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Bubble Value At Risk

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A Countercyclical Risk Management Approach

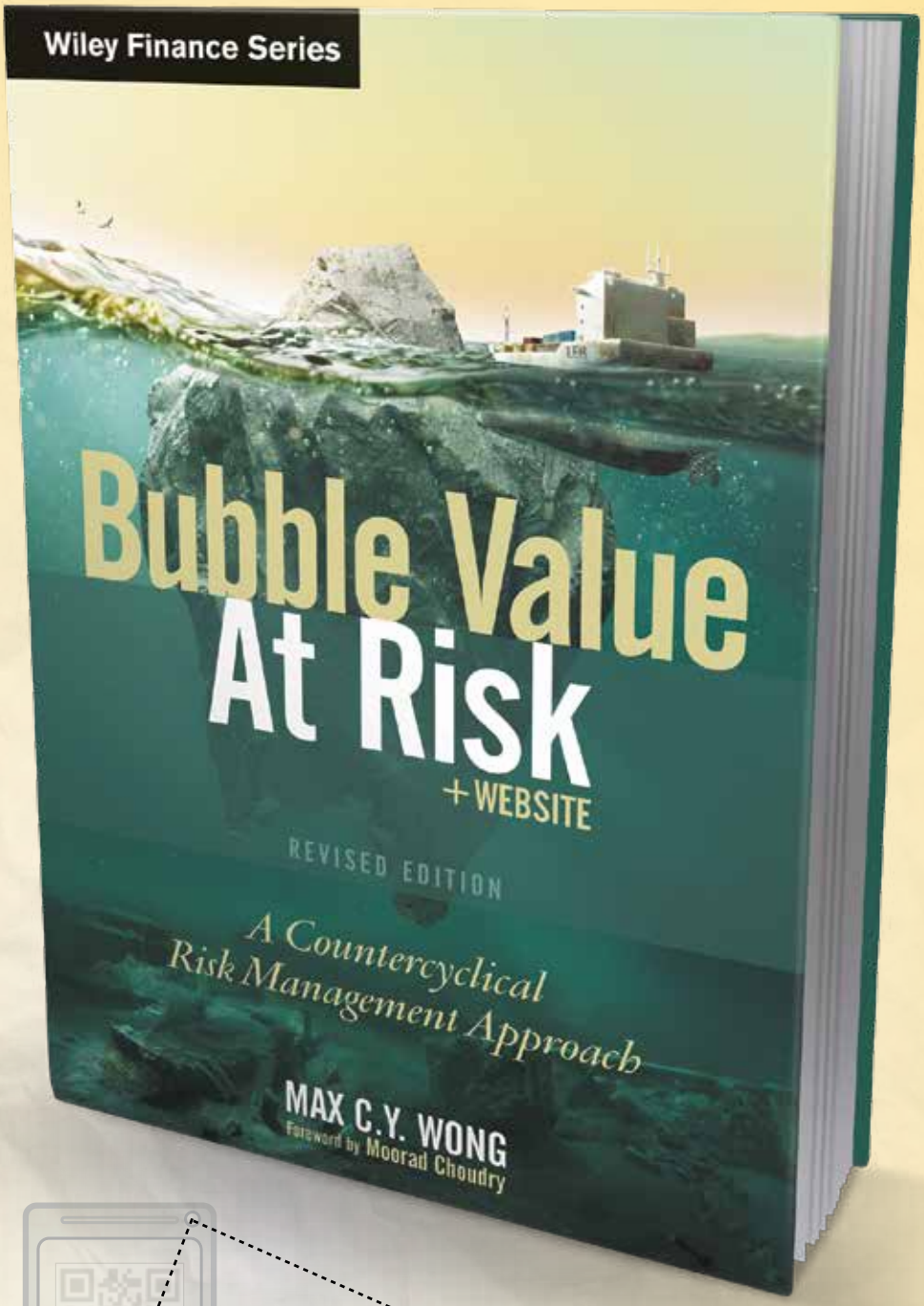
MAX C.Y. WONG

Foreword by Moorad Choudry

Most risk management books introduce Value at Risk (VaR) by focusing on what it can do and its statistical measurements. The credit crisis in 2008 was a tidal wave that debunked this well-established risk metric. In this book, the author introduces VaR by looking at its failures instead and explores possible alternatives for effective crisis risk management, including a new method of measuring risks called Bubble Value at Risk that is countercyclical and can potentially buffer against market crashes.

The frequentist statistics-based VaR is predictive during normal circumstances but often fails patently during rare crisis episodes. In reality, crisis periods span only a tiny portion of financial market history. By relying on VaR for crisis risk management, we are using a tried-and-tested tool for the wrong occasion— mistaking the trees for the forest. The book argues that we need to unlearn our existing "science" of risk measurement and discover more robust ways of managing risk and calculating risk capital.

The book illustrates virtually every key concept or formula with a practical, numerical example, many of which are contained in interactive Excel spreadsheets.



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To my heavenly Father, who gave me this assignment

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About the Author

Max Wong is a specialist in the area of risk modeling and Basel III. He started his career as a derivatives consultant at Credit Suisse First Boston in 1996. During the Asian crisis in 1998, he traded index futures at the open-outcry floor of SIMEX (now SGX). From 2003 to 2011, he worked for Standard Chartered Bank as a risk manager and senior quant. He is currently head of VaR model testing at the Royal Bank of Scotland.

He has published papers on VaR models and Basel capital, recently looking at innovative ways to model risk more effectively during crises and to deal with the issues of procyclicality and Black Swan events in our financial system. He has spoken on the subject at various conferences and seminars.

He holds a BSc in physics from the University of Malaya (1994) and an MSc in financial engineering from the National University of Singapore (2004). He is an adjunct at Singapore Management University, a member of the editorial board of the *Journal of Risk Management in Financial Institutions*, and a member of the steering committee of PRMIA Singapore chapter.

Foreword

Financial markets are all about risk management. Banking and capital markets activities throw up all manner of risk exposures as a matter of course, and these need to be managed accordingly such that stakeholders are comfortable. "Market risk" traditionally referred to risks arising from a change in market factors, and when we say "risk" we mean risk to the profit and loss account or to revenues. These market factors might be interest rates, foreign currency rates, customer default rates, and so on. Managers of a financial institution should expect to have some idea of the extent of their risk to these dynamic factors at any one time, so that they can undertake management action to mitigate or minimize the risk exposure. This is Finance 101 and is as old as commerce and money itself.

Measuring market exposure has always been a combination of certain methods that might be called scientific and others that might be described as application of learned judgment. I have always been a fan of "modified duration" for interest rate risk and I still recommend it. Of course it has its flaws, which estimation method doesn't? But when Value-at-Risk (VaR) was first presented to the world it appeared to promise to make the risk manager's job easier, because it seemed to offer a more accurate estimate of risk exposure at any time. And the latter was all it ever was, or claimed to be: an estimation of risk exposure. A measure of risk, no better and no worse than the competence of the person who was making use of the calculated numbers.

Unfortunately, in some quarters VaR was viewed as being somehow a substitute for "risk management" itself. It didn't help that the assumptions underpinning every single methodology for calculating VaR were never widely understood, at least not at the senior executive level, which made explaining losses that exceeded the VaR estimate even more difficult than usual. In 2012 JPMorgan announced losses of up to $9 billion in a portfolio of corporate credits that were managed by its London-based chief investment office. Depending on which media report one follows, the VaR number reported for the bank as a whole the day before the announcement was alleged to be between 1 percent and 10 percent of this value. Is there any point in going to the trouble of calculating this estimate if at any time it can be demonstrated to be so completely off the mark?

The short answer is yes and no. VaR is a tool, nothing more nor less, and like all tools must be used within its limitations. One could argue that a

bank the size and complexity of JPMorgan is going to struggle to ever get a meaningful estimate of its true risk exposure under all marker conditions, but therein lies the value and the worthlessness of any statistical measure like VaR: it is reasonable for some, indeed most, of the time but when it does get out of kilter with market movements the difference could be huge (an order of magnitude of up to 100 times out, if some recent headlines are to be believed). It reminds one of the apocryphal story of the statistician who drowned in a lake that had an "average" depth of six inches.

The circle is complete of course. It was JPMorgan that gave the world VaR back in 1994 (one or two other banks, including CSFB, were applying a similar sort of methodology around the same time), and eighteen years later the bank saw for itself just how inaccurate it could be. Does that mean we should dispense with VaR and go back to what we had before, or look to devise some other method?

Again, yes and no. The key accompanying text for any statistical measurement, VaR most definitely included, has *always* been "use with care, and only within limitations." That means, by all means, continue with your chosen VaR methodology for now, but perhaps be aware that an actual loss under conditions that the model is not picking up could well be many times beyond your VaR estimate. In other words, bring in your interest rate risk and credit risk exposure limits because the true picture is going to be in excess of what you think it is. That is true for whichever firm one is working at.

But that isn't all. Knowing VaR's limitations means also seeking to develop an understanding of what it doesn't cover. And this is where Max Wong's very worthwhile and interesting book comes in. In the Basel III era of "macroprudential regulation," Mr Wong applies a similar logic for VaR and presents a new concept of Bubble VaR, which is countercyclical in approach and would be pertinent to a bank running complex exposures across multiple markets and asset classes. But I also rate highly the first half of the book, which gives an accessible description of the vanilla VaR concept and its variations before launching into its limitations and how Bubble VaR is a means of extending the concept's usefulness. The content herein is technical and arcane by necessity, but remains firmly in the domain of "know your risk," which is something every senior banker should be obsessed with.

This book is a fantastic addition to the finance literature, written by that rare beast in financial markets, management consulting, or academia: a person delivering something of practical value for the practitioner and that advances our understanding and appreciation of finance as a discipline. Finance 201, so to speak, for everyone with an interest in financial risk management.

Professor Moorad Choudhry
Department of Mathematical Sciences
Brunel University
16th December 2012

Preface

This is a story of the illusion of risk measurement. Financial risk management is in a state of confusion. The 2008 credit crisis has wreaked havoc on the Basel pillars of supervision by highlighting all the cracks in the current regulatory framework that had allowed the credit crisis to fester, and ultimately leading to the greatest crisis since the Great Depression. Policy responses were swift—UK's Financial Services Authority (FSA) published the *Turner Review*, which calls for a revamp of many aspects of banking regulation, and the Bank of International Settlements (BIS) speedily passed a Revision to its Basel II, while the Obama administration called for a reregulation of the financial industry reversing the Greenspan legacy of deregulation. These initiatives eventually evolved into the Basel III framework and Dodd-Frank Act respectively.

The *value-at-risk* risk measure, VaR, a central ideology for risk management, was found to be wholly inadequate during the crisis. Critically, this *riskometer* is used as the basis for regulatory capital—the safety buffer money set aside by banks to protect against financial calamities. The foundation of risk measurement is now questionable.

The first half of this book develops the VaR riskometer with emphasis on its traditionally known weaknesses, and talks about current advances in risk research. The underlying theme throughout the book is that VaR is a faulty device during turbulent times, and by its mathematical sophistication it misled risk controllers into an illusion of safety. The author traces the fundamental flaw of VaR to its statistical assumptions—of normality, i.i.d., and stationarity—the Gang of Three.

These primitive assumptions are very pervasive in the frequentist statistics philosophy where probability is viewed as an objective notion and can be measured by sampling. A different school of thought, the Bayesian school, argues for subjective probability and has developed an entire mathematical framework to incorporate the observer's opinion into the measurement (but this is subject matter for another publication). We argue that the frequentist's strict mathematical sense often acts as a blinder that restricts the way we view and model the real world. In particular, two "newly" uncovered market phenomena—extremistan and procyclicality—cannot be engaged using the

frequentist mindset. There were already a few other well-known market anomalies that tripped the VaR riskometer during the 2008 crisis. All these will be detailed later.

In Part Four of the book, the author proposes a new risk metric called *bubble VaR* (buVaR), which does not invoke any of the said assumptions. BuVaR is not really a precise measurement of risk; in fact, it presumes that extreme loss events are unknowable (extremistan) and moves on to the more pressing problem—how do we build an effective buffer for regulatory capital that is countercyclical, and that safeguards against extreme events.

This book is an appeal (as is this preface) to the reader to consider a new paradigm of viewing risk—that one need *not* measure risk (with precision) to protect against it. By being obsessively focused on measuring risk, the risk controller may be fooled by the many pitfalls of statistics and randomness. This could lead to a false sense of security and control over events that are highly unpredictable. It is ultimately a call for good judgment and pragmatism.

Since this book was first published in 2011, the financial industry has experienced a sea change in Basel regulation and new risk modeling requirements under the Basel III capital framework. There are also exciting developments in the modeling of risk at the research frontier. This revised edition is an update to include some of these topics, even though the primary objective remains to encourage an alternate paradigm of looking at market risk.

AUDIENCE

This book is intended to reach out to the top management of banks (CEOs and CROs), to regulators, to policy makers, and to risk practitioners—not all of whom may be as quantitatively inclined as the specialized risk professional. But they are the very influencers of the coming financial reregulation drama. We are living in epic times, and ideas help shape the world for better (or for worse). It is hoped that the ideas in this book can open up new and constructive research into countercyclical measures of risk.

With this target audience in mind, this book is written in plain English with as few Greek letters as possible; the focus is on concepts (and illustrations) rather than mathematics. Because it is narrowly focused on the topic, it can be self-contained. No prior knowledge of risk management is required; preuniversity-level algebra and some basic financial product knowledge are assumed.

OVERVIEW OF THE CONTENTS

In order to internalize the idea of risk, this book takes the reader through the developmental path of VaR starting from its mathematical foundation to its

advanced forms. In this journey, fault lines and weaknesses of this methodology are uncovered and discussed. This will set the stage for the new approach, buVaR.

Chapter 2 goes into the foundational mathematics of VaR with emphasis on intuition and concepts rather than mathematical rigor.

Chapter 3 introduces the basic building blocks used in VaR. The conventional VaR systems are then formalized in Chapter 4. At the end of the chapter, readers will be able to calculate VaR on a simple spreadsheet and experiment with the various nuances of VaR.

Chapter 5 discusses some advanced VaR models developed in academia in the last decade. They are interesting and promising, and are selected to give the reader a flavor of current risk research.

Chapter 6 deals with the tools used by banks for VaR reporting. It also contains a prelude to the Basel Rules used to compute minimum capital.

Chapter 7 explores the phenomenology of risks. In particular, it details the inherent weaknesses of VaR and the dangers of extreme risks not captured by VaR.

Chapter 8 covers the statistical tests used to measure the goodness of a VaR model.

Chapter 9 discusses the weaknesses of VaR, which are not of a theoretical nature. These are practical problems commonly encountered in VaR implementation.

Since this book deals primarily with market risk, Chapter 10 is a minor digression devoted to other (nonmarket) risk classes. A broad understanding is necessary for the reader to appreciate the academic quest (and the industry's ambition) for a unified risk framework where all risks are modeled under one umbrella.

Chapter 11 gives a brief history of the Basel capital framework. It then proceeds to summarize the key regulatory reforms (Basel III) that were introduced from 2009 to 2010.

Chapter 12 discusses developments in measuring and detecting systemic risks. These are recent research initiatives by regulators who are concerned about global crisis contagion. Network models are introduced with as little math as possible. The aim is to give the reader a foretaste of this important direction of development.

The final part of this book, Part Four—spanning five chapters in total—introduces various topics of bubble-VaR. Chapter 13 lays the conceptual framework for buVaR, formalized for market risk.

Chapter 14 shows that with a slight modification, the buVaR idea can be expanded to cover credit risks, including default risk.

Chapter 15 contains the results of various empirical tests of the effectiveness of buVaR.

Chapter 16 is a concluding chapter that covers miscellaneous topics for buVaR. In particular, it summarizes how buVaR is able to meet the ideals proposed by the *Turner Review*.

Lastly, Chapter 17 lists suggestions for future research. It is a wish list for buVaR which is beyond the scope of this volume.

ADDITIONAL MATERIALS

Throughout this book, ideas are also formulated in the syntax of Excel functions so that the reader can easily implement examples in a spreadsheet. Exercises with important case studies and examples are included as Excel spreadsheets at the end of each chapter and can be downloaded from the companion website: www.wiley.com/go/bubblevalueatrisk.

Excel is an excellent learning platform for the risk apprentice. Monte Carlo simulations are used frequently to illustrate and experiment with key ideas, and, where unavoidable, VBA functions are used. The codes are written with pedagogy (not efficiency) in mind.

Acknowledgments

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The production of the book involved many excellent individuals. I thank Lim Tai Wei for grammatical edit work, Sylvia Low for web design and the cover design team in Beijing: Michael Wong, Kenny Chai, Liu DeBin, and Xiao Bin. I am grateful to Nick Wallwork and the staff at Wiley for the production of the revised edition.

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PART
One

Background

CHAPTER 1

Introduction

The 2008 global credit crisis is by far the largest boom-bust cycle since the Great Depression (1929). Asset bubbles and manias have been around since the first recorded tulip mania in 1637 and in recent decades have become such a regularity that they are even expected as often as once every 10 years (1987, 1997, 2007). Asset bubbles are in reality more insidious than most people realize for it is not the massive loss of wealth that it brings (for which investor has not entertained the possibility of financial ruin) but because *it widens the social wealth gap*; it impoverishes the poor. The 2008 crisis highlighted this poignantly—in the run-up to the U.S. housing and credit bubble, the main beneficiaries were bankers (who sold complex derivatives on mortgages) and their cohorts. At the same time, a related commodity bubble temporarily caused a food and energy crisis in some parts of the developing world, notably Indonesia, the fourth-most-populous nation in the world and an OPEC member (until 2008). When the bubble burst, $10 trillion dollars of U.S. public money was used to bail out failing banks and to take over toxic derivatives created by banks. On their way out, CEOs and traders of affected banks were given million-dollar contractual bonuses, even as the main economy lost a few million jobs. Just as in 1929, blue-collar workers bore the brunt of the economic downturn in the form of unemployment in the United States.

The ensuing zero interest rate policy and quantitative easing (printing of dollars by the Fed) induced yet other bubbles—commodity prices are rising to alarming levels and asset bubbles are building up all over Asia, as investors chase non-U.S. dollar assets. We see home prices skyrocketing well beyond the reach of the average person in major cities. The wealthy are again speculating in homes, this time in East Asia. In many countries, huge public spending on infrastructure projects that is meant to support the headline GDP caused a substantial transfer of public wealth to property developers and cohorts. The lower income and underprivileged are once again left behind in the tide of inflation and growth.

The danger of an even larger crisis now looms. The U.S. dollar and treasuries are losing credibility as reserve currencies because of rising public debt. This means that flight-to-quality, which has in the past played the role of a pressure outlet for hot money during a crisis, is no longer an appealing option.

If there is a lesson from the 2008 crisis, it is that asset bubbles have to be reined in at all costs. It is not just John Keynes' "animal spirits" at work here—the herd tipping the supply-demand imbalance—but the spirit of "mammon"—unfettered greed. There is something fundamentally dysfunctional about the way financial institutions are incentivized and regulated. Thus, a global regulatory reform is underway, led by the United Kingdom, the European Union (EU), and the United States, with target deadlines of 2012 and beyond. Our narrow escape from total financial meltdown has highlighted the criticality of systemic risks in an interconnected world; we can no longer think in isolated silos when solving problems in the banking system. The coming reregulation must be holistic and concerted.

One major aspect of the reform is in the way risk is measured and controlled. The great irony is that our progress in risk management has led to a new risk: the risk of risk assessment. What if we are wrong (unknowingly) about our measurement? The crisis is a rude wake-up call for regulators and bankers to reexamine our basic understanding of what risk is and how effective our regulatory safeguards are.

We start our journey with a review of how our current tools for measuring financial market risks were evolved. In this chapter, we will also give a prelude to two important concepts that grew out of crisis response—*extremistan* and *procyclicality*. These will likely become the next buzz words in the unfolding regulatory reform drama. The final section offers *bubble VaR*, a new tool researched by the author, which regulators can explore to strengthen the safeguards against future financial crises.

1.1 THE EVOLUTION OF RISKOMETER

Necessity is the mother of invention.
—Plato, Greek philosopher, 427–347 BC

Ask a retail investor what the risks of his investment portfolio are, and he will say he owns USD30,000 in stocks and USD70,000 in bonds, and he is *diversified* and therefore *safe*. A lay investor thinks in notional terms, but this can be misleading since two bonds of different duration have very different risks for the same notional exposure. This is because of the convexity

behavior peculiar to bonds. The idea of duration, a better risk measure for bonds, was known to bankers as early as 1938.

In the equities world, two different stocks of the same notional amount can also give very different risk. Hence, the idea of using volatility as a risk measure was introduced by Harry Markowitz (1952). His mean-variance method not only canonized standard deviation as a risk measure but also introduced correlation and diversification within a unified framework. Modern portfolio theory was born. In 1963, William Sharpe introduced the single factor beta model. Now investors can compare the riskiness of individual stocks in units of beta relative to the overall market index.

The advent of options introduced yet another dimension of risk, which notional alone fails to quantify, that of nonlinearity. The Black-Scholes option pricing model (1973) introduced the so-called Greeks, a measurement of sensitivity to market parameters that influence a product's pricing, an idea that has gone beyond just option instruments. Risk managers now measure sensitivities to various parameters for every conceivable product and impose Greek limits on trading desks. The use of limits to control risk taking gained acceptance in the mid-1980s but sensitivity has one blind spot—it is a local risk measure. Consider, for example, the delta of an option (i.e., option price sensitivity to a 1% change in spot) that has a strike near spot price. For a 10% adverse move in spot, the real loss incurred by the option is a lot larger than what is estimated by delta (i.e., 10 times delta). This missing risk is due to nonlinearity, a behavior peculiar to all option products. The problem is more severe for options with complex (or exotic) features.

The impasse was solved from the early 1990s by the use of stress tests. Here, the risk manager makes up (literally) a set of likely bad scenarios—say a 20% drop in stocks and a 1% rise in bond yield—and computes the actual loss of this scenario. While this full revaluation approach accounts for loss due to nonlinearity, stress testing falls short of being the ideal *riskometer*—it is too subjective and it is a static risk measure—the result is not responsive to day-to-day market movements.

Then in 1994, JP Morgan came out with RiskMetrics, a methodology that promotes the use of value-at-risk (VaR) as the industry standard for measuring market risk.[1] VaR is a user-determined loss quantile of a portfolio's return distribution. For example, if a bank chooses to use a 99%-VaR, this result represents the minimum loss a bank is expected to incur with a 1% probability. By introducing a rolling window of say 250 days to collect the distributional data, VaR becomes a dynamic risk measure that changes with new market conditions.

In 1995, the Basel Committee of Banking Supervision enshrined VaR as the de facto riskometer for its *Internal Model* approach for market risk.

Under Basel II, all banks are expected to come up with their implementation of VaR (internal) models for computing minimum capital.

1.2 TALEB'S EXTREMISTAN

The idea of *extremistan* was made popular by Nassim Taleb, author of the *New York Times* bestseller *The Black Swan*.[2] The book narrates the probabilistic nature of catastrophic events and warns of the common misuse of statistics in understanding extreme events of low probability. It is uncanny that the book came out a few months before the subprime fiasco that marked the onset of the credit crisis.

The central idea is the distinction between two classes of probability structures—*mediocristan* and *extremistan*. Mediocristan deals with rare events that are *thin tailed* from a statistical distribution perspective. Large deviations can occur, but they are inconsequential. Take for example the chance occurrence of a 10-foot bird, which has little impact on the ecosystem as a whole. Such distributions are well described by the (tail of) bell-shaped Gaussian statistics or modeled by random walk processes. On the other hand, extremistan events are *fat tailed*—low probability, high impact events. *Past occurrences offer no guidance on the magnitude of future occurrences*. This is a downer for risk management. The effect of the outcome is literally immeasurable. Some examples are World Wars, flu pandemics, Ponzi schemes, wealth creation of the super rich, a breakthrough invention, and so on.

A philosophical digression—mediocristan and extremistan are closely associated with scalability. In mediocristan, the outlier is not scalable—its influence is limited by physical, biological, or environmental constraints. For example, our lone 10-foot bird cannot invade the whole ecosystem. Extremistan, in contrast, lies in the domain of scalability. For example, capitalism and free enterprise, if unrestrained by regulation, allow for limitless upside for the lucky few able to leverage off other people's money (or time). Because of scalability, financial markets are extremistan—rare events of immeasurable devastation or *Black Swans* occur more often than predicted by thin-tailed distributions.

Another reason why financial markets are more extremistic than nature is because they involve thinking participants. The inability of science to quantify its cause and effect has pushed the study of this phenomenon to the domain of behavioral finance, with expressions such as *herd mentality*, *animal spirits*, *madness of the crowd*, *reflexivity*, *endogeneity of risk*, and *positive feedback loops*.

VaR is a victim of extremistan. Taleb, a strong critic of VaR, sees this method as a potentially dangerous malpractice.[3] The main problem is that

financial modelers are in love with Gaussian statistics in which simplistic assumptions make models more tractable. This allows risk modelers to quantify (or estimate) with a high degree of precision events that are by nature immeasurable (extremistan). That can lead to a false sense of security in risk management. Taleb's extremistan, vindicated by the 2008 crisis, has dealt a serious blow to the pro-VaR camp.

This book introduces, *bubble VaR* (buVar), an extension of the VaR idea that denounces the common basic statistical assumptions (such as stationarity). It is fair to say that the only assumption made is that one cannot measure the true number. It is hypothetical, and it is a moving target. In fact, we *need not* measure the true expected loss in order to invent an effective safeguard. This is what buVaR attempts to achieve.

1.3 THE TURNER PROCYCLICALITY

The idea of procyclicality is not new. In a consultative paper, Danielsson and colleagues (2001)[4] first discussed procyclicality risk in the context of using credit ratings as input to regulatory capital computation as required under the Internal Rating Based (IRB) approach. Ratings tend to improve during an upturn of a business cycle and deteriorate during a downturn. If the minimum capital requirement is linked to ratings—requiring less capital when ratings are good—banks are encouraged to lend during an upturn and cut back loans during a downturn. Thus, the business cycle is self-reinforced artificially by policy. This has damaging effects during a downturn as margin and collateral are called back from other banks to meet higher regulatory minimum capital.

This danger is also highlighted in the now-famous *Turner Review*,[5] named after Sir Adair Turner, the new Financial Service Authority (FSA) chief, who was tasked to reform the financial regulatory regime. The review has gone furthest to raise public awareness of hard-wired procyclicality as a key risk. It also correctly suggested that procyclicality is an inherent deficiency in the *VaR measure* as well. Plot any popular measure of value at risk (VaR) throughout a business cycle, and you will notice that VaR is low when markets are rallying and spikes up during a crisis.

This is similar to the *leverage effect* observed in the markets—rallies in stock indices are accompanied by low volatility, and sell downs are accompanied by high volatility. From the reasoning of behavioral science, fear is a stronger sentiment than greed.

However, this is where the analogy ends. The leverage effect deals with the way *prices* behave, whereas VaR is a *measurement* device (which can be corrected). The *Turner Review* says our VaR riskometer is faulty—it contains hardwired procyclicality. Compounding the problem is that trading

positions are recorded using mark-to-market accounting. Hence, in a raging bull market, profits are realized and converted into additional capital for even more investment just as (VaR-based) regulatory capital requirements are reduced. It is easy to see that this is a recipe for disaster—the rules of the game encourage banks to chase the bubble.

To mitigate the risk of procyclicality, the *Turner Review* calls for a longer observation period—the so-called through-the-cycle rather than point-in-time (what VaR is doing currently) measures of risk—as well as more stress tests. Some critics[6] argue that the correct solution is not simply to make the capital charge larger or more penal for banks, but also more timely. It is unavoidable that VaR based on short histories is procyclical, precisely because it gives a timely forecast. Efforts to dampen procyclicality by using a longer history will worsen the forecast; it is no longer market sensitive and timely.

As we shall see, buVaR addresses the procyclicality problem by being countercyclical in design, without sacrificing timeliness.

1.4 THE COMMON SENSE OF BUBBLE VALUE-AT-RISK (BuVaR)

The idea of buVar came from a simple observation: when markets crash, they fall downwards, rather than upwards (?). Yes, this basic asymmetry is overlooked by present-day measures of risks. Let's think along.

Even in the credit crisis in 2008 when credit spreads crashed upwards, that event came after a period of unsustainable credit-spread compression. So, to be more precise, a market crash happens only after an unsustainable price rally or decline—often called a bubble—and in the opposite direction to the prevailing trend.

If this is a universal truth, and there is overwhelming evidence that it is, then does it not make sense that market risk at point C is higher than at points A, B, and D? (Figure 1.1). We know this intuitively and emotionally as well; suppose you do not have any trading views, then a purchase (or sale) of stocks at which level would make you lose sleep? Because while the bubbles are obvious, when they will burst is not. Hence the trader's adage "the markets climb the wall of worry."[7]

Yet the conventional measure of risk, VaR, does not account for this obvious asymmetry. Table 1.1 compares the 97.5% VaR[8] for the Dow Jones index at various points. Notice that A, B, and C have about the same risks.

Only *after* the crash (at D) does VaR register any meaningful increase in risks. It's like a tsunami warning system that issues alerts after the waves have reached landfall! It seems VaR is reactive rather than preventive. What happened?

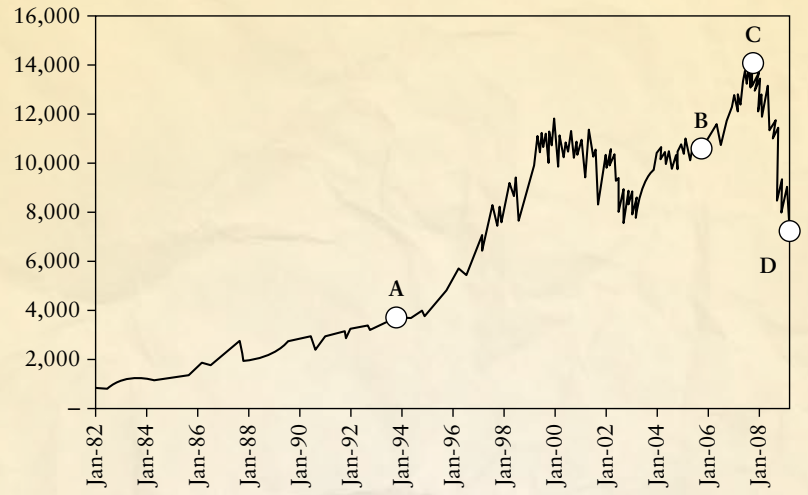

FIGURE 1.1 Dow Jones Index

TABLE 1.1 97.5% Value-at-Risk for Dow Jones Index Using Historical Simulation

Point in Time	97.5% VAR (weekly)	VAR (mean adjusted)	Maximum Weekly Drawdown	Max Weekly Drawdown (St. Dev)
A	−2.3%	−2.5%	−3.4%	2.7
B	−3.3%	−3.4%	−3.6%	2.1
C	−3.2%	−3.5%	−4.3%	2.5
D	−6.4%	−5.8%	−20.0%	6.9

The same situation can also be observed for Brent crude oil prices (Figure 1.2 and Table 1.2). Is VaR just a peacetime tool? The root cause can be traced back to model assumptions.

VaR and most risk models used by banks assume returns are *independent and identically distributed* (or i.i.d.), meaning that each return event is not affected by past returns, yet they are identical (in distribution)! As a result, the return time series is *stationary*. Here *stationary* means that if you take, say, a 250-day rolling window of daily returns, its distribution looks the same in terms of behavior whether you observe the rolling window today, a week ago, or at any date. In other words, the distribution is *time invariant*. Let's look at one such time series, the one-day *returns* of the Dow Jones index (Figure 1.3). Compared to Figure 1.1, the trend has been

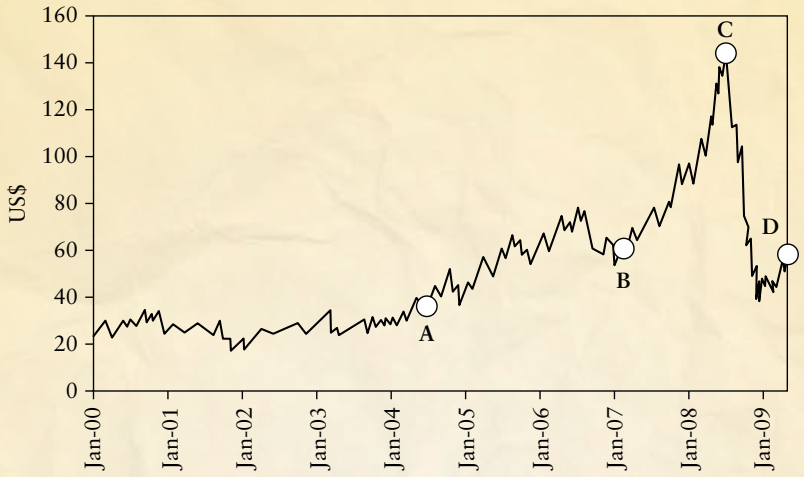

FIGURE 1.2 Crude Oil Price (in U.S. dollars)

TABLE 1.2 97.5% Value at Risk for Crude Oil Price

Point in Time	97.5% VAR (weekly)	VAR (mean adjusted)	Maximum Weekly Drawdown	Max Weekly Drawdown (St. Dev)
A	−8.2%	−8.5%	−25.4%	6.0
B	−7.1%	−7.3%	−9.0%	2.5
C	−6.4%	−7.0%	−9.0%	2.5
D	−13.7%	−13.6%	−29.7%	4.4

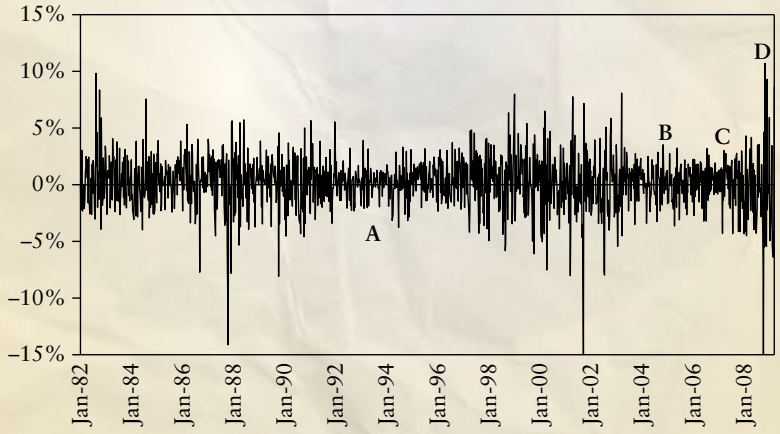

FIGURE 1.3 Daily Price Change of Dow Jones Index

removed completely (*detrended* by taking the daily change); you are left with wiggles that look almost identical anywhere along the time scale (say at A, B, or C) and almost *symmetrical* about zero. At D, risk is higher only because it wiggles more.

VaR models are built on statistics of only these detrended wiggles. Information on price levels even if they contain telltale signs—such as the formation of bubbles, a price run-up, widening of spreads—are ignored (they do not meet the requirement of i.i.d.). VaR is truly nothing more than the science of wiggles. The i.i.d. assumption lends itself to a lot of mathematical tractability. It gives modelers a high degree of precision in their predictions.[9] Unfortunately precision does not equate to accuracy. To see the difference between precision and accuracy, look at the bull's-eye diagrams in Figure 1.4. The right-side diagram illustrates the shotgun approach to getting the correct answer—accurate but not precise. Accuracy is the degree of authenticity while precision is the degree of reproducibility.

In risk measurement, Keynes's dictum is spot on: "It is clearly better to be approximately right, than to be precisely wrong." The gross underestimation of risk by VaR during the credit crisis, a Black Swan event, is a painful objective lesson for banks and regulators. The events of 2008 challenge the very foundation of VaR and are a wake-up call to consider exploring beyond the restrictive, albeit convenient, assumption of i.i.d. BuVaR is one such initiative.

The *Turner Review* calls for the creation of countercyclical capital buffers on a global scale. It will be ideal if we have a VaR system that

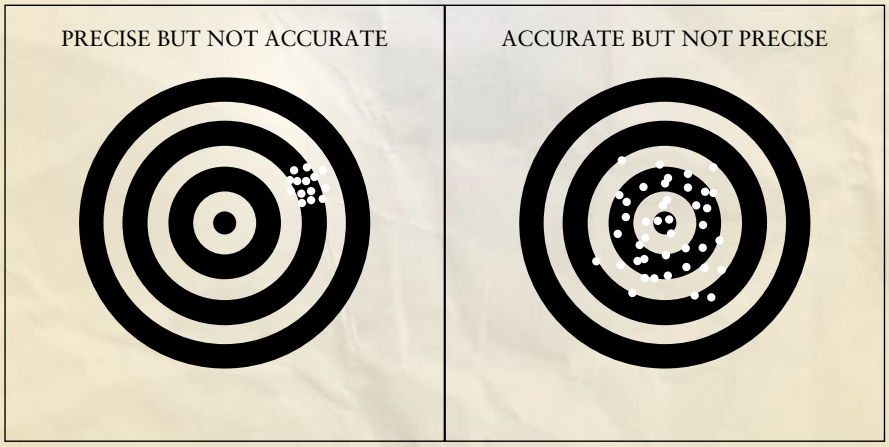

FIGURE 1.4 Precision versus Accuracy

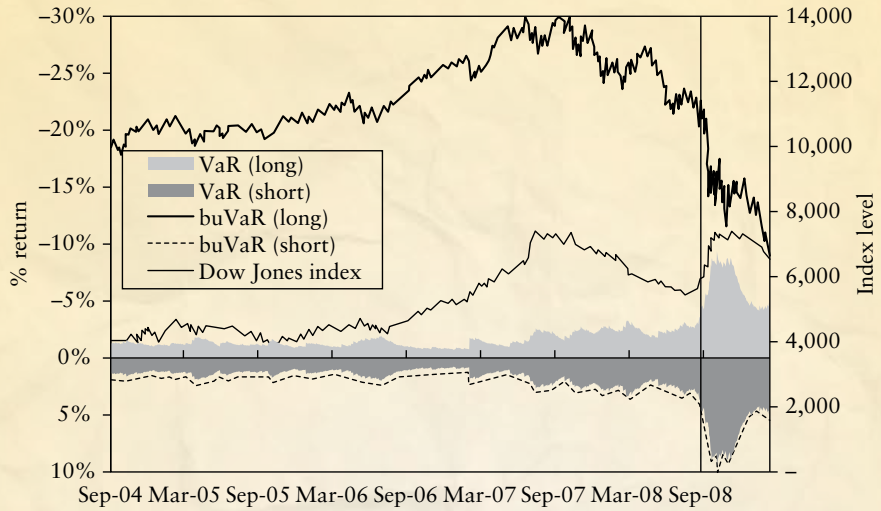

FIGURE 1.5 BuVaR and VaR Comparison

automatically penalizes the bank—by inflating—when positions are long during a bubble rally, and continues to penalize the bank during a crash. Then when the crash is over and the market overshoots on the downside, VaR penalizes the short side positions instead. As we shall learn, buVaR does this—it is an asymmetrical, preventive, and countercyclical risk measure that discourages position taking in the direction of a bubble.

Figure 1.5 is a preview of buVaR versus VaR^{10} for the Dow Jones index during the recent credit crisis. VaR is perpetually late during a crisis and does not differentiate between long and short positions. BuVaR peaks ahead of the crash (is countercyclical) and is always larger than VaR, to buffer against the risk of a crash on one side. It recognizes that the crash risks faced by long and short positions are unequal. Used for capital purposes, it will penalize positions that are chasing an asset bubble more than contrarian positions.

If implemented on a global scale, buVaR would have the effect of regulating and dampening the market cycle. Perhaps then, this new framework echoes the venerable philosophy of the FED:

> *It's the job of the FED to take away the punch bowl just as the party gets going.*
>
> —William McChesney Martin Jr., FED Chairman 1951–1970

NOTES

1. There are claims that some groups may have experimented with risk measures similar to VaR as early as 1991.
2. Taleb, 2007, *The Black Swan: The Impact of the Highly Improbable.*
3. See the discussion "Against Value-at-Risk: Nassim Taleb Replies to Phillip Jorion," Taleb, 1997.
4. Danielsson et al., "An Academic Response to Basel II," Special Paper 130, ESRC Research Centre, 2001.
5. Financial Service Authority, 2009, *The Turner Review—A Regulatory Response to the Global Banking Crisis.*
6. RiskMetrics Group, 2009, "VaR Is from Mars, Capital Is from Venus."
7. This is supported by empirical evidence that put-call ratios tend to rise as stock market bubbles peak. This is the ratio of premium between equally out-of-money puts and calls, and is a well-studied indicator of fears of a crash.
8. The VaR is computed using a 250-day observation period, and expressed as a percentage loss of the index. VaR should always be understood as a loss; sometimes a negative sign is used to denote the loss.
9. By assuming i.i.d., the return time series becomes stationary. This allows the Law of Large Numbers to apply. This law states that, as more data is collected, the sample mean will converge to a stable expected value. This gives the statistician the ability to predict (perform estimation) with a stated, often high, level of precision.
10. The VaR is computed by the RiskMetrics method using exponentially decaying weights.

Bubble Value At Risk

A Countercyclical Risk Management Approach

+WEBSITE
REVISED EDITION

MAX C.Y. WONG
Foreword by Moorad Choudry

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A risk professional with fifteen years of experience in financial services, **Max C.Y. Wong** heads the VaR model validation team at RBS. Prior to this, he has worked in other roles such as market strategist, futures trader, and financial analyst at various financial institutions. He was an "open outcry" pit trader during the Asian crisis in 1997 and a quant risk manager during the credit crisis in 2007. He holds a BSc in physics and MSc in financial engineering. Max's current interest is in the area of financial regulatory reform and innovative risk management. He is based in Singapore and is a regular speaker at conferences in the region as well as a part-time lecturer at Singapore Management University and National University of Singapore.

The cover image is designed by **Michael Wong**,
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"Bubble Value at Risk offers a critical rethinking of some of the deficiencies in the calculation of risk capital. I particularly liked the more applied wisdom scattered throughout the text. Here is a practitioner explaining how things really work, or for that matter, don't work in the real world. These remarks will definitely open the eyes of the more academic researcher."

—Paul Embrechts, Director of RiskLab, ETH Zurich

"Reading Bubble Value at Risk is an intensive master class in risk management. As a busy risk management practitioner, I found Bubble Value at Risk extremely worthwhile in that Wong, with the theoretic detail of an academic but with the intuition of a practitioner, very efficiently surveys the evolution of financial risk management thought since the credit crisis. The book is well written, organized, thought-provoking, and to the point. After constructively critiquing pre-crisis risk management for its conceit that it could precisely model extreme events, Wong pragmatically breaks with risk dogma and introduces the concept of Bubble Value at Risk as a more prudent means of allocating sufficient capital to buffer tail risk in light of the fact that tail risk is inherently unknowable. The book is simply a very good use of time for anyone fighting the guerrilla war with risk."

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"John Maynard Keynes is famous for many things, including this quote on bankers: 'A sound banker, alas, is not one who foresees danger and avoids it, but one who, when he is ruined, is ruined in a conventional way along with his fellows, so that no one can really blame him.' This quote, originally found in The Consequences to the Banks of the Collapse of Money Values (1931), describes very accurately the robotic use of the value at risk concept at many financial institutions. Max Wong skewers the conventional wisdom on value at risk in this original book from a very talented and experienced market participant. Mr. Wong illustrates the mathematical problems with value at risk with many worked examples and insights from the 2007-2011 credit crisis. He suggests an alternative to the conventional wisdom, ' Bubble Value at Risk,' which addresses many of the shortcomings in conventional VaR calculations that were starkly revealed during the credit crisis. We highly recommend this candid and enlightening book to any risk analyst who finds himself surrounded by a large contingent of 'sound bankers.'"

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"Wong establishes his reputation as an inventive risk manager with the innovative idea to express expected shortfall (also called expected tail loss, or conditional VaR) in terms of previous price levels. This book also has some interesting ideas on financial regulatory reform and should be attractive to non-quant readers seeking knowledge of the pitfalls of Value-at-Risk, as it is usually measured."

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