1. Introduction and Outline

Who/ How/What, "Tech. Index", Messages, Personal Note

1. For Whom is This Book Written?

This book is primarily for PhD scientists and engineers who want to learn about quantitative finance, and for graduate students in finance programs[1]. Practicing quantitative analysts ("quants") and research workers will find topics of interest. There are even essays with no equations for non-technical managers.

2. How Can This Book Benefit You?

This book will enable you to gain an understanding of practical and theoretical quantitative finance and risk management.

3. What is In This Book?

The book is a combination of a practical "how it's done" book, a textbook, and a research book. It contains techniques and results for quantitative problems with which I have dealt in the trenches for over fifteen years as a quant on Wall Street. Each topic is treated as a unit, sometimes drilling way down. Related topics are presented parallel, because that is how the real world works. An informal style is used to convey a picture of reality. There are even some stories.

4. What is the "Tech. Index"? What Finance Background is Needed?

The "Tech. Index" for each chapter is a relative index for this book lying between 1-10 and indicating mathematical sophistication. The average index is 5. An index 1-3 requires almost no math, while 8-10 requires a PhD and maybe more. No background in finance is assumed, but some would definitely be helpful.

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[1] **History:** The book is an outgrowth of my tutorial on Risk Management given annually for five successive years (1996-2000) at the Conference on Intelligence in Financial Engineering (CIFEr), organized jointly by the IEEE and IAFE. The attendees comprised roughly 50% quantitative analysts holding jobs in finance and 50% PhD scientists or engineers interested in quantitative finance.

5. How Should You Read This Book? What is in the Footnotes?

You can choose topics that interest you. Chapters are self-contained. The footnotes add depth and commentary; they are useful sidebars.

6. Message to Non-Technical Managers

Parts of this book will help you get a better understanding of quantitative issues. Important chapters have discussions of systems, models, and data. Skip sections with equations (or maybe read chapters with the Tech. Index up to 3).

7. Message to Students

You will learn quantitative techniques better if you work through derivations on your own, including performing calculations, programming and reflection. The mathematician George Polya gave some good advice: "The best way to learn anything is to discover it by yourself". Bon voyage.

8. Message to PhD Scientists and Engineers

While the presentation is aimed at being self-contained, financial products are extensive. Reading a finance textbook in parallel would be a good idea.

9. Message to Professors

Part of the book could be used in a PhD finance course (Tech. Index up to 8), or for MBAs (Tech. Index up to 5). Topics you may find of interest include: (1) Feynman path integrals and Green functions for options, (2) The Macro-Micro model with explicit time scales connecting to both macroeconomics and finance, (3) Optimally stressed correlation matrices, (4) Enhanced/Stressed VAR.

10. A Personal Note

This book is largely based on my own work and/or first-hand experience. It is in part retrospective, looking back over trails traversed and sometimes blazed. Some results are in 1988-89 CNRS preprints when I was on leave from the CNRS as the head of the Quantitative Analysis Group at Merrill Lynch, in my 1993 SIAM Conference talk, and in my CIFEr tutorials. Footnotes entitled "*History*" contain dates when my calculations were done over the years, along with recollections[2].

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[2] **History:** To translate dates, my positions were VP Manager at Merrill Lynch (1987-89); Director at Eurobrokers (1989-90), Director at Fuji Capital Markets Corp. (1990-93), VP at Citibank (1993), and Director at Smith Barney/Salomon Smith Barney/Citigroup (1993-2003). I managed PhD Quantitative Analysis Groups at Merrill, FCMC, and at SB/SSB/Citigroup through various mergers.

Summary Outline: Book Contents

The book consists of six divisions.

I. Qualitative Overview of Risk

A qualitative overview of risk is presented, plus an instructive and amusing exercise emphasizing communication.

II. Risk Lab for Derivatives (Nuts and Bolts of Risk Management)

The "Risk Lab" first examines equity and FX options, including skew. Then interest rate curves, swaps, bonds, caps, and swaptions are discussed. Practical risk management including portfolio aggregation is discussed, along with static and time-dependent scenario analyses.

This is standard textbook material, and directly relevant for basic quantitative work.

III. Exotics, Deals, and Case Studies

Topics include barriers, double barriers, hybrids, average options, the Viacom CVR, DECs, contingent caps, yield-curve options, reloads, index-amortizing swaps, and various other exotics and products.

By now, this is mostly standard material. The techniques presented in the case studies are generally useful, and would be applicable in other situations.

IV. Quantitative Risk Management

Topics include optimally stressed positive-definite correlation matrices, fat-tail volatility, Plain/Stressed/Enhanced VAR, CVAR uncertainty, credit issuer risk, model issues and quality assurance, systems issues and strategic computing, data issues, the Wishart Theorem, economic capital, and unused-limits risk. This is the largest of the six divisions of the book.

Much of this material is standard, although there are various improvements and innovations.

V. Path Integrals, Green Functions, and Options

Feynman path integrals provide an explicit and straightforward method for evaluating financial products, e.g. options. The simplicity of the path integral technique avoids mathematical obscurity. My original applications of path integrals and Green functions to options are presented, including pedagogical examples, mean-reverting Gaussian dynamics, memory effects, multiple variables, and two related straightforward proofs of Girsanov's theorem. Consistency with the stochastic equations is emphasized. Numerical aspects are

treated, including the Castresana-Hogan path-integral discretization. Critical exponents and the nonlinear-diffusion Reggeon Field Theory are briefly discussed.

The results by now are all known. The presentation is not standard.

VI. The Macro-Micro Model (A Research Topic)

The Macro-Micro model, developed initially with A. Beilis, originated through an examination of models capable of reproducing yield-curve dynamical behavior – in a word, producing yield curve movements that look like real data. The model contains separate mechanisms for long-term and short-term behaviors of rates, with explicit time scales. The model is connected in principle with macroeconomics through quasi-random quasi-equilibrium paths, and it is connected with financial models through strong mean-reverting dynamics for fluctuations due to trading. Further applications of the Macro-Micro model to the FX and equities markets are also presented, along with recent formal developments. Option pricing and no-arbitrage in the Macro-Micro framework are discussed. Finally a "function toolkit", possibly useful for business cycles and/or trading, is presented.

I believe that these topics will form a fruitful area for further research and collaborations.

2. Overview (Tech. Index 1/10)

In this overview, we look at some general aspects of quantitative finance and risk management. There is also some advice that may be useful. A reminder: the footnotes in this book have interesting information. They function as sidebars, complementing the text[1].

Objectives of Quantitative Finance and Risk Management

The general goal of quantitative finance and risk management is to quantify the behavior of financial instruments today and under different possible environments in the future. This implies that we have some mathematical or empirical procedure of determining values of the instruments as well as their changes in value under various circumstances. While the road is long, and while there has been substantial progress, for many reasons this goal is only partially achievable in the end and must be tempered with good judgment. Especially problematic are the rare extreme events, which are difficult to characterize, but where most of the risk lies.

Why is Quantitative Finance a Science?

Outwardly, the quantitative nature of modern finance and risk management seems like a science. There are models that contain theoretical postulates and proceed along mathematical lines to produce equations valuing financial instruments. There are "experiments" which consist of looking at the market to determine values of financial instruments, and which provide input to the theory. Finally, there are computer systems, which keep track of all the instruments and tie everything together.

Why is Quantitative Finance not a Science?

In science there is real theory in the sense of Newton's laws (F = ma) backed by a large collection of experiments with high practical predictive power and known

[1] **Why Read the Footnotes?** Robert Karplus, the physicist who taught the graduate course in electromagnetism at Berkeley, said once that the most interesting part of a book is often in the footnotes. The footnotes are an integral part of this book.

domains of applicability (for Newton's laws, this means objects not too small and not moving too fast).

In contrast, financial theoretical "postulates", when examined closely, turn out to involve assumptions, which are at best only partially justifiable in the real world. The financial analogs to scientific "experiments" obtained by looking at the market are of limited value. Market information may be quite good, in which case not much theory is needed. If the market information is not very good, the finance theory is relatively unconstrained. Finance computer systems are always incomplete and behind schedule (this is a theorem).

Quantitative Finance is Not Science but Phenomenology

The situation characterizing quantitative finance is really what physicists call "phenomenology". Even if we could know the "Newton laws of finance", the real world of finance is so complex that the consequences of these laws could not be evaluated with any precision. Instead, there are financial models and statistical arguments that are only partially constrained by the real world, and with unknown domains of applicability, except that they often break when the market conditions change in an extreme fashion. The main reason for this fragility is that human psychology and macroeconomics are fundamentally involved. The worst cases for risk management, such as the onset of collective panic or the potential consequences of a deep recession, are impossible to quantify uniquely—extra assumptions tempered by judgment must be made.

What About Uncertainties in the Risk Itself?

A characteristic showing why risk management is not science deals with the lack of quantification of the uncertainties in risk calculations and estimates. Uncertainty or error analysis is always done in scientific experiments. It is preferable to call this activity "uncertainty" analysis because "error" tends to conjure up human error. While human error should not be underestimated, the main problem in finance often lies with uncertainties and incompleteness in the models and/or the data. Risk measurement is standard, but the *uncertainty* in the risk itself is usually ignored.

We will discuss one example in determining the uncertainty in risk when we discuss the uncertainties in the components of risk (CVARs) that lead to a given total risk (VAR) at a given statistical level. We hope that such measures of uncertainty will become more common in risk management.

In finance, there is too often an unscientific accounting-type mentality. Some people do not understand why uncertainties should exist at all, tend to become ill tempered when confronted with them, and only reluctantly accept their existence. The situation is made worse by the meaningless precision often used by risk managers and quants to quote risk results. Quantities that may have uncertainties of a factor of two are quoted to many decimal places. False confidence, misuse and misunderstanding can and does occur. A fruitless activity is attempting to

explain why one result is different from another result under somewhat different circumstances, when the numerical uncertainties in all these results are unknown and potentially greater than the differences being examined.

Tools of Quantitative Finance and Risk Management

The main tools of quantitative finance and risk management are the models for valuing financial instruments and the computer systems containing the data corresponding to these instruments, along with recipes for generating future alternative possible financial environments and the ability to produce reports corresponding to the changes of the portfolios of instruments under the different environments, including statistical analyses. Risk managers then examine these reports, and corrective measures or new strategies are conceived.

The Greeks

The common first risk measures are the "Greeks". These are the various low-order derivatives of the security prices with respect to the relevant underlying variables. The derivatives are performed either analytically or numerically. The Greeks include delta and gamma (first and second derivatives with respect to the underlying interest rate, stock price etc.), vega[2] (first derivative with respect to volatility), and others (mortgage prepayments, etc.). The Greeks are accurate enough for small moves of the underlying, i.e. day-to-day risk management.

Hedges

Hedges are securities that offset risk of other securities. Knowledge of the hedges is critical for trading risk management. Say we have a position or a portfolio with value C depending on one or several variables $\{x_\alpha\}$ (e.g. interest rates, FX rates, an equity index, prepayments, gold, ...). Say we want a hedge H depending on possibly different variables $\{y_\beta\}$. Naturally, the trader will not hedge out the whole risk, because to do so he would have to sell exactly what he buys (back-to-back). Therefore, there will be a decision, consistent with the limits for the desk, to hedge out only part of the risk. Hedging risk can go wrong in a number of ways. Generically, the following considerations need to be taken into account:

[2] **Vega the Greek?** Who thought up this name? Vega does happen to be the 5th brightest star, but this is irrelevant.

1. The hedge variables $\{y_\beta\}$ may not be the same as the portfolio variables $\{x_\alpha\}$, although reasonably correlated. However, historically reasonable hedges can and do break down in periods of market instability.

2. Some of the hedge variables may have little to do with the portfolio variables, and so introduce a good deal of extra risk on their own.

3. The hedge may be too costly to implement, not be available, etc.

Scenarios ("What-if", Historical, Statistical)

In order to assess the severity of loss to large moves, scenario or statistical analyses are employed. A "what-if" scenario analysis will postulate, during a given future time frame, a set of changes of financial variables. A historical scenario analysis will take these changes from selected historical periods. A statistical analysis will use data, also from selected historical periods, and categorize the anomalous large moves ("fat tails") statistically. Especially important, though because of technical difficulties often overlooked, are changes in the correlations. We will deal with these issues in the book at length.

Usually the scenarios are treated using a simplistic time-dependence, a quasi-static assumption. That is, a jump forward in time by a certain period is assumed, and at the end of this period, the changes in the variables are postulated to exist. The jump forward in time is generally zero ("immediate changes") or a short time period (e.g. 10 days for a standard definition of "Value at Risk"). This can be improved by choosing different time periods corresponding to the liquidity characteristics of different products (short periods for liquid products easy to sell, longer periods for illiquid products hard to sell).

Usually, the risk is determined for a portfolio at a given point in time. Scenarios can also involve assumptions about the future changes in the portfolios. For example, under stressed market conditions and losses, it might be postulated that a given business unit would sell a certain fraction of inventory, consistent with business objectives. Extra penalties can be assessed for selling into hostile markets. These require estimation of the action of other institutions, volumes, etc. The worst is an attitude similar to "I don't care what you think your buggy whip is worth, I won't pay that much" that leads to the bottom falling out of a market.

Monte-Carlo Simulation

A more sophisticated risk approach uses a Monte Carlo simulator, which generates possible "worlds" marching forward in time. Either a mathematical formula can be given to generate the possible worlds, or successive scenarios can be chosen with subjective probabilities. Such calculations have more assumptions

(this is bad) but lead to more detailed information and avoid some of the crude approximations of the static analyses (this is good).

For the most part, complete Monte-Carlo simulations (except for small portfolios or large portfolios on a limited basis) are a topic for future risk management. Implementation requires a parallel-processing systems effort, as described in Ch. 35.

Data and Risk

Knowledge of the historical data changes in different time frames plays a large role in assessing risk, especially anomalously large moves as well as the magnitudes of moves at different statistical levels. It is also important to know the economic or market forces that existed at the time to get a subjective handle of the probability that such moves could reoccur. While "the past is no guarantee of the future", the truth is nonetheless that the past is the only past we have, and we cannot ignore the past.

Problematic Topics of Risk: Models, Systems, Data

A summary of topics treated in more detail in other parts of the book includes:

1. *Models:* (Model Risk; Time Scales; Mean Reversion; Jumps and Nonlinear Diffusion; Long-Term Macro Quasi Random Behavior; Model Limitations; Which Model; Psychological Attitudes; Model Quality Assurance; Parameters).

2. *Systems:* (What is a System?; Calculators; Traps; Communication; Birth and Development; Prototyping; Who's in Control?; Mergers and Startups; Vendors; New Paradigms; Systems Solutions)

3. *Data:* (Consistency, Reliability, Completeness, Vendors)

The Traditional Areas of Risk Management

Risk management is traditionally separated into Market Risk and Credit Risk. There is a growing concern with Operation Risk.

Market Risk

Market risk is the risk due to the fluctuation of market variables. Market risk is separated out into functional business areas, including Interest Rates, Equities, FX, Emerging Markets, Commodities, etc. Further subdivisions include cash products (bonds, stocks), derivatives (plain vanilla, exotics), structured products (MBS, ABS), etc. Individual desks correspond to further detail (e.g. the desk for

mortgage derivatives, or the high-yield bond desk). Each area will have its own risk management expertise requirements. We will spend a lot of time in this book discussing market risk.

A corporate-level measure of market risk is called VAR (Value at Risk). We will discuss various levels of sophistication of VAR, ending with a quite sophisticated measure that in this book is called Enhanced/Stressed VAR.

Credit Risk

Credit risk includes several areas, including traditional credit risk assessment of corporations, credit issuer risk, and counterparty risk.

Traditional credit risk assessment by rating agencies involves financial statistics (balance sheet, cash flows), comparisons, and in-depth analysis.

Credit issuer risk is the risk due to defaults and downgrades of issuers of securities, notably bonds. We will discuss issuer risk in some detail in this book.

Counterparty risk is due to nonperformance of counterparties to transactions. We will only mention counterparty risk briefly.

Unified Market and Credit Risk Management?

Market risk and credit risk are correlated. In times of bad markets, credit risk increases. Conversely, if credit risk is increasing because of economic weakness, the markets will not be bullish. Moreover, there are double counting issues. For example, market risk for credit products is determined using spread fluctuation data. There are technical market spread components and potential default spread components. We will see in Ch. 31 that spread movements can be distinguished for particular definitions of market and credit risk. However, it would be better if market and credit risk management were integrated. Unfortunately, the languages spoken by the two departments are largely disjoint and there can be legacy structural issues that hamper communication and integration.

Operational Risk

Operational risk deals with the risk of everything else, losses due to the "1001 Risks". One presentation tried to get the topics of operational risk on one slide. The slide contained such small font that it appeared black. Operational risk can be thought of as "Quantifying Murphy's Law" with large entropy of possibilities that can go wrong. Included here are human error, rogue traders, fraud, legal risk, organizational risk, system risk etc. Model risk could be regarded as operational (it has to go somewhere). The recent accounting and analyst scandals would also be classified as operational risk. The worst part about a major loss from operational risk is that it is always new and unexpected.

When Will We Ever See Real-Time Color Movies of Risk?

Soon after starting work on the Street in the mid 80's, I had a vision of real-time risk management, with movies in color of risk changing with the market and with the portfolio transactions. I'm still waiting. Drop me an e-mail if you see it.

Many People Participate in Risk Management

In a general sense, a vast number of people are involved in risk management. These include traders, risk managers (both at the desk level and at the corporate level), systems programmers, managers, regulators, etc in addition to the quants. All play important roles. Commonly, risk management is thought of in terms of a corporate risk management department, but it is more general.

Systems Programmers

Systems play a large role in the ability to carry out successful risk management. Systems programmers naturally need expertise in traditional computer science areas: code development, databases, etc. It is often overlooked but it is advantageous from many points of view if programmers understand what is going on from a finance and math point of view.

Traders

Traders need to understand intimately the risks of the products they trade. Sometimes traders are quants on the desk. Risk reports are designed by analysts or traders and coded by the programmers. There are however innumerable exceptions—for example, a trader writing her own models on spreadsheets and generating local desk risk reports from them. Traders use the models while exercising market judgment to gauge risk.

Risk Managers

Desk and corporate risk managers need some quantitative ability and must possess a great deal of practical experience. Risk managers also have a responsibility to understand the risks of business decisions and strategies (e.g. customer-based or proprietary trading, new products, etc).

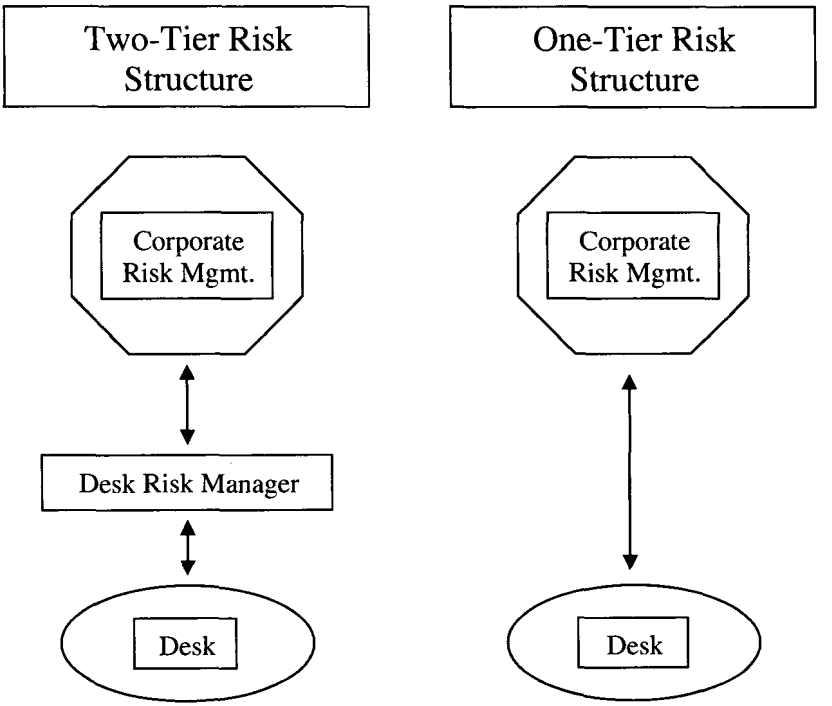
Corporate Risk Management

Corporate risk management aggregates and analyzes portfolio risk, and analyzes deals with unusual risk. Corporate risk management also performs limit oversight for the business units. The risk results are summarized for upper management in presentations. A corporate-level assessment of risk is extremely difficult because

of the large number of desks and products. Collecting the data can be a monumental task. Inconsistent risk definitions between desks and other issues complicate the task.

Two Structures for Corporate Risk Management

There are two common structures for corporate risk management. The diagram illustrates the alternatives of the two-tier or one-tier risk management structure:



In the one-tier risk structure, the corporate risk management department is in direct contact with traders on a given desk. In this structure, the corporate risk manager follows the day-to-day trading risk details as well as participating in the other activities of corporate risk management. In the two-tier risk structure there is an intermediate desk or business risk manager. Here, the desk risk manager interacts with the traders. The desk risk manager then summarizes or emphasizes unusual risk to the corporate risk department[3].

[3] **Risk Management Structure:** The paradigm adopted depends on the risk-management philosophies of the trading desks and of corporate risk management. Different structures may apply to different desks. The two-tier solution requires a division of responsibilities. There are advantages and disadvantages for each of the structures.

Quants in Quantitative Finance and Risk Management

First, what is a "Quant"? This is a common (though not pejorative) term mostly applied to PhDs in science, engineering, or math doing various quantitative jobs on Wall Street [4], also called The Street.

Jobs for Quants

We start with jobs involving models. Risk is measured using models. Here the standard paradigm is that models are developed by PhD quants writing their own code, while systems programmers develop the systems into which models are inserted.

A quant writing a model to handle the risks for a new product needs to understand the details of the financial instruments he/she is modeling, the theoretical context, the various parameters that become part of the model, the numerical code implementing the model etc. The numerical instabilities of the models need to be assessed and understood.

Many other jobs for quants exist besides writing or coding models. They include risk management, computer work, database work, becoming a trader, etc.

Looking for a Job

If you are serious about pursuing a career, try to find people in the field and talk to them. Networking is generally the best way for finding a job. Headhunters can be useful, but be aware that they probably have many resumes just as impeccable as yours. At this late date, there are many experienced quants out there. If you get to the interview stage, find out as much as possible about what work the group actually does. You have to want to do the job, and be willing to give 110%. Enthusiasm counts.

On the Job: What's the Product?

The product on the job depends on the situation. Changing conditions can and do lead to changing requirements. Flexibility is important. Don't be afraid to make a suggestion – you may have a good idea. An essential piece of advice is to "Solve problems and don't cause problems".

Creativity and the 80-20 Rule

Creative thinking and prioritized problem-solving abilities are key attributes for a quant, along with the skill to apply the "80-20" rule (get 80% of the way there with 20% of the effort) in a reasonable time.

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[4] **"Wall Street":** This means any financial institution, not just the street in New York.

Communication Skills

Communication is critical. Decisions often must (or at least should) be made with input involving quantitative analyses. Specifically the skills needed to write clear concise memos or to give quick-targeted oral presentations in non-quantitative terms while still getting the ideas and consequences across are very important and should not be overlooked[5].

Message to PhD Scientists and Engineers Who Want to Become Quants

For model building and risk management, you need to know how to program fluently in at least one language (C, C^{++}, or Fortran) [6]. No exceptions. Fluent means that you have had years of experience and you do not make trivial mistakes. Prototyping is important and extremely useful. Prototyping can be done with spreadsheets (also Visual Basic), or with packages like Mathematica, PV Wave, Matlab, etc. However, prototyping is not a replacement for serious compiled code. Knowledge of other aspects of computer science can also be useful (GUIs, databases and SQL, hardware, networking, operating systems, compilers, Internet, etc).

For background, in addition to this book (!), read at least one finance text and some review articles or talks[i]. Conferences can be useful. Try to learn as much as possible about the jargon. Become acquainted to the extent possible with data and get a feel for numerical fluctuations. Be able to use the numerical algorithms for modeling, including Monte Carlo and diffusion equation discretization solvers. Learn about analytic models. Learn about risk.

Message to Quants Who Want to Become Quant-Group Managers

If you learn too much about quantitative analysis, finance and systems—and if you can manage people—you may wind up as the manager of a Quant Group. You now have to work out the mix between managing responsibilities and continuing your work as a quant.

Managing quants can be rather like a description of the Israeli Philharmonic Orchestra when it was founded: the orchestra was said to be hard to conduct because all the players thought they should be soloists. There are good books about managing people[ii], and there are in-house and external courses. My advice is to be genuine, work with and alongside your quants, understand the details,

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[5] **Exercise:** Please note the practical and amusing but really dead serious exercise in the next chapter. Communication skills are a major part of this exercise.

[6] **Language Wars:** It is amazing how heated discussions on computer languages resemble fights over religious dogma. It is easiest to go along with the crowd, whatever that means. See Ch. 34.

understand the difficulties, gain the group's respect, set achievable goals that are appreciated by the management, and generally be a leader.

Depending on the situation, you can have the option of providing innovative thinking and leadership while working hard and hands-on. You need to have the strength to work independently. You need to continue to give an effort of 110%. You need to deliver the product, but be very careful about definitions. Try never to use pronouns, and especially not the pronoun "it"[7].

You will broaden your horizons, meeting smart, friendly experts who can teach you a lot, interacting with management, and experiencing the sociology of the many tribes in finance, all speaking different languages. Always assume that you can learn something.

Sometimes you will need courage. While most people are up-front and helpful, you will encounter a variety of sharks. You may also need to cope at various times with adversity, possibly including: misunderstanding, tribalism, secrecy, Byzantine power politics, 500-pound gorillas, wars, lack of quantitative competence, sluggish bureaucracy, myopia, dogmatism, interference, bizarre irrationality, nitpicking, hasty generalizations, arbitrary decisions, pomposity, and unimaginative people who like to Play Death to new ideas. However, while they do occur, these negative features are exceptions, not the rule.

All in, it is fascinating, challenging, and even fun. Bon voyage.

References

[i] **Finance: Sample References**

Hull, J. C., *Options, Futures, and Other Derivative Securities*. Prentice Hall, 1989.

Willmott, P., Dewynne, J., and Howison, S., *Option Pricing – Mathematical models and computation*. Oxford Financial Press, 1993.

Dash, J. W., *Derivatives in Corporate Risk Management*. Talk, World Bank, Finance Professionals Forum, 1996.

[ii] **Management**

Lefton, R.E., Buzzotta, V.R., and Sherberg, M., *Improving Productivity Through People Skills – Dimensional Management Strategies*. Ballinger Publishing Co (Harper & Row), 1980.

[7] **The Dangerous "It" Word and Too Many Pronouns:** The pronoun "it" is probably the most dangerous word in the English language, leading to all sorts of misunderstandings and friction. More generally, people speak with "too many pronouns". What you refer to by "it" is in all probability not exactly what your interlocutor is thinking, and the two concepts may not be on the same planet. You can be burned by "it".

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3. An Exercise (Tech. Index 1/10)

This practical and amusing (but dead-serious) exercise will give you some glimmer in what it can be like carrying out a few activities in practical finance regarding a little data, analysis, systems, communication, and management issues. The exercise is illustrative without being technical. There are important lessons, the most important being communication. The idea is not just to read the exercise and chuckle, but actually try to do it.

Remember, the footnotes provide a running commentary and extension of the topics in the main text. Footnotes are actually sidebars and form an integral part of the book.

Part #1: Data, Statistics, and Reporting Using a Spreadsheet

Step 1: Data Collection

Find the 3-month cash Libor rate and the interest rates corresponding to the prices of the first twelve Euro-dollar 3-month futures[1]. Keep track of each of these thirteen rates every day[2] for two weeks[3] using the spreadsheet program Excel[4,i] and note the rate changes each day.

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[1] **Libor and ED Futures**: There are a number of different interest rates used for different purposes. You need to spend some time learning about the conventions and the language. Libor is probably the most important to understand first. The "cash" or "spot" 3-month USD Libor rate is the interest rate for deposits of US dollars in banks in London starting now and lasting for 3 months. The related Eurodollar (ED) futures give the market "expected" values of USD Libor at certain times called "IMM dates" in the future. ED futures are labeled by MAR, JUN, SEP and DEC with different years, e.g. SEP04. The interest rate in %/year corresponding to a future is [100 - price of the future].

[2] **"The Fundamental Theorem of Data"**: Collecting and maintaining reliable data is one of the Black Holes in finance (this statement is a Theorem). What you are being asked to do here is to get a tiny bit of first-hand experience of how painful this process really is. Notice for example that you weren't told where to find the data.

[3] **Time:** Two weeks is 10 business days. Time in finance is sometimes measured in weird units. For example, one year can be 360 days (used for Libor and ED futures).

[4] **Spreadsheets:** If you don't know much about spreadsheets, regardless of what you know about programming or quantitative packages, this seemingly trivial exercise is

Step 2: Statistics and Reporting

At the end of the 2 weeks, calculate the average and standard deviation of the nine changes of the first futures rate, expressed in bp/yr[5]. Type exactly what you did on the top of the spreadsheet with the dates and label everything[6]. Next, use the Excel Wizard to draw a graph of these changes, label the graph clearly including the units, and print it out. Also, print out the spreadsheet as a report[7].

Step 3: Bis for Steps 1,2

Repeat the above two steps for the 10 daily differences of the first future rate minus the cash Libor rate[8].

Step 4: Correlations

Calculate the correlation of the daily changes of cash Libor with respect to the daily changes of the first futures rate[9]. Next, define the "Return" from time t to time t + 1 by this daily change of the rate divided by the rate at time t. Calculate the correlation of the cash Libor returns with respect to the first future rate

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already a potential problem for you. Spreadsheets are ubiquitous. For quants, spreadsheets are useful for prototyping. The alternative can be a restriction in your employment possibilities. Excel is the de-facto standard spreadsheet.

[5] **Basis Point bp:** A basis point is %/100 or 0.0001 in decimal. Time-differences of rates (and also spreads, i.e. differences between different rates at the same time) are commonly quoted in bp/yr. Usually the /yr unit is left off.

[6] **Spreadsheet Labeling and Organization:** Clear spreadsheet formatting is key to help prevent errors and confusion that easily arise, especially in large spreadsheets. This is not to mention confusion for yourself if you come back in 6 months and try to understand what you did. One handy tip is to use colors with bold type for important quantities (e.g. input numbers green, intermediate results yellow, output results blue). Unlabelled spreadsheets create misunderstandings.

[7] **Graphs and Reports:** Graphs and reports are ubiquitous in risk management. Reports that are clear to people apart from the creator of the report are sadly not always the norm.

[8] **Why do Another Calculation?** There are many reported quantities. This one measures Libor curve risk. This step gets you initiated to repetitive work that can be part of the job.

[9] **Correlations:** Correlations are critical in risk management. We will spend a lot of time in the book discussing correlations, including how to stress them consistently. By now you should have figured out that a spreadsheet has built-in canned functions to do correlation calculations and many others.

returns. Now look at how different the result is for the correlation using the rate returns from the correlation using the rate changes[10].

Step 5: Written Communication

Write a two-paragraph memo about what you did, clearly, carefully and neatly enough so you could turn it in to your old English professor[11].

Step 6: Verbal Communication

Staple your nice spreadsheet report and graph to the memo, and hand over the package to somebody. Tell her what you did in no more than 3 minutes, and ask her to spend no more than 3 minutes looking at the material. Ask her to feed back what she understood[12].

Step 7: Celebrate

Go have a beer[13].

Analysis of Part #1

You were just walked through a soup-to-nuts exercise. Each step corresponds to a common activity. This included written and verbal communication..

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[10] **Definitions:** The correlations for differences and the correlations for returns are not exactly the same. Many risk measures have different possible definition conventions. You may have to dig deep to find out which definitions are being used in a report.

[11] **Written Communication, Management, and Goat Language**: This part is important. You shouldn't skip it because if you can't write what you did clearly, you may not be paid as much. Assuming you do not report to another quant, your potential Wall Street manager will not speak your language and is probably neither willing nor capable of learning it. The communication of even a summary of technical information or its significance is often hard. On the other hand, some managers have excellent intuition, understand the thrust of a technical argument quickly, and make valuable suggestions for improvement. You will be lucky if you report to such a person. You should make memos as clear and simple as possible without sacrificing the message. A wise manager, Gary Goldberg, gave some good advice for quants to use simple "Goat Language". Good luck.

[12] **Verbal Communication and Management:** This part is important and difficult. Again, you shouldn't skip it because if you can't clearly describe orally what you did, you won't be paid as much. By the way, your manager may only speed-read your memos. Face-to-face communication may be the only way you can transmit your message. You will probably not be given much time for the meeting. Hit the important points. Be prepared for a possibly arcane experience. You have to try to learn how to adjust.

[13] **Beer:** This is not pointless, and gives some idea of the sociology. Still, this activity is not as common as some people might imagine. People work hard and go home.

Communication skills are essential and many quants perform them badly, to their detriment. *The worst error consists of using the pronoun IT* [14]. Hopefully you used Microsoft Word or Word Perfect (not the *vi* editor in UNIX) to write your short report so that it looks like a professional document that a manager will take seriously. Appearance counts[15].

For you PhDs who feel insulted by the trivial technical aspects of this exercise, be aware that most quant work on the Street is not academic. You may well have sideline activities like those described above – though the work can be more difficult, fast moving, and challenging than you might imagine.

Part #2: Repeat Part #1 Using Programming

Instead of the spreadsheet, write a program in your favorite computer language along with file inputs to perform the same steps as in Exercise Part #1. Document your source code[16] by clearly writing at the top what it is you are doing, in good English with complete sentences. If you skipped the memo and verbal communication, it's time to bite the bullet [17]. Print out your report and graph[18].

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[14] **Second Warning: The Most Dangerous Word in the English Language is "It":** Again, the probability is 100% that every person will have a different definition of the word "it" for any given reference. Besides the confusion generated, you can get severely burned if the management thinks you are saying something or promising something other than what you are intending.

[15] **Appearance of Documents and Presentations:** There are people who have greatly improved their careers producing easy-to-read documents and PowerPoint color presentations. Upper management is usually NOT interested in the details and IS interested in getting summary information quickly and painlessly. You can learn from these people.

[16] **Source Code Comments:** Good programming practice, remember? I once had to try to make sense out of some complex mortgage code that had no comments at all. The remark of the programmer was that the code was completely obvious. *&*(%$#.

[17] **Written and Verbal Communication:** No, you can't skip this activity.

[18] **Graphs and Programmers:** Can you (ahem!) produce graphs using your compiled code? It is hard to describe the frustration with systems groups that as a matter of "principle" only work with compiled code and hate spreadsheets, but have trouble producing reasonable reports and graphs.

Analysis of Exercise, Part #2

You have just carried out the same exercise in "production mode", as opposed to the spreadsheet "prototype mode".

Part #3: A Few Quick and Tricky Hypothetical Questions

Question 1: System Risk

What would you estimate to be the amount of data such that programming would be preferred over spreadsheets? [19] Under which situations would you recommend replacing the files with a database? Next, suppose you are ordered to take over either the spreadsheet or the source code from somebody who has left the company and has documented nothing[20]. Now which approach would you favor?

Question 2: Should we do this Deal or not?

Say you have to estimate the risk for a Backflip Libor option lasting for 1 year. What time period of historical data would you recommend in order to get a handle on the potential risk of this animal, and when will you have the answer?[21]

Question 3: Market Risk

Based on the ridiculously small 10-day sample, if your boss came to you right now, what would you say would be a reasonable measure for Libor risk ?[22, 23].

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[19] **Programs vs. Spreadsheets:** Portfolios can have hundreds of correlated variables and thousands of deals. On the other hand, you may need to provide an answer by 2 p.m. for a risk analysis depending on a few variables for a deal perhaps about to go live.

[20] **Personnel Risk:** The situation described is not academic – it happens all the time. By the way, did *you* document *your* code?

[21] **The Backflip Option and the Time Crunch:** You have never heard of the Backflip Option; the name is fictitious. In practice, you may not have time to analyze a complicated option in detail or even get the precise definition much in advance. You need to get used to the pace – you're not going to publish a journal article. In fact, the desk wants an answer by 2 pm. So based on the information, what are you going to do?

[22] **Management Communication Will Not Go Away:** Your boss knows nothing about statistics other than having a hazy impression of the basic concepts. Do you think that he/she understood what you said? It is critical for your career that the management understands what you are doing and why it is important. The challenge for you is that their eyes may glaze over after two minutes of explanation. The particular issue of Libor risk in the example will not come up because industrial-strength databases and quants have solved it, but the communication issue is always there.

Messages and Advice

To Computer Programmers Who Skipped Exercise Part #1

Now is the time to go back and do Exercise Part #1 in Excel that you may have skipped, no matter how impure you find it and no matter how much you hate Microsoft. You will be regarded as more useful and valued by a business unit if you ALSO know how to use a spreadsheet for quick calculations, reports, and prototyping. Please try writing the memo and describing your work verbally – these skills will really be useful for you. You will be definitely be more effective by learning something about finance, even if you are a programmer.

To Those Who Can't Program and Skipped Exercise Part #2

So maybe you are on your way to sales or investment banking. Still, this is a good time to learn at least the rudiments of a compiled computer language if you don't already know one. Even if you never have to program in your future career on the Street, the chances are high that you will be interacting in some fashion with computer people. The more you know about systems and the way the technology guys think, the better you will be able to communicate with them, understand what the problems are, and get done what you want. Otherwise, computer land can turn out to be a frustrating black-box experience.

References

[i] **Excel**

Campbell, M., *Using Excel.* Que Corporation, 1986.

Jackson, M. and Staunton, M., *Advanced modelling in finance using Excel and VBA.* John Wiley & Sons, 2001.

[23] **Simple Procedures, Accuracy, and Communication:** The use of simple procedures is a double-edged sword. An important potential advantage is better communication to non-technical management. The downside is that management may neither understand nor remember the limitations of a simple procedure. Try to get a handle on the uncertainty. If the approximation is reasonable, communicate up front that you are using a simple but reasonable approximation, possibly with the aim of improving it as priorities permit.