Risk as a History of Ideas

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The perception of risk throughout history has reflected the temper and times in each society as the emphasis has swung from gut to measurement and back to gut. As long as people sensed they had no control over their futures, chance explained the entire outcome of risk taking. Then, the collection of ideas we call the Renaissance freed the human spirit for experimentation and exploration, demonstrating that choice is a valid human activity and that risk is something to be taken as well as faced. Quantification became essential, leading to the development of the laws of probability. In more modern times, uncertainty has replaced many of the neat concepts of probability and has even begun to attack the roots of the capital ideas of finance: mean–variance, the efficient market hypothesis, and the capital asset pricing model.

Risk has always been a matter of measurement and gut. As measurement and gut intertwine in ever-changing ways over time, they reflect the development of the most basic philosophical underpinnings of society. This shifting interaction is what makes risk as a history of ideas so important and so exciting.

Risk as a history of ideas is especially pertinent right now. I refer to more than the parochial attack on the quantitative risk measurements featured in mean–variance theories and the capital asset pricing model (CAPM). The very structure of the world as we have known it seems to be trembling at its foundations, intensifying the search for novel risk management techniques at all levels of human activity.

I shall begin at the beginning and trace how risk evolved from superstition to the theory of probability to the notion of uncertainty. Because the unknown is always with us, the way humans have responded to the fog of the future can tell us a great deal about what has motivated us and shaped our beliefs about ourselves and the universe. The story goes in a straight line, with three brief digressions.

For by far the largest part of human history, the future was a black hole. As long as people sensed that they had no control over their futures, chance explained the entire outcome of risk taking. Oracles and priests—especially priests—were the forecasters of choice, because people believed that these seers had a direct line to the powers that controlled the elements. But the random track records and obscure methodologies of these seers created little confidence in their predictions; like Macbeth, their constituents believed what they wanted to believe and rejected the rest.

No one can study this long history without being astonished by the absence of anything that resembles the laws of probability as we know them today. After all, evidence of gambling reaches all the way back to the earliest days of human civilization. Yet, any form of systematic analysis of the likelihood of future events is less than 600 years old.

One can only speculate about why even the master mathematicians and philosophers of ancient Greece had no interest in this subject. The entire Mediterranean basin from about 500 BC to 300 BC was a hotbed of scientific research, much of which has dominated the work of scientists right up to our own time. Indeed, knowledge of these matters reaches back even farther. The priests in the temples of Egypt and Babylon knew quite a bit about geometry before Euclid came upon the scene, and the Pythagorean Theorem about the square of the hypotenuse provided a strategic element to architecture in the Tigris–Euphrates Valley as early as 2000 BC.

The Greeks were special, less because of their many remarkable discoveries than because they were the first civilization to be free of the intellectual strait-

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jackets imposed by secretive and all-powerful priesthoods. As a consequence, the Greeks refused to accept at face value the rules of thumb that older societies passed on to them. The unique quality of the Greek spirit was their insistence upon logical proofs that would validate what they were told.

Still, they shut their eyes to the laws of probability. I do not mean to suggest that they were ignorant of probability as a general idea. The surprise is that they turned their back on quantification.

The key to this puzzle is in the Greek view of the distinction between heaven and earth. The Greeks were great astronomers who discovered order, regularity, and perfection in the skies. In contrast, irregularity and unpredictability defined the earth for them. The idea of laws of probability for earthlings was a contradiction in terms, an alien concept. There was no point in seeking order where no order could possibly exist. This viewpoint, which is articulated repeatedly in all Greek drama, was pervasive in Greek civilization.

As long as people sensed that they had no control over their futures, chance explained the entire outcome of risk taking. But that view vanished abruptly with the arrival of Christianity. Now random chance was out; God's will was in. "Thy will be done" became the dominant paradigm for determining the future and explaining the past. As a consequence, scientific research was crushed. In Alexandria in 380 AD, for example, the monks of St. Cyril murdered Hypatia, a brilliant mathematician, by scraping her naked body with oyster shells.

But even the Church, calling on the highest authority of them all, could not stifle human curiosity. The authority of religion ultimately crumbled before the endless search for a better life on earth.

For the West, the defining event was the Crusades, with the culture shock of Arabic civilization and, in particular, the numbering system the Arabs had inherited from the Hindus nearly a thousand years earlier. This story is worth an essay of its own, but here I can only emphasize its overwhelming importance. Try writing an algebraic equation with Roman numerals or without regard to zero. How about II^{II}? As the great philosopher Alfred North Whitehead put it,

> The point about zero is that we do not need to use it in the operations of daily life. No one goes out to buy zero fish. It is in a way the most civilized of the cardinals, and its use is only forced on us by the most cultivated modes of thought.

Unlike the alphabetical numbering systems of the Hebrews, Greeks, and Romans, the Hindu numbers are the inputs to calculations and are only incidentally used to record calculation. As people were liberated from the constraints of the counting frame, or abacus, a whole new world of mathematics became possible, offering the limitless character of the abstract, not merely the tangible.

As digression number one, I want to mention the earliest known work on Arabic arithmetic. It was written about 825 by a man whose name was al-Khowârizmî. The name is the derivation of the word "algorithm," which with its unmistakable diphthong, I had always assumed had a respectable Greek origin. al-Khowârizmî was the first mathematician to establish rules for adding, subtracting, multiplying, and dividing with the new Hindu numerals. He also wrote a treatise on the subject of *al-jahr*, which is the derivation of "algebra." Thanks to al-Khowârizmî, schoolchildren have been learning the multiplication tables for more than 1,000 years.

The combination of the Crusades, the early development of trade, and the beginning of serious geographical exploration made people explicitly aware, for the first time in human history, that perhaps they did have some control over their futures, that choice is a valid human activity, and that risk is something to be taken as well as something to be faced. After all, the word "risk," so often defined in relation to loss, has its roots in the early Italian *risicare*, which means to dare, or from the Greek *rhiza*, which pertains to sailing around a cliff. That was what the Renaissance was all about: the freeing of the human spirit for experimentation, innovation, exploration.

Now, measurement became not only interesting but also essential. A literature in mathematics began to develop to explain the new numbering system and how to apply it to real-time problems. (Again, I skip over fascinating material such as the pioneering work in algebra of the poet Omar Khayyam about 1100 AD and, a hundred years later, of Leonardo Fibonacci of the mysterious Fibonacci numbers.) The most important book in mathematics to appear in the early years of the Renaissance was *Summa de arithmetic, geometria et proportionalità*, published in Venice in 1494 and written by a cosmopolitan and widely traveled Franciscan named Luca Paccioli. The *Summa* drew heavily on Fibonacci's work, but it was also the first serious effort to explain double-entry bookkeeping, an innovation with economic consequences comparable to the discovery of the steam engine 300 years later.

Paccioli also set out the basic principles of algebra, in the course of which he posed the following problem:

> A & B are playing a fair game of balla. They agree to play until one has won six rounds. The game actually stops when A has won five and B three. How should the stakes be divided?

This puzzle, which is known as the problem of the points, sounds innocuous, but it is not. It appears repeatedly in the writings of the mathematicians of the 16th and 17th centuries, with many different variations but always with the same question: How do we divide the stakes in an incomplete game? The answers were not obvious to the mathematicians of those times and led to heated disputes. The problem of the points turned out to be the origin of the calculus of probability. The definitive solution had to wait for nearly 150 years.

Before telling you how that solution came about, I must stop for digression number two. Probability, as a systematic concept, really started in the mid-1550s with an Italian who was a contemporary of Benvenuto Cellini and Copernicus. His name was Girolamo Cardano, and I fail to understand why so few people are acquainted with this fascinating man. Cardano described himself as "hot-tempered, single-minded, and given to women," as well as "cunning, crafty, sarcastic, diligent, impertinent, sad, treacherous, magician and sorcerer, miserable, hateful, lascivious, obscene, lying, obsequious, fond of the prattle of old men."

Cardano wroee 131 printed works, claims to have burned 170 more, and left 111 in manuscript form at his death. His writings spanned math, astronomy, physics, urine, teeth, the life of the Virgin Mary, Jesus Christ's horoscope, morality, immortality, Nero, music, and dreams. He wrote a book on venereal disease, but it was never published because, as he noted in his autobiography, "Hi libri corrupti sunt urina felis."

Cardano's great book in mathematics, *Ars Magna* (*The Great Art*), appeared in 1545 and was the first major work to concentrate on algebra. Cardano marched right into the solutions to cubic and quadratic equations. He even wrestled with square roots of negative numbers, totally unknown concepts before the introduction of the Hindu numbering system and still mysterious and inconceivable to many people.

Cardano was a passionate and compulsive gambler, whose treatise on the subject, *Liber de Ludo Aleae*, appears to have been the first serious effort to develop the principles of probability. Cardano wrote the book in 1525 and rewrote it in 1565, claiming to "have discovered the reason for a thousand astounding facts." Note the use of the words "reason for." Cardano issued the theoretician's customary lament that ". . . these facts contribute a great deal to understanding but hardly anything to practical play." The book was never published in Cardano's lifetime but was found among his manuscripts when he died. Its first public appearance came much later, when it was printed in Basle in 1663.

Cardano's generalizations about the probabilities in gambling have high importance. He sensed the concept of the law of large numbers. He defined, for the very first time, what is now the conventional format for expressing probability as a fraction. He even had to teach his readers that the probabilities on throws of two six-sided dice were to be based on 36 possibilities, not 12.

Now, return to the problem of the points. In 1654, at about the moment when Cardano's book on gambling appeared, a wealthy French nobleman with an addiction to gambling put the question to a religious freak who was also a great mathematician. This man then turned to a provincial lawyer whom he had never met but who played with the theory of numbers in his spare time. The noble gambler was the Chevalier de Méré; the mathematicians were Blaise Pascal and Pierre de Fermat. Between them, they set the stage for all the work in probability theory that was to follow, right up to Gauss's development of the normal distribution, based upon his geodesic and astronomical studies from 1809 to 1816, and Galton's proposition of the regression to the mean and the coefficient of correlation, based on his explorations into generations of sweetpeas in the 1880s. Where would finance theorists and practitioners be without these two men?

Galton was a wealthy Victorian and amateur scientist whose diverse achievements included the invention of eugenics and fingerprinting. Measurement was Galton's obsession. "Wherever you can, count," was one of his favorite expressions.

Galton took note of the size of heads, noses, arms, legs, heights, and weights, and of the color of eyes, the sterility of heiresses, the number of fidgets made by people listening to lectures, and the degree of color change as the audience at a derby watched the horses run a race. He classified the good looks of girls he passed on the street, pricking a hole in a left-pocket card when the subject was comely and pricking a right-pocket card when she was plain (the London girls scored highest; the girls of Aberdeen were at the bottom).

Galton's compulsion to measure accompanied him even on a trip in darkest Africa in 1849 to hunt big game in what is now known as Namibia. When he arrived at a village of Hottentots, one of the women caught his attention. As a scientific man, he reported, he was "exceedingly anxious to obtain accurate measurements of her shape." He could speak no Hottentot and was uncertain how to undertake this urgent piece of research, but he still accomplished his goal:

> Of a sudden, my eye fell upon my sextant; the bright thought struck me, and I took a series of observations upon her figure in every direction. . . . [T]his being done, I boldly pulled out my measuring tape, and measured the distance from where I was to the place where she stood, and having thus obtained both base and angles, I worked out the results by trigonometry and logarithms.

Although the theory of probability was developing into a mighty tool to help humans grasp at the unknown future, an underground set of ideas was beginning to gain a foothold. The progenitor of these new concepts was in Daniel Bernoulli's so-called Petersburg Paradox in 1738. Bernoulli described a game in which a player at coin flipping has a chance to win an infinite amount. What should the player pay for this opportunity?

The Petersburg Paradox provoked intense controversy that continued long after Bernoulli died in 1782, but everyone agreed that there are good arguments against paying an infinite amount for the opportunity to win an infinite amount. That was the intellectual point of inflection: If utility functions are concave rather than straight lines, then the number of utility functions you can draw is limitless. In other words, gut has returned to the scene and measurement recedes into the background. Uncertainty has begun to confront probability.

The big break in risk perceptions, however, came when World War I blasted into smithereens the conventional wisdoms of the Victorian and Edwardian eras. A world that had once seemed predictable and orderly turned out to be unpredictable and disorderly in the extreme. It is no coincidence that Frank Knight's great book *Risk, Uncertainty, and Profit* appeared in 1921 and that he chose these words to express his central theme: "There is much question as to how far the world is intelligible at all. . . . It is only in very special and crucial cases that anything like a mathematical study can be made." Nor is it a coincidence that Keynes's *Treatise on Probability* also appeared in 1921 and is, in essence, an attack upon the whole idea that mathematics can define the future with any degree of certainty. Keynes even takes up arms against Gauss's worship of the concept of the mean. Later, writing in the shadow of the Great Depression, Keynes described decision making under uncertainty in these words:

> [Most of our decisions] to do something positive . . . can only be taken as a result of animal spirits . . . and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities.

Seen from this perspective, what are we to think about the elegant structure of capital ideas that recently inspired me: mean–variance, CAPM, and the efficient markets hypothesis (EMH)? Although I have not heard anyone refer to this body of theory as classical, its balance, cohesion, clarity, and consistency provide all the necessary hallmarks of classical forms. Today, the classical capital ideas are suspected of suffering from kurtosis, skewness, and other less familiar malignancies. They are under attack from nonlinear hypotheses, overwhelmed by fears of discontinuities rather than pricing volatilities and factors, and frequently made irrelevant by exotic new financial instruments that come in unfamiliar shapes and hedge unfamiliar risks. As the mathematics that define these risks grows increasingly complex, the dimensions, contours, and limits of risk are becoming correspondingly obscure.

These developments do not mean that the classical concepts of finance were in some sense "wrong." The argument runs the other way. The effort to abandon the beautiful and coherent logic of the classical ideas reflects, not on the ideas, but on the changing environment in which we live.

The philosophical roots of mean–variance, CAPM, and EMH, I would argue, stemmed from the optimism of the early postwar years—the 1950s and 1960s. That was a time when people believed that men and women of good will could remake the awful world of the 1930s into a new world: well behaved, functioning within clearly recognized standard deviations, and with generally accepted means to which matters would inexorably regress. I use finance-speak here, but I refer to the contours of life in its broadest sense. In such a world, financial markets are always orderly and risk is recognizable, measurable, manageable, and containable. In such a world, in short, you have some sense of where the shocks will be coming from.

The reluctant acceptance of the classical ideas by practitioners after the turbulence of 1973 and 1974 reflected a search for order at a terrifying moment when OPEC had taken pains to remind us that we were verging on chaos. In the wake of stunning losses of wealth, nominal as well as real, risk control became an explicit goal for the first time in many years—an occasion for which the new theories of portfolio management and market behavior were made to order.

But time has proven once again that the world does not come in neat and familiar packages. In a world that is changing faster than any of us can understand, risk seems less amenable to measurement than most investors had come to believe. The result is that tried-and-true methods of risk management are on the defensive, even though risk aversion is as intense as ever—perhaps more intense than ever. An explosive demand for novel forms of containing risk is developing, some of which, I fear, may in the end make markets more risky rather than less.

All of these developments should come as no surprise. Throughout history, the perception of risk has reflected the temper of the times in each society. From the superstitions of the ancients to the strict regulations of the early Christian church, from the rational views of the Renaissance and the Enlightenment to the upheavals provoked by World War I and the Great Depression, and from the classical concepts of modern portfolio theory to the dark and hidden forces driving us today, perceptions of risk are the most powerful symptoms of what a society is all about.