

SMART
MONEY

How HIGH-STAKES
FINANCIAL INNOVATION
is RESHAPING OUR
WORLD — *for the* BETTER

ANDREW PALMER

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For Julia, Eliza, Joe, and Kasia

Preface

PART I: LESSONS BADLY LEARNED

1. Handmaid to History
2. From Breakthrough to Meltdown
3. The Most Dangerous Asset in the World

PART II: A FORCE FOR GOOD

4. Social-Impact Bonds and the Shrinking of the State
5. Live Long and Prosper
6. Equity and the License to Dream
7. Peer-to-Peer Lending and the Flaws of Finance
8. The Edge: Reaching the Marginal Borrower
9. Tail Risk: Pricing the Probability of Mayhem

Conclusion

Acknowledgments

Glossary

Notes

Index

When I was offered the job of the *Economist's* banking correspondent in the early summer of 2007, my reaction was one of apprehension. Banking was not an industry that I knew anything about. I had a bank account and a mortgage, knew a couple of friends who had gone into the industry and owned much bigger houses than mine, and that was about it. Grappling with the ins and outs of bond markets and bank balance sheets was not just going to be unfamiliar ground—I assumed that it was also going to be boring as hell.

As far as I was concerned, this was an industry that remorselessly piled up profits. The previous few years had seen an epic expansion of bank returns. The largest one thousand banks in the world reported aggregate pretax profits of almost \$800 billion in fiscal year 2007–2008, almost 150 percent higher than in 2000–2001. Banking boasted the largest profit pool in the world in 2006, according to McKinsey, a consulting firm, at 11 percent of the global total.

My professional life was about to consist of interviewing people who made money hand over fist and would presumably continue to do so for as long as I wrote about them. They might be greedy, they might be arrogant, but they certainly knew what they were doing. I didn't realize it at the time, but I was already thinking like a financial regulator.

Fears of a life of tedium turned out to be a bit misplaced. I started on the banking beat in September 2007. The summer had already seen large parts of the financial markets take fright. The downturn in America's subprime-mortgage market had made it impossible for investors to value the holdings of securities backed by these types of loans. The interbank markets, where banks loan money to each other, had suddenly seized up, as institutions realized that they could not be sure of the standing of their counterparties. Something unexpected was happening to the moneymaking machine.

My very first week in the job coincided with a deposit run at Northern Rock, a British lender that came unstuck when it could no longer fund itself in the markets. Some of my earliest interviews on the beat were with people dusting off the manual on how to deal with bank runs. Organizing guided ropes inside bank branches was one tactic: better that than have people spill out onto the street signaling to others that they should join the line. One HSBC veteran happily recounted stories of the financial crisis that gripped Asia in the late 1990s, when tellers were instructed to bring piles of cash into view to reassure people that banks were overflowing with money.

Tales of improvisation from Asia were not supposed to be relevant to the West's ultrasophisticated financial system. But far worse was to come. A chain of events was under way that would lead in time to the collapse of Lehman Brothers, a huge US investment bank, state takeovers of swaths of the rich world's banking systems, a deep global recession, and the Eurozone debt crisis. I observed these later phases of the crisis from the position of the *Economist's* finance editor, a position that I held from July 2009 until October 2013.

The crisis would lead to a complete reversal in public attitudes toward the financial industry.

The decade leading up to the crisis was one in which finance was lionized. Policy makers applauded the march of new techniques, such as securitization, that appeared to send risk away from the bank and spread it more evenly throughout the financial system. Belief in the efficiency of markets was so pervasive that the skeptics were both few in number and easily dismissed.

The events of the past few years have shattered the belief of outsiders in finance's infallibility. That is an entirely good thing. The system is far less Darwinian than the bankers would like to believe. Banking is not the only industry that gets government handouts—in October 2013 the US government booked a loss on the \$50 billion bailout of General Motors, and I don't see much public discussion of the evils of the car industry—but it has clearly benefited from a safety net that others do not have. Now is it really the law of the jungle for individuals in banking. I have met a lot of very bright people in the financial industry, but I have also met some very mediocre ones, and pretty much all of them seem to remain employable.

But when things go so badly wrong, the pendulum almost inevitably swings too far in the other direction. Another type of consensus has emerged, one in which finance is demonized, in which bankers are generally bad, in which there is a "socially useful" bit of the industry that doles out loans to individuals and businesses, and the rest of it is dangerous, unnecessary gambling. Such anger is understandable. But it also has the effect of distorting the public view of the industry.

CHRIS SHEPARD IS THE kind of person that people have in mind when they lament the pull of finance for society's brightest minds. The youthful American used to wear a lab coat working for Genentech, a biotechnology company whose stated mission is to "develop drugs to address significant unmet medical needs." You don't get much more noble than that. Yet Shepard turned his back on the bench, first for a master of business administration (MBA) and a spell in management consulting and then for the world of high finance. His conversation is peppered with references to equity tranches and bond coupons, balance-sheet volatility and payment triggers.

Shepard founded a venture called Structured Bioequity (SBE). The problem he was trying to address is the harm that can be done to a small biotech firm if one of its drugs fails during clinical trials. Clinical trials are designed to gradually widen the pool of people that a new drug is tested on and their results are very unpredictable. About 85 percent of therapies fail in early clinical trials. Shepard was particularly focused on the risks involved in Phase II trials, when tests move from a very small group of human guinea pigs to a larger one.¹

For a very big pharmaceutical firm, with deep pockets and a fatter pipeline of new drugs, a failed trial need not be the end of the road; it can write another check in order to keep development teams together. For smaller firms, which often have no more than two or three drugs in the queue, the damage caused by an unsuccessful clinical trial can be terminal. If the lead drug of one of these firms fails, the entire value of the company can be lost, and it may well fold. The knowledge gained from working on a particular drug scatters, along with the chances of a better outcome the next time around.

Shepard's idea works like an insurance policy. Investors in effect indemnify the firm against failed clinical trial, promising to pay out an agreed amount in that event so that the firm can rebuild its portfolio. In return, SBE offers the chance for investors to participate in the upside of a successful drug, by turning the amount indemnified into an equity stake in the company upon successful completion of clinical trials. By including enough drugs in the portfolio that is being protected, Shepard thinks that investors can be reasonably confident that some medicines will make it to market. And that in turn should mean that promising medical research is not lost when a particular avenue is closed off.

Progress in getting the first investors to bite was slow, as is typical for an entirely new idea, but when I met him in 2013, Shepard was determined to keep going. Asked why he has turned his back on medical research for finance, he shrugs. "I think I can make more of a difference this way than as a scientist." In the wake of the 2007–2008 crisis, that has become an arresting statement to make.

Two broad misconceptions have taken hold as a result of the convulsions of recent years. The first is that if only finance could turn back the clock, all would be well. Banks never used to run with such low levels of equity funding—the money that shareholders put in and that gets wiped out when banks sustain losses. The securitization markets, where a lot of different income-producing assets such as mortgages get bundled together into a single instrument, never used to be so complex. Stock exchanges never used to be the plaything of algorithms. The temptation is to try to identify a point in financial history when everything worked better and get back to that point. The meme that banking should be boring is widespread. Elizabeth Warren, a Democratic senator from Massachusetts, has used this very phrase to promote a bill that would separate American banks into their comfortingly familiar retail businesses (the ones we all use as customers for checking accounts, mortgages, and the like) and their exotic capital-market businesses (where firms raise money and manage risks).

Yet turning back the clock, as well as being impractical, is no answer. The greatest danger often lurks in the most familiar parts of the financial system. Deposits are seen as a "good" source of funding, even though they can be taken out in an instant and get a giant subsidy in the form of deposit insurance. Property is regarded as a bread-and-butter banking activity but is the cause of banking crisis after banking crisis. Secured lending is seen as prudent, even though it can mean decisions are often made on the basis of the collateral being offered (a house, say) rather than the creditworthiness of the borrower (a borrower with no income and no job, say).

If you look at the write-downs recorded during the crisis, where were they found? In investment banks, yes, but also in the retail and commercial banks. The biggest bank failure in US history was that of Washington Mutual, which collapsed in 2008 with \$307 billion in assets and a pile of rotting mortgages on its books. The worst quarterly loss was suffered by Wachovia, another "normal" lender; it chalked up a loss of \$23.7 billion in the third quarter of 2008 because of loans kept on its balance sheet. Irish and Spanish banks managed to blow themselves up without the assistance of securitization and credit-default swaps (CDS). The thread running through the financial crisis of 2007–2008 was bad information—about the quality of borrowers, about who had exposure to whom, about how a default

one place would affect other loans—and it brought down every type of institution, simple and complex.²

The second misconception concerns the benefits of financial creativity. Few areas of human activity now have a worse image than “financial innovation.” The financial crisis of 2007–2009 brought a host of arcane financial processes and products to wider attention. Paul Volcker, one former chairman of the Federal Reserve whose postcrisis reputation remains intact, has implied that the financial innovation of the past twenty-five years matches up to the automatic teller machine in terms of usefulness. Paul Krugman, a Nobel Prize–winning economist-cum-polemicist, has written that it is hard to think of any major recent financial breakthroughs that aided society.³

A conference held by the *Economist* in New York in late 2013 debated whether talented graduates should head to Google or Goldman Sachs. Vivek Wadhwa, a serial entrepreneur, spoke up for Google; Robert Shiller, another Nobel Prize–winning economist, argued for Goldman. Wadhwa had the easier task. “Would you rather have your children engineering the financial system creating more problems for us or having a chance of saving the world?” he asked. Even an audience of *Economist* readers in New York was pretty clear about its choice, plumping heavily for Mountain View over Wall Street. Yet Shiller’s arguments are the more powerful. “Finance is the place you can make your mark on the world. . . . You cannot do good for the world by yourself,” he told the conference. “Most important activities have to have a financial basis.”⁴

This book is divided into two parts. The first is designed to give the reader a broader framework for thinking about financial innovation than just the 2007–2008 crisis and its aftermath. The natural response to the idea of financial ingenuity is to say, “No, thanks.” But as the opening chapter demonstrates, the history of human enterprise is also one of financial breakthroughs. The invention of money, the use of derivative contracts, and the creation of stock exchanges were smart responses to fundamental, real-world problems. Financial innovation helped foster trade, smooth risks, create companies, and build infrastructure. The modern world needed finance to come into being.

Without question, the industry did a bad job in the first years of this century of applying itself to big problems. But calling a halt to inventiveness—freezing finance in place, no bright ideas allowed—would not solve the problems associated with the industry. As the second chapter explains, the big risks that finance poses materialize long after the “lightbulb moment.” There is a problem with how financial products and markets evolve, but it is a problem that is deeply associated with scale and familiarity, not novelty and creativity.

The third chapter presents a concrete example of how an absence of innovation can be far more damaging than its presence. Property is the world’s biggest financial asset and mortgages perhaps the industry’s most familiar product. Although people like to think of this as being an area that was taken over by the financial wizards, that is not the right lesson to draw from the crisis. In the United States the industry did come up with inventive ways to pile debt onto inferior borrowers. But in Europe the ordinary mortgage proved just as destructive to many banking systems. Property needs more free thinking, not less.

Although there are ingenious people and products in the big institutions, the revolutionary ideas come disproportionately from outsiders. That is common to many industries, not just finance: it takes an unusual firm to blow its own products out of the water; innovation usually comes from new entrants. But the bad habits formed by years of unrestrained profitability seem particularly hard to shake in finance. “When we describe our business, bankers look at us with blank expressions and confide the founder of one financial start-up. “All they can say is: ‘But you could be charging more. Why don’t you?’”

If the first part of the book makes you doubt that financial innovation is all bad, the second should convince you of its capacity to do good. Despite the crisis—and in some cases because of it—finance is as inventive as it has ever been. The second part looks at some of the efforts being made to resolve an array of enormous social and economic problems.

Many readers of this book will live in countries that need to bring their budgets under control by cutting public spending. Chapter 4 explains how finance can help lure private capital into the gaps left behind. The same readers can also expect to live longer than any generation that has gone before—particularly if people like Chris Shepard can improve drug-development processes. Yet if they are anything like the average citizen, they have far too little saved for their golden years. Chapter 5 looks at some of the industry’s initial answers to the downside of longevity.

As dramatically as society is changing, the technological landscape is changing faster still. The Internet is enabling the suppliers and consumers of financing to connect directly rather than via intermediaries. The rise of “big data”—the ability quickly to capture and process huge amounts of information—is improving the way borrowers are screened and risks assessed. At the same time, the crisis has underlined the need for fresh thinking about the way that finance itself operates, so that its worst features (a love of debt, a tendency to forget danger when the going is good) are blunted.

The next four chapters elaborate on both of these themes. Chapter 6 looks at new ways for students to put themselves through school and for new companies to raise early-stage capital. Chapter 7 explores the world of peer-to-peer financing, in which lenders and borrowers bypass the bank altogether. Chapter 8 revisits the world of the subprime borrower to see how the problem of financing the less creditworthy can be solved without blowing up the world economy. Finally, Chapter 9 describes how the old-fashioned virtue of qualitative analysis is being combined with number-crunching to mitigate the risk of a new pandemic.

Finance should have been scrutinized more intensively before the crisis. By the same token, it should be looked at with a clear eye now. Bright young people should be going into all sorts of different careers, and finance should be one of them. For all of its flaws, there is no more powerful problem-solving machine.

PART I: LESSONS BADLY LEARNED

1. Handmaid to History

Financial Sector Thinks It's About Ready to Ruin World Again

—The *Onion*

The history of financial innovation is also the story of human advance. The early forms of finance met some very basic needs—trade, safekeeping, credit. As societies and technologies have become more complex, so has finance. When maritime trade became more sophisticated, the banking and insurance industries put down roots. When industrialization created demand for more capital, the era of stock exchanges dawned. When financial instruments became more widely available and finance was democratized, governments responded by creating a more intrusive regulatory framework. When computerization took hold, the age of derivatives—financial products that derive their value from another, underlying, asset—soon followed. For good and bad, the industry that we know today is the product of centuries. And the world that we know today is a product of finance.

Money was the original financial breakthrough. Trade depends on the acceptance of a medium of exchange. Without an agreed form of money—whether notes, precious metals, or cowrie shells—every transaction would involve an arduous negotiation between buyer and seller over what form and quantity of payment would be appropriate. Without money, one of whose properties is that it retains some value over time, anyone who had only perishable goods to barter would find life very tough. You are prepared to accept money as payment because you know you can spend it in the future; you are less happy to accept payment in kiwifruits, say, because they will be exchangeable only for so long as they can be eaten.

Forms of money emerged to grease the wheels of trade as long ago as 9000 BC, when livestock were used as payment. Over time, precious metals emerged as a better form of money: they are less tasty than cows but more portable, durable, and divisible. The first coins were produced in Lydia, what is now Turkey, in the seventh century BC. The coins were made of electrum, a naturally occurring mixture of gold and silver, and the technology soon spread to Greek cities. The first paper money was invented in China in the ninth century, paving the way for the modern system of fiat money, which is issued by the state and—unlike coins made of precious metals—has no intrinsic value.¹

Even in modern times, fiat money can still be driven out by commodity forms of exchange. In the immediate aftermath of World War II in Germany, no one had any faith in the Reichsmark, the local currency. Instead, American cigarettes came to be used as the means of payment on the black market: cigarettes were divisible, they lasted well, there was a decent supply of them via imports by American troops, and demand was high—not least because they suppressed appetite in a time

rationing. Money can change its shape to suit the circumstances.²

Once ancient societies had an agreed form of exchange that could hold its value, they could develop more ambitious financial instruments. The earliest financial contracts date back to Mesopotamia in the fourth millennium BC: clay tablets inscribed with records of a person's obligation to pay would be sealed inside a type of clay envelope called bullae; these envelopes could themselves act as money, since the obligations they contained were payable to the bearer. Forms of payment ranged from honey to bread, but livestock seems to have been the type of "money" that gave the world the concept of interest. Herds of cattle or flocks of sheep have a natural tendency to multiply: you might lend someone twenty cows, and by the time you get them back, their number will have increased. Those extra heads would have acted as compensation for the risk of lending out the original herd. The evolving language of finance was drawn directly from this pastoral form of interest. The Sumerian word for *interest* was the same as the word for *calves*; the Latin word for *flock* is *pecus*, root of our own term *pecuniary*.³

By the time of Hammurabi, a Babylonian king who ruled in the second millennium BC, the role of money and credit had developed to such an extent that the set of laws known as the Code of Hammurabi contained very specific rules on a number of familiar economic relationships. Today we send electronic money into bank accounts for safekeeping; back then, when grain functioned as a means of exchange, the code stipulated terms for grain-storage contracts, an early form of deposit taking. The code also governed relations between debtors and creditors, setting limits on the interest rate that lenders could charge farmers for advancing them equipment, land, and seed and specifying the types of collateral that could be used to secure loans.⁴

In the aftermath of a massive debt bubble, it may seem odd to celebrate the innovation of debt. But it truly is a wonderful invention. Like other forms of finance, debt enables capital to flow from savers to investors (we may not like debt crises, but we also don't much like credit crunches). Lenders are incentivized by the promise of a payback to give money to borrowers; in return, they take on the risk of default. Borrowers give up their claim to some of their future income in return for the capital they need now. Debt's special magic is what economists like to call "intertemporal exchange." People have two forms of capital: they have financial capital, which is the money they actually accumulate, and they have human capital, which is their potential to make money through their future earnings. These two forms of capital are out of sync. Old people have depleted their human capital but have (hopefully) accumulated financial capital. Most young people have a lot of human capital but not much cash. Finance is what bridges the gap between these two states. In the time of Hammurabi, for example, farmers would borrow what they needed to cultivate land in return for payments that would come out of their future income.

It is no different today. The acts of saving and borrowing are both forms of time travel: they are transactions that we undertake with our future selves. We save in order to fund the older us—the retirement from the job we do not yet have or the tuition fees for the children we do not have with the partner we have not met. The more connected we feel to our future selves, the more likely we are

save for “them.” Studies indicate that people who are shown a digital avatar of themselves in old age are more likely to put money aside for retirement. Similarly, young people are able to borrow now by unlocking the earnings power of their future selves. When a lender gives you a thirty-year mortgage, is in effect contracting with the higher-paid, grayer-haired edition of yourself.⁵

Debt is not the only form of financing, of course. Debt entails an obligation to repay, but it also caps the income for lenders to an agreed amount of interest. This obligation on the borrower reduces the risk to creditors, particularly when a loan is secured by collateral (in the way that a house secures a mortgage). But the rewards are correspondingly lower, too: however well a borrower does, the income paid to the lender does not exceed the agreed amount. Equity offers a different proposition to investors. The risks are higher because equity holders get only what’s left when the creditors have been paid off; however, the potential rewards are also greater because the owners will share in all the profits if the venture is a success.

Ancient societies also developed various contracts for equity: the Romans had an early form of business corporation called the *societas publicanorum*, which allowed people to buy and sell shares in partnerships that provided outsourced public services. Maritime trade in medieval Italy was fostered by a form of partnership called the *commenda*, in which one partner invested labor and the other put money; the profits from the journey were split between the two parties, with a common division being 75 percent to the moneyman and 25 percent to the traveler. As well as being a financial contract, the *commenda* also defined the obligations that the traveler had to carry out when he was voyaging. This was an early attempt to solve the “principal-agent” problem that bedevils corporate governance today, in which shareholders have to rely on managers to exercise good judgment in running the companies they own.⁶

Equity and debt enable people with money to spare to allocate it to people who need capital. They are also ways of sharing risk, another of finance’s most fundamental jobs. Lenders can spread their money around a lot of different borrowers, as can equity investors, reducing their concentration of risk. By the same token, sharing equity in a company means that the original owners can diversify their risks rather than locking up all their money in one venture.⁷

This same principle of diversification underpins the origins of another vital arm of finance: insurance. Maritime trade again provided much of the initial impetus for a product that offered protection against the worst. Chinese merchants are thought to have self-insured by splitting their cargoes up among several vessels to reduce the chance of a catastrophic loss from any one ship sinking. The Code of Hammurabi contained clauses on “bottomry,” a loan secured against the keel, the bottom, of a ship that also functioned as a form of insurance because the loan was forgiven if the vessel sank. The Romans had a very similar arrangement, the *foenus nauticum*, in which an insurer loaned a merchant the funds to undertake a voyage. The debt was canceled if the ship was lost, but returned along with a bonus if the voyage was completed. The basic idea is not that different from the catastrophe (or cat) bonds that we will meet later in the book.⁸

The world’s oldest extant insurance contract was struck in Genoa in 1298, with an agreement

between a wheeler-dealing merchant named Benedetto Zaccaria and two external investors named Enrico Suppa and Baliano Grillo. In fact, the contract is far more convoluted than a simple insurance arrangement. Zaccaria's fortune was built on importing alum—an all-purpose compound used for everything from dyeing textiles to making glues—from the Black Sea to western Europe. His contract with Suppa and Grillo centered on the transportation of thirty tonnes of alum to Bruges in modern-day Belgium, which he sold to them for an upfront sum before the cargo had begun its voyage. So far, so simple. But the parties also agreed to an option to repurchase, whereby if the alum arrived safely in Bruges, Zaccaria could buy it back from Suppa and Grillo at a higher price. As for the insurance element of the deal, if the alum was damaged because of a mishap en route, then the two counterparties were liable for the loss in value.⁹

It's all a bit of a blow to those who complain about the complexity of modern finance. The option to repurchase the alum that Zaccaria worked out with his negotiating partners is an early example of a derivative, a financial instrument whose value derives from another, underlying, asset. An option gives the buyer the right, but not the obligation, to buy or sell an underlying asset. A call option to buy a share at ten dollars in six months' time, say, is known as a call option; a put option gives the buyer the right to sell the same share at a specified price. Yet options predated even Zaccaria by more than fifteen hundred years. The first known call option was described by Aristotle, who recounts the story of a philosopher named Thales of Miletus (now part of Turkey), who paid a deposit for all the olive-oil presses in Miletus and Chios. This was, in effect, an option to control the market, a bet that paid off handsomely when that year's crop of olives was a good one and Thales was able to charge pretty much what he wanted to have them pressed.

THE HISTORY OF FINANCE until medieval Italy reveals something that can be easily forgotten in the aftermath of the recent global financial crisis: how essential finance is to solving some very basic human requirements. Whether providing a way of storing wealth, of connecting capital with investments, of bridging the gap between the present and the future, or of sharing and managing risk, finance has helped people to meet their objectives since the very earliest civilizations.

But from the start, these new financial instruments posed a problem—working out which people are going to be able to pay back their loans, which enterprises are going to make the most money for their owners, and which risks are likely to materialize. Whether you are a Babylonian lender or a Wall Street banker, these issues get at the essence of finance. The true currency of the industry is information: about the prospects of certain companies, the creditworthiness of borrowers, the probability of different events, and the value of collateral. Information is what brings investors and borrowers together on exchanges and in bilateral contracts, and almost every problem that we will encounter in this book can be resolved into a question of how to gather, assess, and transmit information.

The lending problem is a prime example of the informational challenge: how do you pick the

best borrower? There are various ways of solving this problem. One option is for creditors to loan money only to those people they know personally. The friends-and-family approach to finance draws on bonds of trust and familiarity to reduce the risks of default. But it also reduces the amount of lending that goes on. If an economy is to provide capital beyond a certain scale, you need a mechanism that brings together a lot of different lenders and many different borrowers who do not know each other. You need an intermediary that takes the savings of some people and matches that money with creditworthy borrowers. In other words, you need a bank.

There were institutions in ancient Greece and in Rome that we would recognize as forerunners of banks, money changers who provided safe-deposit boxes for people to store their money and then used that money to provide loans. Wealth accrued to bankers from the start: in the fourth century BC, a former slave named Pasion rose to run a large private bank and become one of Athens's richest citizens. By the time of the Roman Empire, funds were being stored, pooled, and reallocated in a manner that we would just about recognize today.

The fall of the Roman Empire paved the way for the Dark Ages, one characteristic of which was a less sophisticated financial system. Banking had to be reinvented all over again in the medieval Italian city-states—places such as Venice, Florence, and Genoa. Financiers would work from benches or counters in the trading halls of these Renaissance cities, financing farmers, insuring buyers against crop failures, and providing a storage place for bills of exchange. The word *bank* is supposed to be derived from *banca*, the Italian word for *counter*; *bankrupt* may be a corruption of *banca rotta*, *broken counter*.

The invention of the bank was a response to the constraints of relationship-based finance. An intermediary could bridge the gap between lenders and borrowers, providing a place where pools of capital could come together and develop a specialized expertise in assessing the creditworthiness of borrowers. The intermediary could also reap the benefits of diversification: by making a lot of different loans, a bank would reduce the probability that any one of them could scupper the institution if it went bad.

The bank also offered an ingenious solution to another problem: the illiquidity of long-term investments, which required lenders to lock up their money for years until they got it back. The bankers of medieval Italy and the goldsmiths of medieval London soon noticed that when people deposited coins and valuables with them for safekeeping, they didn't all want to have them back at the same time. At any given moment, there was a pile of coins in the vault that were just sitting idle. Why not use them as funding for new loans?

The same logic applies today. Banks do not sit on your deposits, waiting for you to turn up and request your cash back. Because they assume that depositors will not all pull their money out at once, banks loan that money out to people who want to borrow and keep only a fraction of it on hand to meet depositors' demand for cash. That enables banks to pull off two very important tricks. First, by loaning a proportion of all the money they get in as deposits, banks multiply the amount of money in circulation. Second, banks can achieve what the experts like to call "maturity transformation."

English what that means is that banks borrow money at a shorter duration than they loan money out.

The classic example of this maturity transformation is the deposit and the mortgage. Your deposit is a liability for the bank that holds it—it has to be repaid. Unless otherwise specified, it is also instantly redeemable. That means you can get your money out whenever you want: it is the ultimate in short-term lending. A mortgage, by contrast, can last for twenty or thirty years. A short-term debt is transformed into a long-term asset, which makes everyone happy. Creditors don't have to lock their money up for years, borrowers can draw on their long-term future income, and banks can make money in the middle because the rate they pay to borrow money short is less than the rate they can charge to loan money long. Society benefits, too: long-term investments can be financed far more easily because they do not require creditors to sacrifice liquidity.

The downside of maturity transformation is that a lot of creditors do sometimes want their money back at the same time. The most visible manifestation of this is the bank run, with people lining up outside branches to retrieve their cash. A bank run is the moment when the magic of maturity transformation is revealed as a cheap trick. The bank doesn't have deposits on hand to meet demand, so the customers who turn up first are the ones who get their money back. Everyone has an interest in joining the run. The purpose of deposit insurance, which was introduced in the United States in the 1930s and is common to most but not all countries, is to prevent runs by reassuring people that they will never lose money below a certain threshold, even if the bank goes bust.

BANKS SOLVE THE PROBLEM of liquidity by standing in between savers and borrowers, promising the former instant access to their money even as they loan it out for long periods to the latter. Public securities markets take a different approach to liquidity: they provide a place for buyers and sellers to connect directly. That means an owner of a security (either debt or equity) can, in theory, sell it whenever he or she wants to do so.

The first securities markets also date back to medieval Italy, where city-states such as Venice and Genoa forced their well-to-do citizens to loan them money but then consolidated the debt into bonds—instruments that could be sold to others. But the dawn of the era of stock exchanges dates to seventeenth-century Amsterdam, and once again maritime trade was central to the story.

Shipping companies were conventionally financed on an expedition-by-expedition basis: they were liquidated once the voyage had been made. The Dutch East India Company (VOC, to use its Dutch acronym) was founded in 1602 and was granted a twenty-one-year monopoly over Dutch trade with its Asian colonies. The VOC immediately raised capital for expansion in a public offering that entitled its owners to a share of its earnings. That was revolutionary enough, but what really matters for our story is the fact that the directors of the VOC first ignored a ten-year interim deadline for liquidating the company and then later requested an extension of its twenty-one-year charter, which was granted. Investors in other shipping companies ran big risks, but they had previously been confident that a liquidation would return their money to them. The VOC closed that exit door. It had

fixed amount of capital and no intention of winding itself up; it was dissolved only in 1800. To get their money, investors either needed to find a way to live a lot longer or required a secondary market in which they could sell (and buy) equity when they wanted.¹⁰

The Amsterdam Stock Exchange fulfilled that role. It rapidly developed many of the attributes of a modern-day exchange. Derivatives quickly emerged. Forward transactions (agreements to buy shares at a fixed price at a future date) started to show up in the documents of Amsterdam notaries a mere five years after the subscription to VOC shares took place in 1602. Options (the right to buy or sell shares at a certain price) and repo transactions (the sale of securities with an agreement to buy them back) soon followed.

Market makers also made their first appearance in Amsterdam. Although markets theoretically allow for buyers and sellers to transact directly, the odds are heavily against a precise match between demand and supply. A seventeenth-century citizen of Amsterdam who wanted to buy some VOC shares might turn up at the newly built exchange building during the designated hour of trading and find an existing shareholder willing to sell in the quantities he wanted. But he also might have to hang around for days on end. The assurance of liquidity came from market makers, intermediaries who held an inventory of VOC shares and cash from which to meet demand from any would-be buyers and sellers.

The first proper market makers seem to have been two seventeenth-century Dutch brothers named Christoffel and Jan Raphoen. The evidence for the Raphoens' role comes from the register of transactions they undertook in VOC shares. Despite making a lot of deals, the capital they kept invested in the company was low on average, which suggests they were making their money by trading in the shares. By providing liquidity, the Raphoens made it easier for people to buy and sell, which in turn made the market more attractive to financial traders and increased the volume of transactions on the exchange. The Raphoens would not recognize the form of their modern counterparts—computerized trading firms that zip in and out of holdings at staggering speeds—but their functions would be familiar enough.

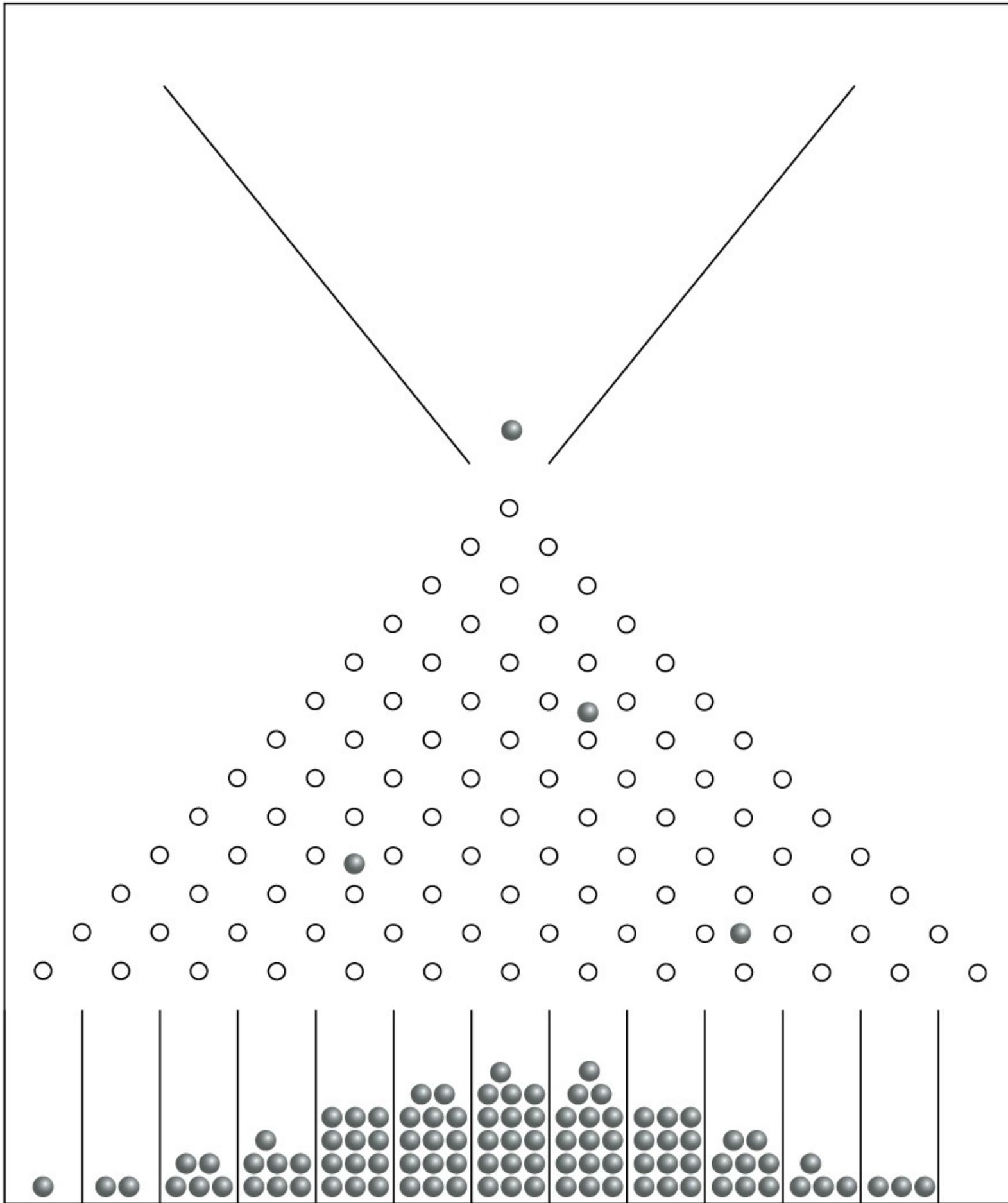
THE INSURANCE MARKET also took a big leap forward in the seventeenth century, thanks to the forgetfulness of a London baker named Thomas Farynor. His failure to properly put out the ashes of a fire at his shop on Pudding Lane led to a blaze that started in the early hours of September 2, 1666, and four days later had spread across the center of the city and destroyed 13,200 homes. The Great Fire of London remade London's skyline: the task of rebuilding St. Paul's Cathedral and fifty other churches was handed to Sir Christopher Wren in its aftermath.

The Great Fire also sparked an idea in the mind of Nicholas Barbon (catchy middle name: I-Jesus-Christ-Had-Not-Died-For-Thee-Thou-Hadst-Been-Damned), an energetic and aggressive doctor-turned property developer. His Insurance Office is thought to have been the world's first insurance firm and provided fire-insurance protection to London home owners in return for a premium. His work

a private-sector response to the vulnerabilities exposed by the Great Fire. Like the rival firms that soon emerged, Barbon's company employed watermen working up and down the Thames to act as private firefighting forces in the event of a blaze. It also used the power of market pricing to start to influence the behavior of home owners, charging far higher premiums for houses made of wood than for those made of brick.¹¹

Barbon's venture hit on a very different logic from that of conventional maritime-insurance contracts. Just as shipping companies had had finite life spans until the VOC came along, the fire insurance agreements were struck for individual voyages. The likes of Barbon were not interested in underwriting just one house against the risk of fire. Insurance needs to write protection against more risks not only in order to make more money but also to be *safer*. The wonky definition of this "law of large numbers" is that the more exposures an insurer can underwrite, the greater the probability that its actual losses will equal its expected losses.

One way of demonstrating this proposition is to use a device called a Galton Board (see figure 1), which consists of rows of evenly spaced pegs on an upright board. The pegs in each row are staggered, so that when a ball is dropped from the top of the board, it hits a peg in the first row, a peg in the next row, and so on. Each time it hits a peg, the ball has a fifty-fifty chance of going either right or left. But because it will have to take more deviations in a single direction on its way down to end up at the sides, a ball is much more likely to end up in the middle of the board by the time it reaches the bottom. A few might end up at the extremes, but most will end up clustering in the middle in what statisticians call a "normal distribution." If you drop only one ball, you might get unlucky and have one of the oddballs at the edges. But the more balls you drop, the closer your average outcome gets to the expected outcome. Large numbers reduce the odds of an unusual average outcome.



Example of a Galton Board. Source: Marcin Floryan

In thinking about the course of financial innovation, mathematical insights like the law of large numbers have a large part to play. This particular idea was formalized by Jacob Bernoulli, a Swiss mathematician, in a posthumous work published in 1713. But the advances made by finance ever since medieval Italy have been pulled along in large part by mathematical breakthroughs. “Quants,” the name given to the mathematical whiz kids who now pervade the industry, were a big part of finance before the term was even coined.

One of the earliest practitioners of financial mathematics was Leonardo of Pisa (1170–1240) who is better known to us as Fibonacci. His *Liber Abaci*, or Book of Calculation (1202), is most famous for outlining the Fibonacci sequence (in which numbers are the sum of the previous two: 1, 2, 3, 5, 8, and so on) that is observable in many natural settings. But it also contains a number of practical calculations that are very familiar to modern finance. One was a technique that allowed merchants to calculate the relative values of spices such as saffron and pepper, just as modern-day arbitrageurs assess the relative values of different securities in the hope of exploiting anomalies in their pricing. Another was a way of dividing profits among the financial investors in a *commenda* when there was more than one of them. Perhaps the most important of Fibonacci’s insights was a method for working out the “present value” of cash flows—that is, how much a future amount of money is worth today, given that money can earn interest in the meantime. The process of “discounting” is central to financial analysis today—from businesses working out whether to invest in a new plant to pension schemes assessing whether they have enough money to pay their members’ retirement benefits—and is connected to Fibonacci by an eight-hundred-year thread.¹²

If Fibonacci’s contribution to finance is little known compared to his more famous observations, the same goes for Edmond Halley. Another of the great polymaths that previous ages routinely turned out, Halley was an English astronomer royal who gave his name to the comet that is visible from Earth every seventy-five to seventy-six years (its next visit is due in 2061). The comet won him immortality, but his major financial breakthrough was concerned with death. Halley developed the first proper “life table,” which used demographic data from the German city of Breslau to calculate how many people in the city were alive at every age up to eighty-four. His numbers showed that there were, for example, 1,000 people alive aged one, 855 aged two, 798 aged three, and so on. This information then enabled him to calculate the present value of life annuities (an insurance product that pays an income to someone until someone’s death) based on the age of the person insured and the likely number of years left to him and on interest rates. If the actuarial profession has a Big Bang moment, Halley’s 1693 paper on life annuities is it.¹³

The annuities business also saw the principle of diversification being taken to another level, an approach that foreshadowed the development of securitization. The essence of securitization is that it smooshes together a lot of different income-generating assets (mortgages, car loans, rent payments, and so forth) into a single security. The concept goes back at least as far as prerevolutionary France. The eighteenth-century French state used to raise money by selling life annuities (*rentes viagères*). A creditor would pay a sum of money upfront, and the state would pay

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