Ph.D., CFA is the President of Financial Risk Management, LLC, a financial risk management consulting firm focused on market risks (www.frmhelp.com). Brooks has retired from a 37-year career as a finance professor focused on financial risk management. He was also the founding partner of Blue Creek Investment Partners, LLC, a money management firm (merged with Keel Point, LLC in 2014).

Brooks is the author of over 85 articles appearing in the *Journal of Financial and Quantitative Analysis*, *Journal of Derivatives*, *Journal of Banking and Finance*, *Financial Management*, and others. Further, he is the co-author of *An Introduction to Derivatives and Risk Management* (Seventh through Tenth Editions) with Don Chance and has authored several books including *Building Financial Risk Management Applications with C++*. Brooks has been quoted in several print media, including *The Wall Street Journal*, *Bloomberg News*, *New York Times*, and *The Bond Buyer*. Brooks has also testified in a subcommittee hearing of the U. S. House of Representatives in Washington, D.C. as well as in a field hearing of the SEC in Birmingham, Alabama.

Brooks has consulted with major public utilities, energy companies, auditing firms, corporations, investment bankers, elected municipal officials, and commercial bankers regarding managing financial risks, derivatives valuation and software development. Brooks has served as an expert witness in several court cases and enjoys speaking opportunities on various aspects of finance, particularly the intersection of worldview and finance. For more details, click the CV tab at www.robtebrooks.org.