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**Riccardo Rebonato: Plight of the Fortune Tellers**

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## CHAPTER 1

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### WHY THIS BOOK MATTERS

But what I... thought altogether unaccountable was the strong disposition I observed in [the mathematicians of Laputa] toward news and politics, perpetually enquiring into public affairs, giving their judgement on matters of state, and passionately disputing every inch of a party opinion. I have indeed observed the same disposition among the mathematicians I have known in Europe, although I could never observe the least analogy between the two sciences, unless those people suppose that because the smallest circle hath as many degrees as the largest, therefore the regulation and management of the world require no more abilities than the handling and turning of a globe.

Jonathan Swift, writing about the mathematicians of Laputa

### STATISTICS AND THE STATE

**T**his book is about the quantitative use of statistical data to manage financial risk. It is about the strengths and limitations of this approach. Since we forget the past at our own peril, we could do worse than remind ourselves that the application of statistics to economic, political, and social matters is hardly a new idea. The very word “statistics” shares its root with the word “state,” a concept that, under one guise or another, has been with us for at least a few centuries. The closeness of this link, between compilations of numbers, tables of data, and actuarial information on the one hand and the organization and running of a state on the other

may today strike us as strange. But it was just when the power of this link became evident that statistics as we know it today was “invented.” So, in its early days probability theory may well have been the domain of mathematicians, gamblers, and philosophers. But even when mathematicians did lend a helping hand in bringing it to life, from the very beginning there was always something much more practical and hard-nosed about statistics.

To see how this happened, let us start at least close to the beginning, and go back to the days of the French Revolution. In the first pages of *Italian Journey* (1798), Goethe writes:

I found that in Germany they were engaged in a species of political enquiry to which they had given the name of *Statistics*. By statistical is meant in Germany an inquiry for the purpose of ascertaining the political strength of a country, or questions concerning matters of state.

By the end of the eighteenth century, when Goethe explained his understanding of the word “statistics,” the concept had been around in its “grubby” and practical form for at least a century. It is in fact in 1700 that we find another German, Leibniz, trying to forward the cause of Prince Frederick of Prussia who wanted to become king of the united Brandenburg and Prussia. The interesting point for our discussion is that Leibniz offers his help by deploying a novel tool for his argument: statistics. Prince Frederick of Prussia was at a disadvantage with respect to his political rivals, because the population of Prussia was thought to be far too small compared with that of Brandenburg to command a comparable seat at the high table of power. If at the time the true measure of the power of a country was the size of its population, the ruler could not be a Prussian. What Leibniz set out to prove was that, despite its smaller geographical size, Prussia was nonetheless more populous than was thought, indeed almost as populous as Brandenburg—and hence, by right and might, virtually as important. How did he set out to do so in those pre-census days? By an ingenious extrapolation *based solely on the Prussian*

*register of births*, which had been started seventeen years earlier and carefully updated since.\*

The details of how the estimate was reached need not concern us here—probably so much the better for Leibniz, because the jump from the birth data collected over seventeen years to the total size of the population was, by modern statistical standards, flawed. What *is* of great current interest is the logical chain employed by Leibniz, i.e., the link between some limited information that we *do* have but that, per se, we may consider of little importance—What do we care about births in Prussia?—to information that we *would* desperately like to have but is currently beyond our reach: for Leibniz and Prince Frederick, ultimately, what is the might of the Prussian army? If anyone were ever to doubt that there is real, tangible power in data and in data collection, this first example of the application of the statistical line of argument to influence practical action should never be forgotten. The modern bank that painstakingly collects information about failures in the clearing of cheques, about minute fraud, about the delinquency of credit card holders and mortgagors (perhaps sorted by age, postcode, income bracket, etc.) employs exactly the same logic today: data give power *to actions and decisions*. To the children of the Internet age it may all seem very obvious. But, at the beginning of the eighteenth century, it was not at all self-evident that, in order to gain control over the running of the state, looking at hard, empirical, and “boring” data might be more useful than creating engaging fictions about “natural man,” “noble savages,” social contracts between the king and the citizens, etc. The first statisticians were not political philosophers or imaginative myth-makers: they were civil servants.

The parallels between these early beginnings and today’s debates about statistics run deeper. As soon as the power of basing decisions on actual data became apparent, two schools of thought quickly developed, one in France (and Britain, Scotland

\*Hacking, *The Taming of Chance*.

in particular) and one in Prussia. Generalizing greatly,\* the French school advocated an interpretation of the data on the basis of the “regularities of human nature”: deaths, births, illness, etc., were, according to the French and British schools of thought, no less regular, and therefore no less amenable to rigorous quantitative analysis, than, say, floods or other “natural” phenomena. Ironically, the Prussian school, that had founded the statistics bureau, failed to reap the full advantage of its head start because it remained suspicious of the French theoretical notions of “statistical law” when applied to human phenomena—and, predictably, derided the French statisticians: “What is the meaning of the statement that the average family has 2.33 children? What does a third of a child look like?”

Perhaps it is not surprising that the country of the fathers of probability theory (Descartes, Pascal, Bernoulli, Fermat, etc.) should have been on the quantitative side of the debate. Indeed, 100 years before statistics were born, Bernoulli was already asking questions such as, “How can a merchant divide his cargo between ten ships that are to brave the pirate-infested seas so as to minimize his risk?” In so doing, he was not only inventing and making use of the eponymous probability distribution, he was also discovering risk aversion, and laying the foundations of financial risk management. Probability and statistics therefore seemed to be a match made in heaven: probability theory would be the vessel into which the “hard” statistical data could be poured to reach good decisions on how to run the state. In short, the discipline of probability, to which these French minds contributed so much, appeared to offer the first glimpses of an intriguing promise: a quantitative approach to decision making.

The Prussian–French debate was not much more constructive than many of the present-day debates in finance and risk management (say, between classical finance theorists and behavioral financiers), with both parties mainly excelling in caricaturing their opponent’s position. Looking behind the squabbling, the

\*For a more nuanced discussion of the two schools, again see Hacking, *The Taming of Chance*.

arguments about the applicability and usefulness of quantitative techniques to policy decisions have clearly evolved, but reverberations of the 200-year-old Franco-Prussian debate are still relevant today. The French way of looking at statistics (and of using empirical data) has clearly won the day, and rightly so. Perhaps, however, the pendulum has swung too far in the French direction. Perhaps we have come to believe, or assume, that the power of the French recipe (marrying empirical data with a sophisticated theory of probability) is, at least in principle, boundless.

This overconfident extrapolation from early, impressive successes of a new method is a recurrent feature of modern thought. The more elegant the theory, the greater the confidence in this extrapolation. Few inventions of the human mind have been more impressive than Newtonian mechanics. The practical success of its predictions and the beauty of the theory took a hold on Western thought that seemed at times almost impossible to shake off. Yet two cornerstones of the Newtonian edifice, the absolute nature of time and the intrinsically deterministic nature of the universe, were ultimately to be refuted by relativity and quantum mechanics, respectively. Abandoning the Newtonian view of the world was made more difficult, not easier, by its beauty and its successes.

It sounds almost irreverent to shift in one paragraph from Newtonian physics and the absolute nature of time to the management of financial risk. Yet I think that one can recognize a similar case of overconfident extrapolation in the current approach to statistics applied to finance. In particular, I believe that in the field of financial risk management we have become too emboldened by some remarkable successes and have been trying to apply similar techniques to areas of inquiry that are only superficially similar. We have come to conclude that we simply have to do “more of the same” (collect more data, scrub our time series more carefully, discover more powerful statistical theorems, etc.) in order to answer *any* statistical question of interest. We have come to take for granted that while some of the questions may be hard, they are always well-posed.

However, if this is not the case but the practice and the policy to control financial risk remain inspired by the nonsensical answers to ill-posed questions, then we are all in danger. And if the policies and practices in question are of great importance to our well-being (as is, for instance, the stability and prudent control of the financial system), we are all in great danger.

### WHAT IS AT STAKE?

Through financial innovations, a marvelously intricate system has developed to match the needs of those who want to borrow money (for investment or immediate consumption) and of those who are willing to lend it. But the modern financial system is far more than a glorified brokerage of funds between borrowers and lenders. The magic of modern financial engineering truly becomes apparent in the way *risk*, not just money, is parceled, repackaged, and distributed to different players in the economy. Rather than presenting tables of numbers and statistics, a simple, homely example can best illustrate the resourcefulness, the reach, and the intricacies of modern applied finance.

Let us look at a young couple who have just taken out their first mortgage on a small house with a local bank on Long Island. Every month, they will pay the interest on the loan plus a (small) part of the money borrowed. Unbeknownst to them, their monthly mortgage payments will undergo transformations that they are unlikely even to imagine. Despite the fact that the couple will continue to make their monthly mortgage payments to their local bank, it is very likely that their mortgage (i.e., the rights to all their payments) will be purchased by one of the large federal mortgage institutions (a so-called “government-sponsored agency”) created to oil the wheels of the mortgage market and make housing more affordable to a large portion of the population. Once acquired by this institution, it will be pooled with thousands of other mortgages that have been originated by other small banks around the country to advance money to similar home buyers. All these

mortgages together create a single, diversified pool of interest-paying assets (loans). These assets then receive the blessing of the federal agency who bought them in the form of a promise to continue to pay the interest even if the couple of newlyweds (or any of their thousands of fellow co-mortgagors) find themselves unable to do so. Having given its seal of approval (and financial guarantee), the federal institution may create, out of the thousands of small mortgages, new standardized securities that pay interest (the rechanneled mortgage payments) and will ultimately repay the principal (the amount borrowed by the Long Island couple).

These new securities, which have now been made appealing to investors through their standardization and the financial guarantee, can be sold to banks, individuals, mutual funds, etc. Some of these standardized securities may also be chopped into smaller pieces, one piece paying only the interest, the other only the principal when (and if) it arrives, thereby satisfying the needs and the risk appetite of different classes of investors. At every stage of the process, new financial gadgets, new financial instruments, and new market transactions are created: some mortgages are set aside to provide investors with an extra cushion against interruptions in the mortgage payments; additional securities designed to act as “bodyguards” against prepayment risk are generated; modified instruments with more predictable cash flow streams are devised; and so on.

So large is this flow of money that every rivulet has the potential to create a specialized market in itself. Few tasks may appear more mundane than making sure that the interest payments on the mortgages are indeed made on time, keeping track of who has repaid their mortgage early, channeling all the payments where they are due just when they are due, etc. A tiny fraction of the total value of the underlying mortgages is paid in fees for this humble servicing task. Yet so enormous is the river of mortgage payments, that this small fraction of a percent of what it carries along, its flotsam and jetsam, as it were, still constitutes a very large pool of money. And so, even the fees earned for the administration of the various cash flows become tradeable instruments in

themselves, for whose ownership investment banks, hedge funds, and investors in general will engage in brisk, and sometimes furious, trading.

The trading of all these mortgage-based securities, ultimately still created from the payments made by the couple on Long Island and their peers, need not even be confined to the country where the mortgage originated. The same securities, ultimately backed by the tens of thousands of individual private mortgage borrowers, may be purchased, say, by the Central Bank of China. This body may choose to do so in order to invest some of the cash originating from the Chinese trade surplus with the United States. But this choice has an effect back in the country where the mortgages were originated. By choosing to invest in these securities, the Central Bank of China contributes to making their price higher. But the interest paid by a security is inversely linked to its price. The international demand for these repackaged mortgages therefore keeps (or, actually, pushes) down U.S. interest rates and borrowing costs. As the borrowing cost to buy a house goes down, more prospective buyers are willing to take out mortgages, new houses are built to meet demand, the house-building sector prospers and employment remains high. The next-door neighbor of the couple on Long Island just happens to be the owner of one small enterprise in the building sector (as it happens, he specializes in roof tiling). The strong order book of his roof tiling business and his optimistic overall job outlook make him feel confident about his prospects. Confident enough, indeed, to take out a mortgage for a larger property. So he walks into the local branch of his Long Island bank. *Au refrain.*

There is nothing special about mortgages: a similarly intricate and multilayered story could be told about insurance products, the funding of small or large businesses, credit cards, investment funds, etc. What all these activities have in common is the redirection, protection from, concentration, or diversification of some form of risk. All the gadgets of modern financial engineering are simply a bag of tricks to reshape the one and only true underlying

“entity” that is ultimately being exchanged in modern financial markets: risk.

But there is more. All these pieces of financial wizardry must perform their magic while ensuring that the resulting pieces of paper that are exchanged between borrowers and lenders enjoy an elusive but all-important property: the ability to flow smoothly and without interruptions among the various players in the economy. All the fancy pieces of paper are useful only if they can freely flow, i.e., if they can be readily exchanged into one another (thereby allowing individuals to change their risk profile at will), or, ultimately, into cash. Very aptly, this all-important quality is called “liquidity.” By itself, sheer ingenuity in inventing new financial gadgets is therefore not enough: the pieces of paper that are created must not only redirect risk in an ingenious way, they must also continually flow, and flow without hindrance.

As the mortgage example suggests, if an occlusion occurs anywhere in the financial flows that link the payments made to the local Long Island bank to the foreign exchange management reserve office of the Bank of China, the repercussions of this clogging of the financial arteries will be felt a long way from where it happens (be it on Long Island or in Beijing). It is because of this interconnectedness of modern financial instruments that financial risk has the potential to take on a so-called “systemic” dimension.

Fortunately, like most complex interacting systems, the financial system has evolved in such a way that compensating controls and “repair mechanisms” become active automatically (i.e., without regulatory or government intervention) when some perturbation occurs in the orderly functioning of the network. Luckily, the smooth functioning of this complex system does not have to rely on the shocks not happening in the first place:

[T]he interesting question is not whether or not risk will crystallize, as in one form or another risks crystallize every day. Rather the important question is whether ... our capital markets can absorb them.\*

\*P. Tucker, Executive Director for Markets and member of the Monetary Policy Committee, Bank of England, *Financial Stability Review* December 2005:73.

And indeed, most of the time, surprises are readily and “automatically” absorbed by the system. But if the shock is too big or if, for any reason, some of the adjusting mechanisms are prevented from acting promptly and efficiently, the normal repair mechanisms may not be sufficient to restore the smooth functioning of the financial flows. In some pathological situations, they may even become counterproductive. If this happens, the effects can quickly be felt well beyond the world of the whirling pieces of paper and can begin to affect the “real economy.” It is exactly because, in a modern economy, the boundaries between the financial plumbing and the real economy have become so blurred and porous that the management of financial risk is today vitally important—and vitally important to everyone, from Wall Street financiers down to the young couple on Long Island.

One of the salient characteristics of the modern economy is that an amazingly complex web of interactions can develop among agents who barely, if at all, know each other, to produce results that give the impression of a strong and conscious coordination (an “intelligent design”). This is, of course, in essence nothing but Adam Smith’s invisible hand in action, but the complexity of modern-day financial arrangements would have been unthinkable when *The Wealth of Nations* was written. Accepting that “no one is in charge” but that an intricate network of transactions will, most of the time, work very well remains to this day difficult to accept from an intuitive point of view. “Please understand that we are keen to move toward a market economy,” a senior Soviet official whose responsibility had been to provide bread to the population of Saint Petersburg in its communist days told economist Paul Seabright,\* “but we need to understand the fundamental details of how such a system works. Tell me, for example, who is in charge of the supply of bread to the population of London.” In the industrialized Western world we may have forgotten how astonishing the reply is (“nobody is in charge”), but

\*P. Seabright (2004), *The Company of Strangers* (Princeton University Press).





















