

EPILOGUE

RIDING THE WALL STREET TRAIL

For at least a few members of the Women's Adventure Club of Centre County, Pennsylvania, the weather was never much of an issue. The Women's Adventure Club had been created by Lisa Wandel, an administrator at Penn State University, after she realized that many women were afraid to hike alone in the woods. The club now had more than seven hundred members, and its sense of adventure had expanded far beyond a walk in the woods. Between them the four women who met me on their bicycles beside the Pennsylvania road had: learned the flying trapeze, swum the Chesapeake Bay, and won silver at the downhill mountain biking world championships; they had finished a road bike race called the Gran Fondo "Masochistic Metric," a footrace called the Tough Mudder, and three separate twenty-four-hour-long mountain bike races; they had graduated from race car driving school and made thirteen Polar Bear Plunges in some local river in the dead of winter. After studying the Women's Adventure Club's website, Ronan had said, "It's a bunch of lunatic women who meet up and do dangerous shit; I got to get my wife into it."

In the bleak January light we pedaled onto Route 45 out of Boalsburg, Pennsylvania, heading east, along what was once the route for the stagecoach that ran from Philadelphia to Erie. It was nine in the morning, and still below freezing, with a stiff breeze lowering the windchill to eleven degrees. The views were of farms and fallow brown fields, and the road was empty except for the occasional pickup truck, roaring past us with real anger. "They hate bikers," explained one of the women adventurers mildly. "They try to see how close they can get."

The women rode this stretch of road every so often, and had noticed when the fiber-optic line was being laid beside it, back in 2010. From time to time one of the road's two lanes was closed by the line's construction crews. You'd see these motley queues of bikes, cars, pickup trucks, Amish horse-drawn carts, and farm equipment waiting for the tail end of the oncoming traffic. The crews trenched the ground between the paved road and the farms, making it difficult for the Amish in their wagons to get back to their homes—sometimes you'd see these Amish kids, the girls in their pretty purple dresses, hopping off the wagon and leaping over the trench. The members of the Women's Adventure Club had been told by a local government official that the fiber-optic line was a government project to provide high-speed Internet access to local colleges. Hearing that it was actually a private project to provide a 3-millisecond edge to high-frequency traders, they had some new questions about it. "How does a private line get access to a public right-of-way?" asked one. "I'm really curious to know that."

WE'RE IN A transition here. That's what the Goldman Sachs people said when you asked them, in so many words, how they could have gone from bringing the wrath of U.S. prosecutors down upon Serge Aleynikov for emailing their high-frequency trading computer code to himself, to helping Brad Katsuyama change the U.S. stock market in ways that would render Goldman's high-frequency trading computer code worthless.

There was a connection between Serge Aleynikov and Goldman's behavior on December 19, 2013. The trial and the publicity that attended it caused a lot of people to think more rigorously about the value of Goldman Sachs's high-frequency trading code. High-frequency trading had a winner-take-all aspect: The fastest predator took home the fattest prey. By 2013 the people charged with determining Goldman's stock market strategy had concluded that Goldman wasn't very good at this new game, and that Goldman was unlikely ever to be very good at it. The high-frequency traders would *always* be faster than Goldman Sachs—or any other big Wall Street bank. The people who ran Goldman Sachs's stock market department had come to understand that what Serge had taken wasn't worth stealing—at least not by anyone whose chief need was speed.

The trouble for any big Wall Street bank wasn't simply that a big bureaucracy was ill-suited to keeping pace with rapid technological change, but that the usual competitive advantages of a big Wall Street bank were of little use in high-frequency trading. A big Wall Street bank's biggest advantage was its access to vast amounts of cheap risk capital and, with that, its ability to survive the ups and downs of a risky business. That meant little when the business wasn't risky and didn't require much capital. High-frequency traders went home every night with no position in the stock market. They traded in the market the way card counters in a casino played blackjack: They played only when they had an edge. That's why they were able to trade for five years without losing money on a single day.

A big Wall Street bank really had only one advantage in an ever-faster financial market: first shot at its own customers' stock market trades. So long as the customers remained inside the dark pool, and in the dark, the bank might profit at their expense. But even here the bank would never do the job as efficiently or thoroughly as a really good HFT. It was hard to resist the pressure to hand the prey over to the more skilled predator, to ensure that the kill was done quickly and discreetly, and then, after the kill, to join in the feast as a kind of junior partner—though more junior than partner. In the dark pool arbitrage IEX had witnessed, for instance, HFT captured about 85 percent of the gains, leaving the bank with just 15 percent.

The new structure of the U.S. stock market had removed the big Wall Street banks from their historic, lucrative role as intermediary. At the same time it created, for any big bank, some unpleasant risks: that the customer would somehow figure out what was happening to his stock market orders. And that the technology might somehow go wrong. If the markets collapsed, or if another flash crash occurred, the high-frequency traders would not take 85 percent of the blame, or bear 85 percent of the costs of the inevitable lawsuits. The banks would bear the lion's share of the blame and the costs. The relationship of the big Wall Street banks to the high-frequency traders, when you thought about it, was a bit like the relationship of the entire society to the big Wall Street banks. When things went well, the HFT guys took most of the gains; when things went badly, the HFT guys vanished and the banks took the losses.

Goldman had figured all of this out—probably before the other big Wall Street banks, to judge from its treatment of IEX. By December 19, 2013, the people newly installed on top of Goldman Sachs's stock market operations, Ron Morgan and Brian Levine, wanted to change the way the market worked. They were obviously sincere. They truly believed that the market at the heart of the world's largest economy had grown too complex, and was likely to experience some catastrophic failure. But they also were trying to put an end to a game they could never win—or control. And so

they'd flipped a switch, and sent lots of their customers' stock market orders to IEX. When they did this they started a process that, if allowed to play out, would take billions from Wall Street and return it to investors. It would also create fairness.

A big Wall Street bank was a complex environment. There were people inside Goldman Sachs less than pleased by what Levine and Morgan had done. And after December 19 the firm had retreated, just a little bit. It was hard even for Brad Katsuyama to know why. Was it changing its collective mind? Had it underestimated the cost of being the first mover? Was it too much to ask Goldman Sachs to look up from short-term profit and study the landscape down the road? It was possible that even Goldman Sachs did not know the answers to those questions. Whatever the answers, something Brian Levine had said still made a lot of sense. "There will be a lot of resistance," he'd said. "There will be a *lot* of resistance. Because a tremendous infrastructure has been built up around this."

It's worth performing a Goldman Sachs-like cost-benefit analysis of this infrastructure, from the point of view of the economy it is meant to serve. The benefit: Stock market prices adjust to new information a few milliseconds faster than they otherwise might. The costs make for a longer list. One obvious cost is the instability introduced into the system when its primary goal is no longer stability but speed. Another is the incalculable billions collected by financial intermediaries. That money is a tax on investment, paid for by the economy; and the more that productive enterprise must pay for capital, the less productive enterprise there will be. Another cost, harder to measure, was the influence all this money exerted, not just on the political process but on people's decisions about what to do with their lives. The more money to be made gaming the financial markets, the more people would decide they were put on earth to game the financial markets—and create romantic narratives to explain to themselves why a life spent gaming the financial markets is a purposeful life. And then there is maybe the greatest cost of all: Once very smart people are paid huge sums of money to exploit the flaws in the financial system, they have the spectacularly destructive incentive to screw the system up further, or to remain silent as they watch it being screwed up by others.

The cost, in the end, is a tangled-up financial system. Untangling it requires acts of commercial heroism—and even then the fix might not work. There was simply too much more easy money to be made by elites if the system worked badly than if it worked well. The whole culture had to want to change. "We know how to cure this," as Brad had put it. "It's just a matter of whether the patient wants to be treated."

FOR A LONG stretch along the Spread Networks line, there was no happy place for a rider to stop. The road's shoulder was narrow, and the cornfields beside it were planted with No Trespassing signs. Apart from the plastic soda bottle and the carcasses of deer killed by the speeding pickup trucks, and a shop or two, the landscape looked a lot like it once did from the Philadelphia-Erie stagecoach. The most insistent signs of modernity were the white poles with their bright orange domes, every few hundred yards, installed three and a half years earlier. After ten miles or so we found an open field without a sign and pulled over beside a white-and-orange pole. The poles stretched into the distance in both directions. An ambitious hiker or cyclist could follow them all the way to a building beside the Nasdaq stock exchange, in New Jersey; or, if he turned and headed west, to the Chicago Mercantile Exchange.

Across the road was a local landmark: the Red Round Barn. One of the women repeated a rural legend, saying that the red barn had been built in the round so that mice had no corners in which to hide. "People don't know how to live in a world that is transparent," Brad Katsuyama had said, and mice were probably no better at it. Beyond the barn was a mountain. On top of the mountain was a microwave tower—a string of them, in fact, perched on the mountains above the valley in which the line was buried.

It takes roughly 8 milliseconds to send a signal from Chicago to New York and back by microwave signal, or about 4.5 milliseconds less than to send it inside an optical fiber. When Spread Networks was laying its line, the conventional wisdom was that microwave could never replace fiber. It might be faster, but whatever was going on between New York and Chicago required huge amounts of complicated data to be sent back and forth, and a microwave signal couldn't transmit nearly as much data as a signal in a fiber-optic cable. Microwave signals needed a direct line of sight to get to wherever they were going, with nothing in between. And microwave signals didn't travel well in bad weather.

But what if microwave technology improved? And what if the data essential for some high-frequency trader to gain an edge over investors in the market wasn't actually all that complicated? And what if the tops of mountains afforded a direct line of sight between distant financial markets?

The risks taken by high-frequency traders were not the usual risks taken by people who purport to sit in the middle of markets, buying from sellers and selling to buyers. They didn't risk buying a bunch of shares in a falling stock, or selling a bunch of shares in a rising one. They were too skittish and well informed for that—with one obvious exception. They were all exposed to the risk that the entire stock market would move, by a lot. A big high-frequency trader might "make markets" in several thousand individual stocks in New Jersey. As the purpose of these buy and sell orders was not to buy and sell stock but to tease out market information from others, the orders would typically be tiny in each stock: 100 shares bid, 100 shares offered. There was little risk in any individual case but great risk in the aggregate. If, say, some piece of bad news hit the market, and the entire stock market fell, it would take all the individual stocks with it. Any high-frequency traders who did not receive advance warning would be left owning 100 shares each of several thousand different stocks they did not want to own, with big losses in each.

But the U.S. stock market had an accidental beauty to it, from the point of view of a trader who wished to trade only when he had some edge. The big moves occurred first in the futures market in Chicago, before sweeping into the markets for individual stocks. If you were able to detect these moves, and warn your computers in New Jersey of price movements in Chicago, you could simply withdraw your bids for individual stocks before the market fully realized that it had fallen. That's why it was so important for high-frequency traders to move information faster than everyone else from the futures exchange in Chicago to the stock markets in New Jersey: to flee the market before others. This race was run not just against ordinary investors, or even Wall Street banks, but also against other high-frequency traders. The first high-frequency trader to reach New Jersey with the news could sell 100 shares each in thousands of different stocks to the others.

After some obligatory staring at the Red Round Barn, we jumped back on our bikes and continued. A few miles down the road, we turned onto the road leading to the summit of a mountain with a tower on top of it. The woman who had won the silver medal at the downhill

mountain biking world championships sighed. “I like going down more than going up,” she said, then took off at speed, leaving everyone else behind. Soon I was watching the backs of female riders, climbing rapidly. It could have been worse: The Appalachians are mercifully old and worn. This particular mountain, once the size of a Swiss Alp, had been shrunken by half a billion years of bad weather. It was now almost beneath the dignity of the Women’s Adventure Club.

It took maybe twenty minutes to puff to the top of the road, where the women adventurers stood waiting. From there we turned onto a smaller road leading into the woods, headed in the direction of the mountaintop. We rode through the woods for a few hundred yards until the road ended—or, rather, was barricaded by a new metal gate. There we ditched our bikes, leapt over the signs warning of various dangers, and hiked onto a gravel path that continued to the mountaintop. The women didn’t think twice about any of this: To them it was just another adventure. A few minutes later the microwave tower came into view.

“I climbed up one of these towers once,” one of the women said a bit wistfully.

The tower was 180 feet high, with no ladder, and festooned with electrical equipment. “Why did you do that?” I asked.

“I was pregnant and it was a lot of work,” she replied, as if that answered the question.

“And that’s why your baby had seven toes!” hooted one of the other women, and they all laughed.

If one of the women had hopped over the fence around the tower and climbed to the top, she would have had an unobstructed view of the next tower and, from there, the tower beyond. This was just one in a chain of thirty-eight towers that carried news of the direction of the stock market from Chicago to New Jersey: up or down; buy or sell; in or out. We walked around the site. The tower showed some signs of age. It could have been erected some time ago, for some other purpose. But the ancillary equipment—the generator, a concrete bunker to hold God knows what—was all shiny and new. The repeaters that amplify financial signals resembled kettle drums, bolted onto the side of the tower: These were also new. The speed with which they transmitted signals, and with which the computers on either end of the chain of towers turned the signals into financial actions, were still as difficult to comprehend as the forces of nature once had been. Anything said about them could be believed. *People no longer are responsible for what happens in the market, because computers make all the decisions.* And in the beginning God created the heaven and the earth.

I noticed, before we left, a metal plate attached to the fence around the tower. On it was a Federal Communications Commission license number: 1215095. The number, along with an Internet connection, was enough to lead an inquisitive person to the story behind the tower. The application to use the tower to send a microwave signal had been filed in July 2012, and it had been filed by . . . well, it isn’t possible to keep any of this secret anymore. A day’s journey in cyberspace would lead anyone who wished to know it into another incredible but true Wall Street story, of hypocrisy and secrecy and the endless quest by human beings to gain a certain edge in an uncertain world. All that one needed to discover the truth about the tower was the desire to know it.