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INSIDE THE BLACK BOX

The Simple Truth About Quantitative Trading

rishi k narang

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This book is dedicated to my father and mother, Thakur and Krishna Narang, to whom I owe so much, and to my wife and partner of many years, Carolyn Wong, whose love and support make a hell of a lot of things really a lot better.

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Preface

An unnecessary opaqueness surrounds quantitative trading strategies (known to many as *black boxes*), despite their importance to the capital markets and the sensational, widely known examples of their successes and failures. This opaqueness, which quants themselves frequently perpetuate, exacerbates an already widespread misunderstanding of quantitative trading in the broader investment community.

This book takes you on a tour through the black box, inside and out. It sheds light on the work that quants do, lifting the veil of mystery that surrounds quantitative trading and allowing those interested in doing so to evaluate quants and their strategies.

The first thing that should be made clear is that people, not machines, are responsible for most of the interesting aspects of quantitative trading. Quantitative trading can be defined as the systematic implementation of trading strategies that human beings create through rigorous research. In this context, *systematic* is defined as a disciplined, methodological, and automated approach. Despite this talk of automation and systematization, *people* conduct the research and decide what the strategies will be, *people* select the universe of securities for the system to trade, and *people* choose what data to procure and how to clean those data for use in a systematic context, among a great many other things. These people, the ones behind quant trading strategies, are commonly referred to as *quants* or *quant traders*.

Quants employ the scientific method in their research. Though this research is aided by technology and involves mathematics and formulae, the research process is thoroughly dependent on human decision making. In fact, human decisions pervade nearly every aspect of the design, implementation, and monitoring of quant trading strategies. As it turns out, quant strategies and traditional discretionary investment strategies, which rely on human decision makers to manage portfolios day to day, are rather similar in what they do.

The differences between a quant strategy and a discretionary strategy can be seen in *how* the strategy is created and in *how* it is implemented. By carefully researching their strategies, quants are able to assess their

ideas the same way that scientists test theories. Furthermore, by utilizing a computerized, systematic implementation, quants eliminate the arbitrariness that pervades so many discretionary trading strategies. In essence, decisions driven by emotion, indiscipline, passion, greed, and fear—what many consider the key pratfalls of "playing the market"—are eliminated from the quant's investment process. They are replaced by an analytical and systematic approach that borrows from the lessons learned in so many other fields: If something needs to be done repeatedly and with a great deal of discipline, computers will virtually always outshine humans. We simply aren't cut out for repetition in the way that computers are, and there's nothing wrong with that. Computers, after all, aren't cut out for creativity the way we are; without humans telling computers what to do, computers wouldn't do much of anything. The differences in how a strategy is designed and implemented play a large part in the consistent, favorable risk/reward profile a well-run quant strategy enjoys relative to most discretionary strategies.

To clarify the scope of this book, it is important to note that I focus on "alpha"-oriented strategies and largely ignore quantitative index traders or other implementations of "beta" strategies. *Alpha strategies* attempt to generate returns by skillfully timing the selection and/or sizing of various portfolio holdings; *beta strategies* mimick or slightly improve on the performance of an index, such as the S&P 500. Though quantitative index fund management is a large industry, it requires little explanation. Neither do I spend much time on the field of financial engineering, which typically plays a role in creating or managing new financial products (e.g., CDOs). Nor do I address quantitative analysis, which typically supports discretionary investment decisions. Both of these are interesting subjects, but they are so different from quant trading as to be deserving of their own, separate discussions carried out by experts in those fields.

This book is divided into three parts. Part One (Chapters 1 and 2) provides a general but useful background on quantitative trading. Part Two (Chapters 3 through 9) details the contents of the black box. Part Three (Chapters 10 through 13) provides an analysis of quant trading and techniques that may be useful in assessing quant traders and their strategies.

It is my aspiration to explain quant trading in an intuitive manner. I describe what quants do and how they do it by drawing on the economic rationale for their strategies and the theoretical basis for their techniques. Equations are avoided, and the use of jargon is limited and explained, when required at all. My aim is to demonstrate that what many call a black box is in fact transparent, intuitively sensible, and readily understandable. I also explore the lessons that can be learned from quant trading about investing in general and how to evaluate quant trading strategies and their

practitioners. As a result, *Inside the Black Box* may be useful for a variety of participants in and commentators on the capital markets. For portfolio managers, analysts, and traders, whether quantitative or discretionary, this book will help contextualize what quants do, how they do it, and why. For investors, the financial media, or anyone with a reasonable knowledge of capital markets in general, this book will engender a deeper understanding of this niche.

RISHI K NARANG

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PART

One

The Quant Universe

CHAPTER 1

Why Does Quant Trading Matter?

Look into their minds, at what wise men do and don't.
—Marcus Aurelius, *Meditations*

John is a quant trader running a midsized hedge fund. He completed an undergraduate degree in mathematics and computer science at a top school in the early 1990s. John immediately started working on Wall Street trading desks, eager to capitalize on his quantitative background. After seven years on the Street in various quant-oriented roles, John decided to start his own hedge fund. With partners handling business and operations, John was able to create a quant strategy that recently was trading over $1.5 billion per day in equity volume. More relevant to his investors, the strategy made money on 60 percent of days and 85 percent of months—a rather impressive accomplishment.

Despite trading billions of dollars of stock every day, there is no shouting at John's hedge fund, no orders being given over the phone, and no drama in the air; in fact, the only sign that there is any trading going on at all is the large flat-screen television in John's office that shows the strategy's performance throughout the day and its trading volume. John can't give you a fantastically interesting story about why his strategy is long this stock or short that one. While he is monitoring his universe of thousands of stocks for events that might require intervention, for the most part he lets the automated trading strategy do the hard work. What John monitors quite carefully, however, is the health of his strategy and the market environment's impact on it. He is aggressive about conducting research on an ongoing basis to adjust his models for changes in the market that would impact him.

Across from John sits Mark, a recently hired partner of the fund who is researching high-frequency trading. Unlike the firm's first strategy, which only makes money on 6 out of 10 days, the high-frequency efforts Mark and

John are working on target a much more ambitious task: looking for smaller opportunities that can make money every day. Mark's first attempt at high-frequency strategies already makes money nearly 95 percent the time. In fact, their target for this high-frequency business is even loftier: They want to replicate the success of those firms whose trading strategies make money every hour, maybe even every minute, of every day. Such high-frequency strategies can't accommodate large investments, because the opportunities they find are small, fleeting. Nonetheless, they are highly attractive for whatever capital they can accommodate. Within their high-frequency trading business, John and Mark expect their strategy to generate at least 200 percent a year, possibly much more.

There are many relatively small quant trading boutiques that go about their business quietly, as John and Mark's firm does, but that have demonstrated top-notch results over reasonably long periods. For example, Quantitative Investment Management of Charlottesville, Virginia, averaged over 20 percent per year for the 2002–2008 period—a track record that many discretionary managers would envy.[1]

On the opposite end of the spectrum from these small quant shops are the giants of quant investing, with which many investors are already quite familiar. Of the many impressive and successful quantitative firms in this category, the one widely regarded as the best is Renaissance Technologies. Renaissance, the most famous of all quant funds, is famed for its 35 percent average yearly returns (after exceptionally high fees), with extremely low risk, since 1990. In 2008, a year in which many hedge funds struggled mightily, Renaissance's flagship Medallion Fund gained approximately 80 percent.[2] I am personally familiar with the fund's track record, and it's actually gotten better as time has passed—despite the increased competition and potential for models to "stop working."

Not all quants are successful, however. It seems that once every decade or so, quant traders cause—or at least are perceived to cause—markets to move dramatically because of their failures. The most famous case by far is, of course, Long Term Capital Management (LTCM), which nearly (but for the intervention of Federal Reserve banking officials and a consortium of Wall Street banks) brought the financial world to its knees. Although the world markets survived, LTCM itself was not as lucky. The firm, which averaged 30 percent returns after fees for four years, lost nearly 100 percent of its capital in the debacle of August–October 1998 and left many investors both skeptical and afraid of quant traders (although it is debatable whether this was a quant trading failure or a failure of human judgment in risk management, and it's questionable whether LTCM was even a quant trading firm at all).

Not only have quants been widely panned because of LTCM, but they have also been blamed (probably unfairly) for the crash of 1987 and (quite

fairly) for the eponymous quant liquidation of 2007, the latter having severely impacted many quant shops. Even some of the largest names in quant trading suffered through August 2007's quant liquidation. For instance, Goldman Sachs' largely quantitative Global Alpha Fund was down an estimated 40 percent in 2007 after posting a 6 percent loss in 2006.[3] In less than a week during August 2007, many quant traders lost between 10 and 40 percent in a few days, though some of them rebounded strongly for the remainder of the month.

Spectacular success and failure aside, there is no doubt that quants cast an enormous shadow on the trading marketplace virtually every trading day. Across U.S. equity markets, a significant, and rapidly growing, proportion of all trading is done through algorithmic execution, one footprint of quant strategies. (*Algorithmic execution* is the use of computer software to manage and "work" an investor's buy and sell orders in electronic markets.) Although this automated execution technology is not the exclusive domain of quant strategies—any trade that needs to be done, whether by an index fund or a discretionary macro trader, can be worked using execution algorithms—certainly a substantial portion of all algorithmic trades are done by quants. Furthermore, quants were both the inventors of, and primary innovators of, algorithmic trading engines. A mere five such quant traders account for about 1 billion shares of volume *per day,* in aggregate, in the United States alone. It is worth noting that not one of these is well known to the broader investing public. The TABB Group, a research and advisory firm focused exclusively on the capital markets, estimates that, in 2008, approximately 58 percent of all buy-side orders were algorithmically traded. TABB also estimates that this figure has grown some 37 percent per year, compounded, since 2005. More directly, the Aite Group published a study in early 2009 indicating that more than 60 percent of all US equity transactions are attributable to short term quant traders.[4] These statistics hold true in non-U.S. markets as well. Black-box trading accounted for 45 percent of the volume on the European Xetra electronic order-matching system in the first quarter of 2008, which is 36 percent more than it represented a year earlier.[5]

The large presence of quants is not limited to equities. In futures and foreign exchange markets, the domain of commodity trading advisors (CTAs), there is a significant presence of quants. The Barclay Group, proprietor of the most comprehensive commercially available database of CTAs and CTA performance, estimates that well over 85 percent of the assets under management among all CTAs are managed by quantitative trading firms. Although a great many of the largest and most established CTAs (and hedge funds generally) do not report their assets under management or performance statistics to any database, a substantial portion of these firms are actually quants also, and it is likely that the "real" figure is still over 75 percent. As

of the end of the third quarter of 2008, the amount of quantitative futures money under management, including only the firms that report to Barclay, was $227.0 billion.

It is clear that the magnitude of quant trading among hedge funds is substantial. Hedge funds are private investment pools that are accessible only to sophisticated, wealthy individual or institutional clients. They can pursue virtually any investment mandate one can dream up, and they are allowed to keep a portion of the profits they generate for their clients. But this is only one of several arenas in which quant trading is widespread. Proprietary trading desks at the various banks, boutique proprietary trading firms, and various "multistrategy" hedge fund managers who utilize quantitative trading for a portion of their overall business each contribute to a much larger estimate of the size of the quant trading universe.

With such size and extremes of success and failure, it is not surprising that quants take their share of headlines in the financial press. And though most press coverage of quants seems to be markedly negative, this is not always the case. In fact, not only have many quant funds been praised for their steady returns (a hallmark of their disciplined implementation process), but some experts have even argued that the existence of successful quant strategies improves the marketplace for all investors, regardless of their style. For instance, Reto Francioni (chief executive of Deutsche Boerse AG, which runs the Frankfurt Stock Exchange) said in a speech that algorithmic trading "benefits all market participants through positive effects on liquidity." Francioni went on to reference a recent academic study showing "a positive causal relationship between algo trading and liquidity."[6] Indeed, this is almost guaranteed to be true. Quant traders, using execution algorithms (hence, "algo trading"), typically slice their orders into many small pieces to improve both the cost and efficiency of the execution process. As mentioned before, although originally developed by quant funds, these algorithms have been adopted by the broader investment community. By placing many small orders, other investors who might have different views or needs can also get their own executions improved.

Quants typically make markets more efficient for other participants by providing liquidity when other traders' needs cause a temporary imbalance in the supply and demand for a security. These imbalances are known as "inefficiencies," after the economic concept of "efficient markets." True inefficiencies (such as an index's price being different from the weighted basket of the constituents of the same index) represent rare, fleeting opportunities for riskless profit. But riskless profit, or arbitrage, is not the only—or even primary—way in which quants improve efficiency. The main inefficiencies quants eliminate (and, thereby, profit from) are not absolute and unassailable but rather probabilistic and requiring risk taking.

A classic example of this is a strategy called *statistical arbitrage*, and a classic statistical arbitrage example is a *pairs trade*. Imagine two stocks with similar market capitalizations from the same industry and with similar business models and financial status. For whatever reason, Company A is included in a major market index, an index that many large index funds are tracking. Meanwhile, Company B is not included in any major index. It is likely that Company A's stock will subsequently outperform shares of Company B simply due to a greater demand for the shares of Company A from index funds, which are compelled to buy this new constituent in order to track the index. This outperformance will in turn cause a higher P/E multiple on Company A than on Company B, which is a subtle kind of inefficiency. After all, nothing in the fundamentals has changed—only the nature of supply and demand for the common shares. Statistical arbitrageurs may step in to sell shares of Company A and buy shares of Company B, thereby preventing the divergence between these two fundamentally similar companies from getting out of hand while improving efficiency in market pricing.

This is not to say that quants are the only players who attempt to profit by removing market inefficiencies. Indeed, it is likely that any alpha-oriented trader is seeking similar sorts of dislocations as sources of profit. And of course, there are times, such as August 2007, when quants actually cause the markets to be *less* efficient. Nonetheless, especially in smaller, less liquid, and more neglected stocks, statistical arbitrage players are often major providers of market liquidity and help establish efficient price discovery for all market participants.

So, what can we learn from a quant's approach to markets? The three answers that follow represent important lessons that quants can teach us—lessons that can be applied by any investment manager.

THE BENEFIT OF DEEP THOUGHT

According to James Simons, the founder of the legendary Renaissance Technologies, one of the greatest advantages quants bring to the investment process is their systematic approach to problem solving. As Dr. Simons puts it, "The advantage scientists bring into the game is less their mathematical or computational skills than their ability to think scientifically."[7]

The first reason it is useful to study quants is that they are forced to think deeply about many aspects of their strategy that are taken for granted by nonquant investors. Why does this happen? Computers are obviously powerful tools, but without absolutely precise instruction, they can achieve nothing. So, to make a computer implement a "black-box trading strategy" requires an enormous amount of effort on the part of the developer. You