The Physics of Wall Street

A Brief History of Predicting the Unpredictable

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EXCERPT FROM

THE PHYSICS OF WALL STREET

INTRODUCTION: OF QUANTS AND OTHER DEMONS

WARREN BUFFETT ISN’T the best money manager in the world. Neither is George Soros or Bill Gross. The world’s best money manager is a man you’ve probably never heard of—unless you’re a physicist, in which case you’d know his name immediately. Jim Simons is co-inventor of a brilliant piece of mathematics called the Chern-Simons 3-form, one of the most important parts of string theory. It’s abstract, even abstruse, stuff—some say too abstract and speculative—but it has turned Simons into a living legend. He’s the kind of scientist whose name is uttered in hushed tones in the physics departments of Harvard and Princeton.

Simons cuts a professorial figure, with thin white hair and a scraggly beard. In his rare public appearances, he usually wears a rumpled shirt and sports jacket—a far cry from the crisp suits and ties worn by most elite traders. He rarely wears socks. His contributions to physics and mathematics are as theoretical as could be, with a focus on classifying the features of complex geometrical shapes. It’s hard to even call him a numbers guy—once you reach his level of abstraction, numbers, or anything else that resembles traditional mathematics, are a distant memory. He is not someone you would expect to find wading into the turbulent waters of hedge fund management.

And yet, there he is, the founder of the extraordinarily successful firm Renaissance Technologies. Simons created Renaissance’s signature fund in 1988, with another mathematician named James Ax. They called it Medallion, after the prestigious mathematics prizes that Ax and Simons had won in the sixties and seventies. Over the next decade, the fund earned an unparalleled 2,478.6% return, blowing every other hedge fund in the world out of the water. To give a sense of how extraordinary this is, George Soros’s Quantum Fund, the next most successful fund during this time, earned a mere 1,710.1% over the same period. Medallion’s success didn’t let up in the next decade, either—over the lifetime of the fund, Medallion’s returns have averaged almost 40% a year,
after fees that are twice as high as the industry average. (Compare this to Berkshire Hathaway, which averaged a 20% return from when Buffett turned it into an investment firm in 1967 until 2010.) Today Simons is one of the wealthiest men in the world. According to the 2011 Forbes ranking, his net worth is $10.6 billion, a figure that puts Simons’s checking account in the same range as that of some high-powered investment firms.

Renaissance employs about two hundred people, mostly at the company’s fortresslike headquarters in the Long Island town of East Setauket. A third of them have PhDs—not in finance, but rather, like Simons, in fields like physics, mathematics, and statistics. According to MIT mathematician Isadore Singer, Renaissance is the best physics and mathematics department in the world—which, say Simons and others, is why the firm has excelled. Indeed, Renaissance avoids hiring anyone with even the slightest whiff of Wall Street bona fides. PhDs in finance need not apply; nor should traders who got their start at traditional investment banks or even other hedge funds. The secret to Simons’s success has been steering clear of the financial experts. And rightly so. According to the financial experts, people like Simons shouldn’t exist. Theoretically speaking, he’s done the impossible. He’s predicted the unpredictable, and made a fortune doing it.

Hedge funds are supposed to work by creating counterbalanced portfolios. The simplest version of the idea is to buy one asset while simultaneously selling another asset as a kind of insurance policy. Often, one of these assets is what is known as a derivative. Derivatives are contracts based on some other kind of security, such as stocks, bonds, or commodities. For instance, one kind of derivative is called a futures contract. If you buy a futures contract on, say, grain, you are agreeing to buy the grain at some fixed future time, for a price that you settle on now. The value of a grain future depends on the value of grain—if the price of grain goes up, then the value of your grain futures should go up too, since the price of buying grain and holding it for a while should also go up. If grain prices drop, however, you may be stuck with a contract that commits you to paying more than the market price of grain when the futures contract expires. In many cases (though not all), there is no actual grain exchanged when the contract expires; instead, you simply exchange cash corresponding to the discrepancy between the price you agreed to pay and the current market price.

Derivatives have gotten a lot of attention recently, most of it negative. But they aren’t new. They have been around for at least four thousand years, as testified by clay tablets found in ancient Mesopotamia (modern-day Iraq) that recorded early futures contracts. The purpose of such contracts is simple: they reduce uncertainty. Suppose that Anum-pisha and Namran-sharur, two sons of Siniddianam, are Sumerian grain farmers. They are trying to decide whether they should plant their fields with barley, or perhaps grow wheat instead. Meanwhile, the priestess Iltani knows that she will require barley next autumn, but she also knows that barley prices can fluctuate unpredictably. On a hot tip from a local merchant, Anum-pisha and Namran-sharur approach Iltani and suggest that she buy a futures contract on their barley; they agree to sell Iltani a fixed amount of barley for a prenegotiated price, after the harvest. That way, Anum-pisha and Namran-sharur can confidently plant barley, since they have already found a buyer. Iltani, meanwhile, knows that she will be able to acquire sufficient amounts of barley at a fixed price. In this case, the derivative reduces to the seller’s risk of producing the goods in the first place, and at the same time, it shields the purchaser from unexpected variations in price. Of course, there’s always a risk that the sons of Siniddianam won’t be able to deliver—what if there is a drought or a blight?—in which case they would likely have to buy the grain from someone else and sell it to Iltani at the predetermined rate.

Hedge funds use derivatives in much the same way as ancient Mesopotamians. Buying stock and selling stock market futures is like planting barley and selling barley futures. The futures provide a kind of insurance against
the stock losing value.

The hedge funds that came of age in the 2000s, however, did the sons of Siniddianam one better. These funds were run by traders, called quants, who represented a new kind of Wall Street elite. Many had PhDs in finance, with graduate training in state-of-the-art academic theories—never before a prerequisite for work on the Street. Others were outsiders, with backgrounds in fields like mathematics or physics. They came armed with formulas designed to tell them exactly how derivatives prices should be related to the securities on which the derivatives were based. They had some of the fastest, most sophisticated computer systems in the world programmed to solve these equations and to calculate how much risk the funds faced, so that they could keep their portfolios in perfect balance. The funds’ strategies were calibrated so that no matter what happened, they would eke out a small profit—with virtually no chance of significant loss. Or at least, that was how they were supposed to work.

But when markets opened on Monday, August 6, 2007, all hell broke loose. The hedge fund portfolios that were designed to make money, no matter what, tanked. The positions that were supposed to go up all went down. Bizarrely, the positions that were supposed to go up if everything else went down also went down. Essentially all of the major quant funds were hit, hard. Every strategy they used was suddenly vulnerable, whether in stocks, bonds, currency, or commodities. Millions of dollars started flying out the door.

As the week progressed, the strange crisis worsened. Despite their training and expertise, none of the traders at the quant funds had any idea what was going on. By Wednesday matters were desperate. One large fund at Morgan Stanley, called Process Driven Trading, lost $300 million that day alone. Another fund, Applied Quantitative Research Capital Management, lost $500 million. An enormous, highly secretive Goldman Sachs fund called Global Alpha was down $1.5 billion on the month so far. The Dow Jones, meanwhile, went up 150 points, since the stocks that the quant funds had bet against all rallied. Something had gone terribly, terribly wrong.

The market shakeup continued through the end of the week. It finally ended over the weekend, when Goldman Sachs stepped in with $3 billion in new capital to stabilize its funds. This helped stop the bleeding long enough for the immediate panic to subside, at least for the rest of August. Soon, though, word of the losses spread to business journalists. A few wrote articles speculating about the cause of what came to be called the quant crisis. Even as Goldman’s triage saved the day, however, explanations were difficult to come by. The fund managers went about their business, nervously hoping that the week from hell had been some strange fluke, a squall that had passed. Many recalled a quote from a much earlier physicist. After losing his hat in a market collapse in seventeenth-century England, Isaac Newton despaired: “I can calculate the movements of stars, but not the madness of men.”

The quant funds limped their way to the end of the year, hit again in November and December by ghosts of the August disaster. Some, but not all, managed to recover their losses by the end of the year. On average, hedge funds returned about 10% in 2007—less than many other, apparently less sophisticated investments. Jim Simons’s Medallion Fund, on the other hand, returned 73.7%. Still, even Medallion had felt the August heat. As 2008 dawned, the quants hoped the worst was behind them. It wasn’t.

I began thinking about this book during the fall of 2008. In the year since the quant crisis, the U.S. economy had entered a death spiral, with century-old investment banks like Bear Stearns and Lehman Brothers imploding as markets collapsed. Like many other people, I was captivated by the news of the meltdown. I read about it obses-
sively. One thing in particular about the coverage jumped out at me. In article after article, I came across the legions of quants: physicists and mathematicians who had come to Wall Street and changed it forever. The implication was clear: physicists on Wall Street were responsible for the collapse. Like Icarus, they had flown too high and fallen. Their waxen wings were “complex mathematical models” imported from physics — tools that promised unlimited wealth in the halls of academia, but that melted when faced with the real-life vicissitudes of Wall Street. Now we were all paying the price.

I was just finishing a PhD in physics and mathematics at the time, and so the idea that physicists were behind the meltdown was especially shocking to me. Sure, I knew people from high school and college who had majored in physics or math and had then gone on to become investment bankers. I had even heard stories of graduate students who had been lured away from academia by the promise of untold riches on Wall Street. But I also knew bankers who had majored in philosophy and English. I suppose I assumed that physics and math majors were appealing to investment banks because they were good with logic and numbers. I never dreamed that physicists were of particular interest because they knew some physics.

It felt like a mystery. What could physics have to do with finance? None of the popular accounts of the meltdown had much to say about why physics and physicists had become so important to the world economy, or why anyone would have thought that ideas from physics would have any bearing on markets at all. If anything, the current wisdom — promoted by Nassim Taleb, author of the best-selling book *The Black Swan*, as well as some proponents of behavioral economics — was that using sophisticated models to predict the market was foolish. After all, people were not quarks. But this just left me more confused. Had Wall Street banks like Morgan Stanley and Goldman Sachs been bamboozled by a thousand calculator-wielding con men? The trouble was supposed to be that physicists and other quants were running failing funds worth billions of dollars. But if the whole endeavor was so obviously stupid, why had they been trusted with the money in the first place? Surely someone with some business sense had been convinced that these quants were on to something — and it was this part of the story that was getting lost in the press. I wanted to get to the bottom of it.

So I started digging. As a physicist, I figured I would start by tracking down the people who first came up with the idea that physics could be used to understand markets. I wanted to know what the connections between physics and finance were supposed to be, but I also wanted to know how the ideas had taken hold, how physicists had come to be a force on the Street. The story I uncovered took me from turn-of-the-century Paris to government labs during World War II, from blackjack tables in Las Vegas to Yippie communes on the Pacific coast. The connections between physics and modern financial theory — and economics more broadly — run surprisingly deep.

This book tells the story of physicists in finance. The recent crisis is part of the story, but in many ways it’s a minor part. This is not a book about the meltdown. There have been many of those, some even focusing on the role that quants played and how the crisis affected them. This book is about something bigger. It is about how the quants came to be, and about how to understand the “complex mathematical models” that have become central to modern finance. Even more importantly, it is a book about the future of finance. It’s about why we should look to new ideas from physics and related fields to solve the ongoing economic problems faced by countries around the world. It’s a story that should change how we think about economic policy forever.

The history I reveal in this book convinced me — and I hope it will convince you — that physicists and their models are not to blame for our current economic ills. But that doesn’t mean we should be complacent about
the role of mathematical modeling in finance. Ideas that could have helped avert the recent financial meltdown were developed years before the crisis occurred. (I describe a couple of them in the book.) Yet few banks, hedge funds, or government regulators showed any signs of listening to the physicists whose advances might have made a difference. Even the most sophisticated quant funds were relying on first- or second-generation technology when third- and fourth-generation tools were already available. If we are going to use physics on Wall Street, as we have for thirty years, we need to be deeply sensitive to where our current tools will fail us, and to new tools that can help us improve on what we’re doing now. If you think about financial models as the physicists who introduced them thought about them, this would be obvious. After all, there’s nothing special about finance—the same kind of careful attention to where current models fail is crucial to all engineering sciences. The danger comes when we use ideas from physics, but we stop thinking like physicists.

There’s one shop in New York that remembers its roots. It’s Renaissance, the financial management firm that doesn’t hire finance experts. The year 2008 hammered a lot of banks and funds. In addition to Bear Stearns and Lehman Brothers, the insurance giant AIG as well as dozens of hedge funds and hundred of banks either shut down or teetered at the precipice, including quant fund behemoths worth tens of billions of dollars like Citadel Investment Group. Even the traditionalists suffered: Berkshire Hathaway faced its largest loss ever, of about 10% book value per share—while the shares themselves halved in value. But not everyone was a loser for the year. Jim Simons’s Medallion Fund earned 80%, even as the financial industry collapsed around him. The physicists must be doing something right.