Introduction

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Yesterday

In 1969, the UC Berkeley campus rocked. What a stark contrast between the bright blue skies and mild temperatures and the fiery atmosphere pulsating from every corner. My eyes burned and ears tingled with the signs of change. Strolling through the sprawl of Sproul Plaza, the center of student activity at the University of California (UC), Berkeley, I counted table after table covered with colorful pamphlets championing gay rights, free love, drugs, and civil rights. The din of demonstrators chanting protests against the unpopular Vietnam War filled my ears, along with the tunes of Janis Joplin, the Rolling Stones, and the Beatles belting out of transistor radios propped on concrete sidewalks. The smells of pot mingled with tear gas filled my nose as soldiers drew their bayonets. Students sporting hippie fashion called out for reforming society.

Surrounded by the sounds, smells, and pull of people looking forward to a world that was different, I couldn't help but think, and even feel, that the world was changing. With the press for reform across the liberal campuses of America, I found myself also contemplating innovation and progress. The winds of change primed me to envisage the future in my chosen field of economics.

I was a late twenty-something-year-old academic, sporting a tweed sports jacket with leather patches on the sleeves and khakis, a head topped in curly brown hair and long bushy sideburns. Several times a

week I taught courses in economics to undergraduate students and courses on quantitative methods, the economics of science and technology, and economics to graduate students. In between classes, I slipped into my office to trade commodities on my black rotary dial phone. My wife, Ellen, too, was a product of the times. Clad in hippy-flowered sheer blouses and jeans and wearing her straight brown hair long past her shoulders, she bore our daughters via natural childbirth, took metalsmithing classes at Berkeley, and served as the founding secretary of the Berkeley chapter of the National Organization for Women. At home, on campus, and in the streets, change was in the air. I couldn't escape it.

Sipping hot instant coffee between classes, my thoughts turned to innovation. Computers and their use on organized markets were still in their infancy. Personal computers did not even exist. Still, nearly 50 years ago, in 1969, I was increasingly convinced that the rise of computers could revolutionize commodities trading and provide improved trading tools. I imagined that using computers to quickly analyze statistical trends might prove invaluable, as a short response time posed a huge advantage in a volatile market. While there was some adoption of computers for clearing, electronic trading wasn't even on the radar screen of any major commodity exchange.

Mind you, the computers of then are *not* the computers of today. Nearly half a century ago, mainframe computers were housed in huge heavily air-conditioned rooms and operated with punch cards, like the IBM 1620 in the basement on which I did statistical analysis for my doctoral thesis. Of course, the iPhone 10 has much greater capacity than that behemoth computer of 1969.

Then an opportunity arose to test my theories.

In the summer of 1969, David Ware, my commodities broker and a key figure of the Commodities Club of San Francisco, a diverse group of agribusiness companies and commodities brokers, approached me with a query. "We are considering launching an electronic and for-profit exchange in San Francisco to trade coconut oil futures," said David. "Could you conduct a study and help us design the new exchange? We're going to call it the Pacific Commodities Exchange."

It was clear to me that the members of the club were onto something. An electronic exchange could improve access for existing participants, along with new speculators and hedgers. It was a transformative way to reduce transaction costs.

But it was *radical*. Electronic for-profit exchange represented a double departure from established norms. Exchanges had always been highly

political organizations that operated not to maximize profit, but to provide specific benefits to their members. So while going electronic constituted breaking one barrier, going for-profit demolished another.

Since there was no existing exchange in San Francisco, it was difficult to attract local speculators to serve as market makers. Without people to buy and sell through the trading day, we had little hope for success. Because there wasn't a history of commodity trading, the Commodities Club of San Francisco was considering computerized trading. Therein lay the request that I draft a research proposal.

In the fall of 1969, I was awarded a \$15,000 grant by the Bank of America to perform a study on the feasibility of a new commodity exchange in San Francisco. My team was perhaps the only one in the Bay area that knew both computers and commodity trading. On September 1, 1969, we established the California Commodity Advisory Research Project (CCARP), and UC Berkeley generously agreed to house our project within the Institute of Business and Economic Research at the School of Business. Phase 1 was to examine the feasibility of an electronic, for-profit exchange. At the time, there were only 12 commodities exchanges worldwide, and none were for-profit — or electronic.

Questions filled my mind. What functions did exchanges perform? What kind of exchange could maximize profits for shareholders and minimize transaction costs for users? Could we computerize the mechanics of floor trading? And how did the functions performed by the exchange change in an electronic, for-profit exchange? To answer these questions, I booked a trip to Chicago to study the operations and trading floor of the city's two largest exchanges: the Chicago Board of Trade (CBOT) and the Chicago Mercantile Exchange (CME).

Prior to visiting the exchanges, which would solidify my understanding of the functions performed by the exchange, I hired a technical consultant, Barry Sacks, an assistant professor in electrical engineering and computer science at Berkeley, to help determine whether computer technology was advanced enough to accommodate an electronic version of such functions. I had befriended Barry after he audited my seminar on inventive activity. We agreed to assemble a software team in Phase II — but only if the feasibility study suggested that we move forward.

First I had to unravel the details and mystery of what went on in the trading pit and how liquidity was actually realized. I flew out to Chicago to find out.

On a crisp Monday morning in October 1969 just minutes before 9 a.m., I stood in the CBOT's Visitors gallery, eager to witness the celebrated open

outcry system of trading. As the opening approached, traders and brokers began to gather in the soybean pit. It was the biggest and most volatile grain and oilseed futures market. I later treaded onto the trading floor, eyes wide with delight. More than 500 people shouting bids and offers for soybeans, corn, and wheat in multicolored jackets stood next to each other in the different pits, gesticulating with their hands. The decibel levels were extremely high, so high that traders who traded every day had hearing problems later in life. Some of them had even taken voice lessons. Shouting 30–40 feet is performance art!

I marveled at how billions of dollars could be traded in one central place, with orders originating from London to New York being matched in this one room in Chicago. How did the traders decipher it all, given how chaotic it looked? I was bedazzled, amazed!

The world's biggest and oldest futures exchange, CBOT was housed in a great old building on West Jackson Boulevard that was celebrated for trading in wheat, corn, and soybean futures. The lobby was filled with art deco fixtures, and the elevator doors were adorned with pewter squares decorated with shocks of wheat. CBOT had a marvelous multi-storied trading floor overlooking LaSalle Street. Reigning over the entire floor from the inside was John W. Norton's three-story mural of Ceres, the Roman goddess of grain. I was gobsmacked. The whole visual of an art deco trading floor with a three-story painting of the Roman goddess of grain was something out of a 1930s movie. Even better than a movie.

By 9:15, the room had begun to fill. In many pits across the trading floor, reporters took their positions in raised stations at each venue where the various commodities were traded.

After a thrilling half-hour in the gallery, I moved to the floor and spoke to market reporters and public relations people. Viewing the exchanges, I noted that the current system spent enormous resources running the trading floor. I knew that an electronic trading system could reduce errors, cut costs, attract more traders into the system, and provide much greater transparency of the transactions made.

But there were two challenges. First, could we configure existing computer technology to replicate order entry and the matching of buyers and sellers? That meant creating a communication network to carry various messages in hard copy, including order messages, market updates, and confirmed trades.

And second, could we cost-effectively invest in and operate the hardware and software for trading? This required understanding exactly what kind of

information floor traders needed to make their decisions. To do so, I had to visit the exchanges again so I could observe and interview more traders.

The pressing problem: designing a systems flowchart for an electronic exchange. The design needed to describe the order entry and matching functions in order to electronically replicate the process that was in place for existing functions. Designing the system felt, in some ways, like simultaneously playing a number of chess games while blindfolded. Each game was separate, but you had to keep all of them in your mind at once. I felt the same fatigue I experienced after playing eight-hour chess sessions.

The essential element of the system was an editor-member communication network that could carry several types of messages in hard copy. These included messages for placing orders, retransforming orders for error control, transmitting fundamental information, communicating market updates, and confirming trades.

Another element of the system included displaying information on a cathode ray tube. Information on the screen was intended to simulate the environment a floor trader was accustomed to seeing on the wall boards. Again, I reminded myself that the screen had to be designed to energize the trader, given the loss of the performance aspect of floor trading. I was inspired by the design of a chessboard. I made an additional visit to existing exchanges in order to more closely identify the type of information used by floor traders in decision-making. This second trip allowed me to better understand both the nature of the matching algorithm and the clearing function of trading.

We also had to design a screen. Floor traders had information concerning a bid or offer, as well as a notion of the quantities available at respective prices. In the exchanges I visited, the last trades were available on either electronic devices or, for commodities with low volume and less continuous trading, a blackboard. Floor traders could easily observe a short-term trend by observing the last three prices. An electronic platform would be able to record both price and volume on a continuous basis. The ability to record price changes and display them on a screen would provide traders with a precise record of price changes so that they would not have to rely solely on their own informed guesses. Fundamental information on the underlying commodity would also be available on screen, rather than posted on exchange walls. Posting open interest on a continuous basis would provide traders with more information during the trading day. All of this additional information theoretically compensated for the liquidity that could be lost amid the transition from open outcry to electronic markets.

My report went on to note that floor traders relied on observing the physical movements of other members in order to determine what their positions might be and whether they would be buyers or sellers. In an electronic exchange, that sort of personal observation would be absent. In order to compensate for some loss of liquidity due to the absence of face-to-face trading, we decided to provide additional information on the breakdown between hedging and speculating activity regularly over the course of the trading day.

One advantage of electronic trading was that access to the market could be achieved over a wider geographic area. It took a while for data on the sources of speculation to emerge, but when it did, the results were not surprising. People who speculated on frozen concentrated orange juice futures tended to live in areas where oranges were grown. Similarly, people who speculated on grain futures tended to live in the Midwest. This proclivity was intuitive as speculators were more familiar with their local economies, and thus the commodities that were indigenous to them. The advent of electronic trading had the potential to change this localized trading pattern. Initially, telecommunication devices would be established in the San Francisco Bay area and complemented by a national network that would subsequently include Chicago, Los Angeles, and New York. These offices could also be used to market the exchanges and provide space for housing professional traders as well as stations for systems experimentation.

Another critical aspect of the electronic system was its ability to incorporate the immediate dissemination of a trade. Markets were often volatile. If an order was placed, given the drawn-out response time, participants could not immediately check the price or the quantity bought and sold. This hurt market liquidity and generated higher transaction costs. By churning out market information by the second, electronic trading would allow hedgers, speculators, and arbitrageurs to simultaneously purchase in the spot or forward market and sell futures, thereby resolving the issue.

The electronic system contained six different programs. A pre-trading program would perform various functions related to initializing values such as volume and the removal of expiring contracts. Three programs would perform on the post-trading day, related to closing, clearing, and auditing. The first related to receiving orders, the second to obtaining quotations, and the third related to confirming trades.

For the technical phase of the project, we had to select hardware and software that best mimicked the conceptual system flowchart. Our selection

was based on considerations to response time, system reliability, and control against order entry errors. As the CCARP team solicited proposals from General Electric and IBM and went through their cost estimates, it became clear that our system could run far more cheaply than the open outcry system. I was elated. Even in a worst-case scenario, with one successful contract and an annual volume of 175,000 contracts, or ADV (average daily volume) of slightly more than 725 contracts, we would be profitable by the third year. This was, and is, an incredibly small volume. By contrast, the ADV of interest rate futures ranges from hundreds of thousands to millions of contracts.

When it came to deciding what contracts to trade, we recommended coconut oil futures to be followed by palm oil, and then iced broilers. We believed that each of these commodities could be standardized, and volatility in prices warranted a futures market.

Strangely enough, the evolution of commodity regulation required commodities to be regulated, but not the futures exchanges. Because our product of choice — coconut oil — was a regulated commodity, we needed the Commodity Exchange Authority (CEA) within the US Department of Agriculture to provide approval to electronic trading. We therefore tailored the bylaws of our exchange to the requirements of the CEA.

In early 1970, I went to Washington, DC to meet with Alex Caldwell, the head of the CEA, and several other USDA economists. Though they were cautious about saying so publicly, Caldwell and the other economists quietly welcomed us to apply as a contract market in coconut oil futures. They were interested in anything that could improve their ability to monitor markets, and a computerized system seemed to provide just that.

Time was very tight. With only one month before our deadline, six of us worked feverishly on finishing our interim report. Barry Sacks evaluated the proposals from vendors while our research assistants each did their part.

Finally, after hundreds of cups of coffee and too many sleepless nights, we finished our report and delivered it to our supporters in early April of 1970. It was 132 pages long. The entire text can be found in Chapter 2.

In just seven months, with a mere \$15,000 — close to \$100,000 in 2017 — we had created a blueprint for an electronic futures exchange that would run as a for-profit company. The world of commodity exchanges would never be the same.

But then I discovered that we were before our time, much to my chagrin. Not by a little, but by a lot! It proved to be a great lesson. You have to be early to be on time, but not *too* early.

David Ware gave initial reactions to the report, admiring it but with questions. I then called the man leading the effort at the Commodity Club, who appeared interested in moving to the next phase. One appendix contained a proposal for Phase II, which called for finalizing hardware and software configurations, recommending a vendor, and developing specifications for the first contract. A target completion date for the next phase was set for mid-September that year on a budget of \$41,525. Over the next weeks, I negotiated the terms of Phase II with the lawyer. Thrilled, I wore an anticipatory smile on my face, aglow like a giddy high school senior accepted to the college of their choice. I couldn't wait to get started. I climbed into bed thinking about the challenge and awoke eager to rethink it some more. It was exhilarating. Energized by the excitement, I clenched my fist and moved my arm up and down and gesticulated. For a mere \$56,525, or about \$300,000 in today's terms, our team would deliver final terms of several futures contracts, an exchange rulebook that not only had new contracts but also embedded the architecture for a for-profit exchange. Members of the Commodities Club of San Francisco, i.e., Bank of America, FCMS, and agribusiness, would receive the final system and specs for hardware and software to run the system. This was a turnkey project that couldn't fail to be funded, I said to myself.

And then I got a call. I had gotten it all wrong. Not some of it, but *all* of it. The lawyer's tone was dismissive, like cleaning off loose papers from his desk.

It's too risky, pronounced the lawyer from the sovereign state of Idaho. The group had decided on a traditional mutual model, adhering to the old, open outcry method.

I tried fervently to call the principal players separately. Perhaps they didn't understand. Maybe they just didn't realize that great change was in the air all over America!

Yet I had underestimated how risk-averse these men were. One by one, they politely told me that the concept was too great a gamble. I placed the telephone receiver back in its cradle.

My face fell. I was devastated. I filed the report in a desk drawer, and then duly submitted a copy to the Institute of Business and Economic Research in the School of Business, the grant administrators. The grin that had lived on my face was gone; reluctantly, I was forced to turn my energy and professional sights to financial futures. When I fail, I just get more determined. It was at that moment that interest rate futures were given life.

Fast forward two decades. The second half of the 1980s ushered in the beginnings of the next major revolution in US futures markets — electronic trading. This in turn led to demutualization and the initial public offerings (IPOs) of all major US futures exchanges. This shift did not occur as a result of a grand plan etched in stone by any single exchange. Rather, the trend was driven by a series of loosely related, and often arbitrary, events in Europe and the United States.

The first exchange in the United States to file for an IPO was the CME, which began trading publicly on December 13, 2002. I started to take a more personal interest in their filings when I realized that it was a follow-up to the work I had done at Berkeley 30 years earlier on CCARP.

E-Speed and its chairman, Howard Lutnick, knew the potential commercial value of the intellectual property and bought the only patent for electronic trading. The patent was developed earlier by Susan Wagner and eponymously named the “Wagner Patent.” After working at the CFTC, Wagner had joined the World Energy Exchange and applied for the patent in 1983. The exchange was a commercial failure and the patent was inherited by a Dallas firm controlled by the principals of the World Energy Exchange. When the CME began its transformation into an electronic exchange, in preparation for an IPO, it was sued by Howard Lutnick for patent infringement.

That lawsuit hit the front page of the Financial Times. My wife, Ellen, spotted it first.

“Richard, check out this headline,” she said, passing me the crisp newspaper. “Didn’t you work on the concept of an all-electronic exchange back in Berkeley?”

“I did,” I agreed, sipping unsweetened Earl Grey tea. Where was that study, I wondered.

Ellen, an artist, had filed for her own patents in three-dimensional photography and was familiar with the concept of “prior art.” My paper, the original blueprint for the Pacific Commodities Exchange, constituted an example of “prior art” of electronic trading. That would imply that the invention would not be valid because there was prior art.

I called up Berkeley’s Institute of Business and Economic Research, the original sponsor of our research, to get a copy of the Project CCARP report. I was dumbfounded to hear that they had neither a copy nor a record of the report. It had gone missing. Surely, this was a mistake! I made several more calls before reaching the director. He made a special effort to trace the whereabouts of the study. He, too, found nothing.

Try rummaging through the basement, suggested Ellen. That's where you stored your old files from Berkeley.

My colleague, Rafael Marques, and an intern left the office to search the dark, dingy, stuffy basement of our apartment building. Under the light of the naked bulb hanging from the ceiling, they perused 40 boxes of my graduate school notes, rough articles from journals, with comments from Nobel Prize laureates on papers I had drafted decades earlier. After seven hours of parsing through dusty, musty boxes, they had found nothing. It was only when they had begun cleaning up that Rafael spotted the report; it had fallen out of a deteriorating box. It was easy to identify due to a flowchart that bore a striking resemblance to the Wagner patent.

By this time, the CME and the CBOT had entered the final stages of negotiation with E-Speed over a license for the Wagner patent. With pending initial public offerings, they did not want to risk delaying the IPO. They each paid \$5 million for the license. NYMEX was the next exchange to go public. I called the Chairman, Vinnie Viola, and arranged to see him. Vinnie got it. They wanted to use the study to contest the Wagner patent on the grounds that the invention should have never been granted a patent, as the system was in the public realm. Unfortunately, they submitted the evidence too late, so it was ruled inadmissible.

I thought the rights to the CCARP idea should be owned by the UC, Berkeley so I called the university's lawyers to see if they had any interest in claiming ownership. Their legal opinion was that they did not own the rights to any subsequent patents. I called Rich Lyons, the dean of the business school, and informed him of the discussion. He indicated that they would publish the study electronically on their website, a decision that pleased me. It was posted there for a limited time. The *Financial Times* ran a story on it that was quickly picked up by other media (Figure 2). Financial News, for example, ran a story that compared the two studies (Figure 3). Figure 1 is the original 1970 Financial Times story on the research at Berkeley. Figure 4 shows the system flowcharts of the Wagner Patent and the original CCARP design side by side. The similarity is difficult to miss.

Aside from the CCARP design, there were other efforts to start electronic exchanges in the 1980s. The International Futures Exchange (INTEX) was the first electronic derivatives exchange, launched on October 25, 1984. A retired Merrill Lynch futures broker whom I knew from the CCARP project started an exchange in Bermuda. Parenthetically, the Merrill Lynch broker happened to be close friends with individuals from the Pacific Commodity Exchange. He embraced our idea of a for-profit,

The Financial Times Thursday June 23 1970

U.S. COMMODITY MARKETS

West Coast looks to the futures

BY A SPECIAL CORRESPONDENT

THE western United States, which has never had a commodities exchange, suddenly has plans underway for two of them, one to be located in San Francisco, the other in Los Angeles.

First expected to open for business will be the West Coast Commodity Exchange in Los Angeles, which plans to begin trading in international commodities by October 1. The proposed new exchange will deal initially in silver, copper, cocoa and sugar futures contracts. Because it will not be trading in U.S. domestic commodities, the WCCE will not be regulated by the U.S. Department of Agriculture's Commodities Exchange Authority.

In San Francisco, a proposed Pacific Commodities Exchange has been incorporated and recently received an initial go-ahead in a feasibility report prepared by the University of California. The preliminary report, commissioned by the newly-formed Pacific Commodities Exchange Inc., states that a computerised exchange dealing in western and Pacific region commodities is both economically and technically feasible.

Computerised

The second part of the feasibility study is set to be completed September 15. It is to determine whether the new exchange should seek operating funds through private sources, through sale of memberships or selling of stock to create a publicly-owned exchange.

The commodity exchange of the kind the University of California is studying would be the first to be fully computerised. It could operate 24 hours a day, seven days a week, with traders working from office or home through a telecommunication system linked with other similar setups to a central computer.

The California Commodity Advisory and Research Project that is making the study is administered by the Institute of Business and Economic Research at the University of California's Berkeley campus. Professor Richard Sandor, project director, sees a western U.S. commodities exchange as possibly "the exchange of the future." He envisages no pit, ring or trading floor but an exchange hooked up by a "vast communication network" computers, split-second automatic execution of buy-sell orders, and poised for the 144m. commodities trading-volume-year he predicts over the next 30 years.

Coconut oil is likely to be the first commodity traded on the Pacific Commodities Exchange, says John Gallwas, president. "If coconut oil proves successful, probably cattle would be next. Actual trading could begin late in 1970 or early in 1971.

"It's a rather mind-expanding project," he adds. "A computer can work 24 hours a day. If this system could work, why not trade foreign exchange and bankers' acceptances?"

He points out still another unique feature of an exchange such as the one now proposed. "Everyone knows Orientals per se love to trade," he declares.

"For the first time, with this telecommunications system and use of satellites, people in the Orient could be close to the floor. There's tremendous potential in terms of trading money. Futures trading on the Pacific Commodities Exchange could include California wines, raisins, tomato paste, cultured pearls, tuna fish, crabmeat and the Pacific currencies of Japan, Taiwan, the Philippines, Australia and Mexico."

Trading pits

The more conventional West Coast Commodity Exchange in Los Angeles will take over 13,000 square feet for its operations. It will use three trading pits for dealing in the four international commodities, with a fourth pit to be added later.

The exchange is to have 500 members, about 100-150 of them from the Midwest and East, the remainder to be signed up in the western U.S. The first 500 memberships reportedly are to be on flat fees and not a bid and offer system as used on established securities exchanges. The first 50 memberships will go for \$1,150 each, the second 50 for \$1,850, the next 100 for \$3,450 on up to a top price of \$5,750. An exchange official says it "definitely" will be open to public ownership, possibly within three years.

Neither Mr. Gallwas in San Francisco nor officials of the West Coast Commodity Exchange sees operational conflicts, with the two exchanges trading in non-competitive markets, the one domestic and the other dealing in international commodities.

Figure 1. Financial Times, June 25, 1970.

Financial Times

Sep 05, 2002

COMPANIES & FINANCE - THE AMERICAS: Document could unravel patent dispute

By Nikki Tait in London and Mary Chung in New York

A 30-year-old document, unearthed in a Chicago basement, could provide firm evidence of "prior art" in an electronic trading patent dispute that has already cost some of the largest futures exchanges tens of millions of dollars.

The discovery could make it much more difficult for Cantor Fitzgerald's eSpeed subsidiary to collect any more money from its "Wagner" patent, which registered the idea of electronic trading for commodity futures in 1990.

News of the discovery comes just days after the Chicago Board of Trade and Chicago Mercantile Exchange settled with eSpeed for \$15m each if it dropped a lawsuit alleging breach of the patent.

But the Cantor subsidiary still has a similar claim outstanding against the New York Mercantile Exchange, and is thought to be planning to pursue other potential licencees.

The 130-page document, which looked into the feasibility of a computerised commodity exchange on the West Coast, was written in 1970 by Richard Sandor, then a professor at the University of California, Berkeley.

The report described in detail how an electronic exchange could work, using diagrams strikingly similar to those contained, more than a decade later, in Susan Wagner's patent. The West Coast idea even featured in a Financial Times article at the time.

"There is no doubt that this is invention of electronic trading," Mr Sandor said.

Although he said he believed "this thing is virtually the [Wagner] patent", he added that he had not taken legal advice.

Mr Sandor said any intellectual property rights associated with the document, which recently fell out of a packing case in his basement, would belong to the University of California.

There has been much talk about the possibility of a prior art defence against the Wagner patent, but efforts by lawyers involved in the case to track down university copies of the PCE project are understood to have been

Figure 2. Financial Times, September 5, 2002.

unsuccessful.

The relevance of another early automated futures trading project in Bermuda in the 1980s has been complicated by its non-US base.

Yesterday, neither the CBOT nor the CME would comment on the document's emergence - although they said the settlement with eSpeed would not be revisited.

"The reason we did it was to put the whole issue behind us," said the CBOT.

Yesterday, Howard Lutnick, chief executive of eSpeed, could not be reached for comment. Paul Devinsky, patent lawyer at McDermott, Will & Emery, said if there was prior art, the Wagner claim could be invalid.

Nymex officials said they would fight the lawsuit. "We know we have a strong case."

Figure 2. (Continued)

electronic exchange and sought to implement it with some partners. Intex was able to sell only half the memberships. Their first contract was gold and their marketing effort was insufficient to capture volume from the COMEX (the Commodity Exchange, or COMEX, was then the primary market for metals). The technology wasn't enough to overcome the wrong choice of contracts. The World Energy Exchange, which first used the Wagner patent, also failed. These examples underscore the message that new technology has to be linked with the correct products and marketing. Innovators in the blockchain space should keep this lesson in mind. We will return to this point later.

For a long time, the Wagner patent was buried and forgotten just as the CCARP design/blueprint had been after the death of the Pacific Commodity Exchange in May 1976. The patent was only later invoked during the E-Speed lawsuit once electronic trading was accepted as commercially viable.

The London International Financial Futures and Options Exchange (LIFFE) was also partially through a process of demutualizing; they were eliminating open outcry and transitioning to electronic trading. I was on the board as well as part of LIFFE Chairman Brian Williamson's team that

eFINANCIAL NEWS

Sandor paper could aid defence

Phillipa Leighton-Jones - 4 Nov 2002

Futures industry struck by similarity of inventions

The University of California has published a document which could show that automated futures trading was invented in 1970, 20 years before the arrival of the Wagner patent. The patent claims to cover the invention of the practice and it is reaping rewards for its present owner, Cantor Fitzgerald's eSpeed division.

The publication of the document could help future defendants in their fight against eSpeed, which has so far claimed that four exchanges are using systems based on the invention that it owns.

The document, written by futures industry veteran Richard Sandor in 1970, was uncovered in September. However, until it was published last month, defendants who were being sued by Cantor for breach of its so-called Wagner patent were unable to use it as defence evidence.

In September, the New York Mercantile Exchange (Nymex), which is involved in litigation with eSpeed over use of the Wagner patent, lost an appeal to use the Sandor document as evidence that eSpeed's patent was invalid.

Nymex requested that the court consider the paper – written when Sandor was an assistant professor at the University of California at Berkeley – as evidence of "prior art" of electronic trading.

The 140-page document outlines the use of computers to automate commodities trading. It was the original blueprint for the Pacific Commodities Exchange, which was to be the first electronic exchange in the world, and is known as the California Commodity Advisory and Research Project (Project CCARP).

That paper pre-dates by 20 years a document patented by Susan Wagner, who would later become a commissioner at the Commodities and Futures Trading Commission, the main US regulatory body for the derivatives industry. Her paper also describes how commodities and futures trading can be automated by using computers. ESPEED bought the Wagner patent in 2001 and, with it, inherited legal action against Nymex.

Nymex, whose case is due to be heard later this year, claimed that Sandor's paper demonstrated "prior art" of electronic trading, which means that although Wagner may never have seen Sandor's document, the invention of electronic trading was his and not hers. Proof of this would invalidate the Wagner patent.

However, on September 25, Judge Theodore Katz in the Southern District of New York, ruled that Sandor's paper was inadmissible as evidence. He denied the request because the paper's submission had missed the July deadline for completion of discovery.

The judge said that to permit such a discovery after the deadline would lead to further delay, expense and prejudice.

Katz added: "Although not necessary to this decision, it appears highly dubious that an unpublished feasibility study, written in 1970, which no one could locate until it fell out of a packing case, is 'highly material' to Nymex's defences."

Figure 3. eFinancial News, November 4, 2002.

Futures industry experts say the two documents bear a remarkable resemblance and would make Project CCARP a strong defence in any further litigation against other exchanges, which could include Euronext Liffe and Eurex.

Both the Wagner patent and Project CCARP work on the premise that the functions traditionally performed by locals, floor brokers and the pit would instead be processed by a central computer system.

Members would be connected to this system via modem connections to their own trading terminals. Other functions performed by an exchange, such as clearing, surveillance, compliance and market information, are not included in the functions of the central system but they have electronic connections to it.

Both are also almost identical in their claims to create computerised exchange systems for buying and selling certain futures commodities contracts by traders using electronic trading terminals. An exchange computer would automatically match bids and offers and send the resulting information to counterparties, clearing houses, compliance systems and audit.

The vital issue for future defendants is whether Sandor's paper demonstrates "prior art". Futures industry sources say the practices outlined in the paper bear a strong resemblance to modern-day electronic futures trading.

Project CCARP does not need to seek its own patent for this to take place. Legal counsel for Berkeley has said that any potential patent rights for the paper have been lost as Sandor did not file for patent protection at the time of publication. Berkeley says that, although it has now published the paper, it is not entitled to intellectual property rights. A source at Berkeley says the university is unlikely to do anything more with the document.

However, Sandor believes the intellectual property is Berkeley's, and he suggests that he is therefore not in a position to seek advice regarding the legal status of the document. However, he says he is pleased that the study – which was conceived before the personal computer was invented but which anticipated its arrival – bears a striking resemblance to today's electronic exchanges.

Even if no action is pursued by Sandor or Berkeley, futures industry sources say the document, published last month, will be the cornerstone of a defence argument by any other exchanges that Cantor pursues.

Judge Katz did not say that the document did not prove "prior art" in electronic trading; he said Nymex was not allowed to subpoena Sandor for the document. Now that it has been published, other defendants will be in a more privileged position.

Figure 3. (Continued)

rescued the exchange. I also made the patent available to them to create LIFFE Connect, the electronic trading platform. Brian Williamson was subsequently knighted for his work in saving LIFFE and helping maintain the City of London as a financial center. Eurex, the German financial futures exchange, had managed to attract all of the business in Bund futures from LIFFE because it was an electronic exchange competing with LIFFE's open outcry system. As an important aside, Eurex was actually the combination of two early leaders in electronic trading in Europe in the late 80s and early 90s — SOFFEX in Switzerland and the Deutsche Terminboerse (DTB) in Germany. Their early adoption of electronic trading gave them an important advantage. Jörg Franke and Andreas Preuss were the key leaders on this process. Andreas and I would later meet and become

Figure 4. Comparing the Wagner Patent with the CCARP Design.

Source: U.S. Patent Office and the University of California at Berkeley.

friends while he worked on a joint venture with the CBOT and Eurex based on the Eurex platform. That's another story. I called Brian Williamson to alert him that they might be sued and offered my help. LIFFE was never sued, nor was any other exchange for infringement of the patent. In retrospect, I keep on wondering who was the person that had read or laid eyes on the CCARP report of 1970 and why it had gone missing.

To this day, it is axiomatic that exchanges are for-profit and electronic. This trend has occurred in Europe since the 1990s and in the United States since the 2000s, some three decades after the creation of CCARP. The world's growth in technology and public economies for trading allowed markets to blossom in the for-profit and electronic realms.

While the legacy of CCARP remains a mystery of the past, with some cinematic elements to the story, it continued to have legs in my future and in my following adventures.

While Eurex and LIFFE proved the concept, the foundation for the CME to go fully electronic had been laid approximately 10 years earlier. The Chicago Board of Trade and Chicago Mercantile Exchange were involved in a competitive battle to get the licensing rights to the Dow Jones Industrial Average in order to launch a futures contract based on that index. The CBOT won that battle. In a brilliant counterpunch, the CME announced the launch of the e-mini S&P futures contract to be traded on their electronic platform termed Globex. The evolution of that platform is yet

another story. This smaller sized contract was designed to attract smaller public traders (retail) that otherwise might trade futures on the DJIA. The S&P 500 futures contract was to remain oriented to institutional users and remain pit traded. The CME facilitated the location of computers in booths surrounding the S&P 500 pit. Electronic orders could be filled with lower transaction costs by arbitraging the e-min contract against the pit-traded S&P 500. That strategy not only countered the CBOT but paved the way for the CME to become the biggest electronic market in the United States, a for-profit business model, and achieve domestic hegemony. For emphasis, the product mix, the for-profit mode and electronic trading facilitated the CME emerging as the world's biggest exchange by volume and market capitalization. But this is another story and is better told by its witnesses, leaders and key drivers Terry Duffy, Jack Sandner and Leo Melamed.

The original architecture of electronic trading and for-profit exchanges is published in its entirety in Chapter 2 of this book. One wonders where the original working papers for the creation of cryptocurrencies and its associated technology, the blockchain, are stored. Are they simply hidden? Will some of that work also go missing?

Transitioning from the trading floor's open outcry model to electronic trading yielded its own kind of magic and liquidity, unrestricted by borders and time zones. Automatic electronic exchange imbued the system with two novel salient elements: instantaneous consummation of transactions and transparency. Akin to purchasing a product on Amazon or Ebay, one could place a trade with the simple press of a button. And among other changes, such as extended hours that spanned nearly round the clock, there was added liquidity and increased price transparency. It was not news that the theatrical cacophony and raucous nature of the open outcry auction in the trading pit took time and included an enormous possibility of error. As such, the aforementioned changes constituted nothing short of a revolution. Engaging noisy chaos in the pit, pulsating with energy, meant that one's verbal bid could easily be "misheard" in the crowd. Picture some 300 people standing side by side in an octagon shaped pit, traders and brokers, 90% men and 10% women, clad in jackets of bright colors (red, green, and blue, reflecting their respective firms), shouting out orders, gesticulating wildly. Using designated hand signals, they tried to make eye contact on the crowded floor to confirm their sell, signaled by a palm facing outward, or buy, signaled by a palm facing inward. They conversed by slicing the air with their fingers, hands, and fists.

“Two bid for \$100!,” yelled someone across the pit. “Sell you 100 at 4.” Another increased the price to 103 at 4. “Sold!,” screamed the buyer. And with a sharp nod, the trade was completed. Only seconds had passed. On average, a floor trade might take seconds in a slower market and less than a second in a fast market.

But notifying the customers could take anywhere from seconds or minutes in fast markets to 30 minutes in slower markets. In the 1970s, floor brokers, or order fillers, were agents for clearing members such as Cargill and Continental Grain. After the introduction of financial futures in 1975, Wall Street giants such as Goldman Sachs and JP Morgan joined the exchange and became clearing members executing proprietary trades or acting as agents for banks, savings and loan associations, pension funds, and others. The trade execution speed was slow, and the chance of an error, known as an out trade, so extensive — numbering from 2% to 4% — that traders had to come in 30 minutes before the market opened to clarify their trades from the previous day. A seller could be misidentified as a buyer, and 100 bond futures contracts could be confused with 1000. Errors could cost \$1000, \$50,000, and \$500,000. Most dangerous was the mistaken buy-buy or sell-sell. Dispute resolution could be very extensive and thorny. With the incorporation of electronic trading, there was none of that. Press the key — and it was done. No possibility of price confusion. Of course, there was always the chance that somebody might hit the wrong button. The system wasn't flawless, but it was significantly better than open outcry. Nobody could convey that story of the transition better than Don Wilson. He was and is the consummate example of how to adapt to change, intellectually suited to succeed in both venues. He shares his experience in Chapter 3.

However, the move to electronic trading did not entirely solve all issues. Even after all of the progress from the last couple of decades, the screen has not yet been able to fully replicate the flow of information a trader would be exposed to on the floor. At the CME, the Commitment of Traders — a report on the number of contracts outstanding and one of the most important pieces of information on futures and options markets — is only released on Friday afternoon based on positions held during the prior Tuesday. Traders are not yet exposed to instantaneous information. That is only one example. Open interest could just as easily be published after every trade.

And the matter of settling the next day and getting the cash remained cumbersome and time-consuming. Brokers had to call their customers. People had to send in money. Checks took days and bank wires occurred the next day. While electronic trading eliminated the inefficiencies in the open

outcry market, clearing and settlement remained unchanged. If we chart the outset of the idea of electronic trading, it took 20 years to commercialize and 30–40 years to attain complete adoption by the industry.

Today

And so it continued until 2008, with no apparent research or study in altering the clearing or settlement process. In October of that year, during a time of financial crisis when people's distrust of the institutions responsible for safeguarding their assets was raw, a pseudonymous programmer — or perhaps a team of programmers, we know not who — identified as Satoshi Nakamoto proposed another path for doing business: digital currency. Nakamoto published a white paper entitled "Bitcoin: A Peer-to-Peer Electronic Cash System" on The Cryptography Mailing List at metzdowd.com in which he/she/they introduced an electronic cash payment system called Bitcoin. Instructive is the first line of the paper's abstract published by the mysterious Nakamoto:

"A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution... Digital signatures provide part of the solution, but the main benefits are lost if a trusted third party is still required to prevent double-spending." Nakamoto continued to explain his/her/their solution:

"We propose a solution to the double-spending problem using a peer-to-peer network. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work."

The second paragraph of the introduction talks about cryptographic proof instead of trust.

"What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. Transactions that are computationally impractical to reverse would protect sellers from fraud, and routine escrow mechanisms could easily be implemented to protect buyers." Nakamoto continues: "In this paper, we propose a solution to the double-spending problem using a peer-to-peer distributed timestamp server to generate computational proof of the chronological order of transactions. The system is secure as long as honest nodes collectively control more CPU power than any cooperating group of

attacker nodes.” Therein lay the next wave of change in the clearing and settlement process in the world of finance and exchanges.

The process and potential of the blockchain are best articulated by the incomparable Don Tapscott. He does so extraordinarily well in Chapter 4: “Cryptocurrencies differ from traditional fiat currencies in that no Federal Reserve, central bank, or government treasurers issues them or controls their supply. Rather, the network itself verifies transactions, bundles them into a bloc, and links it to the previous bloc, forming a chain of blocks — hence, blockchain.” Blockchain is the name for the technology underlying it.

Put simply, the blockchain is an accounting ledger. Just as I could physically record in a ledger “Richard bought x from Ellen.” It’s called a distributive ledger because any number of people on different computers can have transactions and are entered into this accounting framework.

This digital ledger “... is kept and validated simultaneously by a network of computers, almost like a shared Excel document that no one person can change without the agreement of the others.” Importantly, it allows deals to be made without the blessing of a “trusted intermediary,” such as a clearinghouse.

As explained by Avi Salzman in “Beyond Bitcoin: How Blockchain is Changing Banking” published in Barron’s on July 1, 2017: “Bitcoin is more than cash you can trade over the internet. Unlike traditional currencies, the supply of which is controlled by central banks, new Bitcoins are mined about every 10 minutes by a global network of computers that maintain a constantly updated list of Bitcoin transactions. (The network itself is also called Bitcoin.)...”

“There is no physical token involved — Bitcoin owners get codes, or ‘keys,’ to access their money. The keys that each party enters allow the system to verify the transaction and memorialize it in a block. Only 21 million Bitcoins will ever be created (16.4 million of them have already been mined as of 2017), so no central authority can devalue the currency.”

“Bitcoin was not the first idea for a digital, or ‘crypto,’ currency. For at least a decade before it was created, libertarian-minded tech enthusiasts had dreamed of inventing a digital token that would allow them to trade directly with each other and avoid interference from central banks and regulators. Yet early efforts failed to catch on.”

In January 2009, Nakamoto released the first bitcoin software that launched the network and the first units of the bitcoin cryptocurrency, called *bitcoins*.

Satoshi's innovation, explains Don Tapscott in Chapter 4, marked the beginning of the second era of the Internet, what he terms "the Internet of Value."

Satoshi posted now and again over the years from 2009 to 2011. However, the identity and biography of this inventor remain a mystery. Was it just one person, a genius? Was the code too perfect and more likely the product of a team? A team of geniuses? Who knows. Was it shorter than the 13 year lag from Project CCARP to the Wagner Patent? And would it take the same two or three decades to attain complete adoption like electronic trading? Today in 2017, I say I think not.

In those early years when Satoshi was posting, around 2010, this virtual currency piqued my interest as an economist, and I started reading about it. I grew more interested after reading an article in the Economist that referenced Milton Friedman's idea of a steady increase in the supply of money as opposed to a central bank. Intriguing was the argument that economists discuss of rule-based versus discretion in monetary policy. Virtual currencies with a finite supply fit the Friedman model, argued the article. Though it discussed how blockchain technology was used, I made a mental note of it and did not think it through. I continued to follow other articles in the financial press, which focused primarily on bitcoin as an investment. Even today, investment opportunities garner the nucleus of interest. However, my fascination was rooted in where and how the blockchain fit into the ecosystem that succeeded the electronic trade: clearing and settlement. And thus it remained a topic that I explored from afar.

Until an opportunity fell right into my lap.

In March 2014, I flew to Boca Raton to attend the FIA's (Futures Industry Association) Annual International Futures Industry Conference, a gathering of 1000-plus senior-level executives from brokerage firms, asset management firms, international exchanges, and regulatory bodies. This strategic conference brings together leaders in industry and rising stars of the global futures, options, and cleared swaps industry to explore the current state of cleared derivatives ecosystem, set strategic partnerships, and make powerful connections. It's the "leading strategic conference in the global exchange-traded industry landscape." While the conference certainly features informative session topics, much of the real work gets done in networking opportunities and social events.

That year was no exception. A major draw was the private reception held annually at the Boca Raton Museum of Art and hosted by Jane Gladstone. A friend of mine from my multiyear tenure on the board of

ICE, Jane is one of the leaders in the field of Mergers and Acquisitions, ranked by Bloomberg as one of the 50 most influential players in "... markets and shaping ideas and policy." I trusted Jane's keen eye for bringing people together. On that warm spring night in Boca, I was not disappointed.

Invitees were CEOs of exchanges, the Chairman of the CFTC, head of futures commission merchants, leaders of proprietary trading firms: The movers and shakers in the industry. On that clear evening, I approached the long table, a glass of chardonnay in my hand, and introduced myself to the person next me.

"Wences Casares," said the well-appointed man next to me in perfect, Spanish-accented English, shaking my hand firmly. "What do you do," I asked with a smile.

"I just set up a Bitcoin cold-storage vault and wallet startup in Palo Alto called Xapo," said Wences. A technology entrepreneur with global business experience specializing in technology and financial ventures, Wences also shared that he was the son of a rancher hailing from Patagonia, a sparsely populated region at the southern end of Argentina, who grew up accustomed to communicating remotely. He was a ham radio operator as a kid.

Palpable was the unassuming 40-year-old's passion for bitcoin. He was clearly enamored with the possibility that digital currency could make the world economy more stable. Here, too, I sensed some personal resonance: his family's finances had been devastated by the volatile financial fluctuations in his home country of Argentina, including the peso riding a roller coaster of inflation, deflation, and devaluation.

Yet cryptocurrency was thus far too unstable, discomfiting many, explained Casares. People needed to gain confidence in it as a platform for money, he affirmed, a friendlier and safer option. Hence, his company's offer of double protection of a cold-storage vault and wallet.

When I get excited, I get animated. I nod a lot and move my arms. And so it was. My face broke into a huge smile. Chin bobbing, arms flailing. If you could have peered inside my brain, you might have seen sparks fly.

"My background is in financial futures and emissions trading."

I hesitated, reluctant to promote myself.

"I invent markets. Sometimes I get it wrong, and sometimes I get it right."

Now it was Casares turn to grin broadly. "Spot and futures market would be just what the doctor ordered," he quipped, a gleam in his intense brown eyes. "How about starting an exchange for bitcoins?"

Within 48 hours, an invitation from Wences landed in my inbox. Did I want to visit Xapo in Palo Alto in the coming days?

Within a week or two, my colleague Rafael and I boarded a plane to California. En route, I contemplated where bitcoin and blockchain might fit in with electronic trading. The blockchain technology intrigued me as much as bitcoin did. It was a new step in post-trade activities. The ultimate clearing and transfer of ownership really struck me. Was Casares on to something? Was the alleged apostle of Bitcoin right that cryptocurrency could constitute a “leap forward” in the democratization of money?

The taxi pulled up to the entrance to Xapo’s office, which was astride a CVS pharmacy. As we climbed the 40 stairs to the entrance in a building that had no elevator, our eyes were greeted by white walls covered with striking graffiti: a red cash register resting atop loads of bags of bitcoin and dollars, with these words aloft: “It takes money.” The visuals and environs resonated with the early beginnings of the small electronic trading firms. They, too, were located over drug stores and Greek restaurants. Ultimately they evolved into proprietary trading firms or “prop shops” that used computer-driven strategies to make markets or arbitrage, thereby providing a significant amount of worldwide volume on worldwide futures and stock exchanges. (We get to see some of this up close in Don Wilson’s telling of the evolution of his firm DRW Trading in Chapter 3.) The street address told me that this business was put together to facilitate an objective. It had no need for an elegant exterior address or a posh interior. Inside, Xapo felt like a startup dedicated to launching a successful business, not a stately bank. There were no 19th century British paintings decorating the walls, positioned just so over English Chippendale furniture. We walked into an open plan work environment and noted simple desks covered with computers. Some were occupied, others not. A few computer programmers were doing their thing, probably all under 30 and clad in jeans or khakis. No suits, ties, or any other sort of formality. Around the programmers were shuffle boards and ping pong tables.

Those familiar recreational items signaled to me that these programmers were running brain marathons. Ping pong and shuffle board were on hand for the times when they needed to relax their minds and cool down. Intense mental work requires light amusement for breaks, to allow one’s intellectual side to settle, revitalize your thought process, and get back to work. These accessories were tailored to amuse programmers. It felt familiar: my relaxation technique of choice was many-hour matches of competitive chess.

My colleague Rafael and I exchanged knowing looks. *This was the real deal.* You could have dropped this work space into the creative corridors of Berkeley in the 60s or the proprietary trading shops in Chicago during the transition to electronic trading at the turn of the 21st century. Those, too, were also populated by similar teams of techy guys and gals programming at their respective stations, paving a new path. *This was the real deal.* You could see, smell, and even taste the change that was coming. This was Silicon Valley par excellence. If anyone was going to crack the cryptocurrency and the blockchain, it was this team.

I had observed the birthing of electronic trading; the coding, open collars, no suits, and no ties. Then in the 1990s I had slipped Domino's pizza under closed doors at midnight for programmers coding risk management models for derivatives trading and pricing catastrophic risk. The aesthetics and design of the work space, the recreational outlets on hand, the informal nature of it all spoke volumes about Xapo's commitment and tailoring to support creativity in coding.

In that light and airy space, everyone seemed to be working in their roles in this new world of cryptocurrencies and the blockchain.

Rafael and I joined Casares at the end of a long rectangular room. He sat with us for 90 minutes, elaborating on the need for protection for people who bought and sold cryptocurrencies. I learned a lot about the blockchain and its strengths and weaknesses. In the digital world, the place one buys or sells bitcoins from is referred to as a wallet. Wences was simply building what he termed as the most secure wallet in the world.

Toward the end of our engaging, lively discussion, the talk migrated from technology and business to soccer. Rafael hails from Brazil, and our meeting was held three months before the FIFA (International Federation of Association Football) 2014 World Cup, hosted that year in Brazil. I discovered that Casares was as single-minded and passionate about sports as he was about work. He had rented an apartment in Rio de Janeiro for the entire month to watch soccer. Devotees of rivaling teams, Rafael and Casares exchanged playful jabs in Spanish and Portuguese, hoping that the final game might be a face-off between Argentina vs. Brazil. In the end, Argentina made it to the finals — but lost to Germany.

As I climbed down the 40-step staircase, I said to myself, time to jump right in and buy and sell Bitcoin. Reading and studying could only get me so far. I had to risk my own capital for the learning to truly sink in. Being at risk focuses the mind.

Yet my enthusiasm dimmed when I discovered how cumbersome it was to actually open a Bitcoin account. Why did it take five frustrating days? I was vexed like a child struggling to tie his own shoes. Why was this simple task so complex? Buying and selling three or four bitcoins taught me that cryptocurrency was years away from being flushed out. Aha! And thus I spotted a new opportunity. Now I understood firsthand the need for an exchange and filed a patent for trading bitcoins on organized spot and futures markets. We did so, and as I pen this introduction, the patent office released our application for the patent on my daughter Julie's birthday, August 10th. Bitcoin News went on to say that we were the first of three inventors and that "[t]he application itself details a hardware concept for the storage of digital currencies tied to derivatives contracts."

It explains:

"The invention relates to a method to facilitate trading of digital currencies, which comprises electronically storing an amount of a digital currency on an electronic storage device or electronic registry; and physically storing the storage device or electronic registry in a secure, physical repository that is not publicly accessible with the storage device or electronic registry available for use in subsequent delivery of the digital currency."

That, too, is now a part of an ongoing story. I did not actively throw myself into starting a new exchange in cryptocurrencies because I was knee-deep in developing a new benchmark for interest rates, Ameribor, as a replacement or complement to Libor if the latter lost its credibility. We did launch the American Financial Exchange in late 2015 in a venture with the Chicago Board Options Exchange (CBOE). But that is another story for another book.

As an economic innovator, I was enthralled not only by derivatives in cryptocurrencies, but also by the use of the underlying technology in other new financial products. Vast was the potential impact of blockchain on me and on fellow inventors around the world. Knowing that somewhere down the road transaction costs would be minimized or even obliterated meant that we could invent what we wanted.

But good ideas don't always land on their feet on the first try. Sometimes a good idea fails, flops, and fizzles again, before its time comes. Like a good wine, sometimes it has to age. Yet if the idea's fundamental premise is sound, it can evolve into a very important product. And sometimes a new technology such as the blockchain is just the thing needed

to bring greater impetus into an existing or inchoate financial product. Here is some anecdotal evidence of how this process worked.

Months after completing my report on electronic trading, I co-authored an article with Robert Goshay, a colleague at UC Berkeley, on how to hedge insurance risk. We argued that the reinsurance market — in simple terms, reinsurance is insurance purchased by an insurance company — was undercapitalized, and that regulation in the insurance market was ineffective because it discouraged market innovation. Our article, “An Inquiry into the Feasibility of a Reinsurance Futures Market,” was published in the *Journal of Business Finance* in 1973. However, due to its unorthodox approach, or some other reasons unbeknownst to me, it was received with little or no interest by academics or practitioners.

Some 15 years later, my mentor and friend, Les Rosenthal, who had championed financial futures as chair of the board of the CBOT and knew of my insurance derivatives idea, asked if I thought it was still viable. I thought it was. Through my involvement with the CBOT, I helped design the first catastrophe insurance futures to be listed on an Exchange in 1992. But it did not gain traction at CBOT or other exchanges. I simply got it wrong.

Why didn't it catch fire? Successful futures markets rely on a continuous information flow that causes daily, weekly, or monthly volatility. While the commodity markets, interest rates, and stocks all have this, earthquakes don't. (It is still possible to create those markets with tornado and hurricane risk. And that idea may again be revived.) Yet insurance derivatives did inspire other alternative risk transfer mechanisms, such as industry loss warranties (ILWs), swaps, and CAT bonds. Hurricane Harvey may provide us with additional insight on how effectively the CAT bond market, and other capital market financial instruments, worked as well as the implication for the prevalence of their use in the future.

CAT bonds are an example of insurance securitization that transfers a specific set of risks, habitually risks related to catastrophe and natural disasters, from an issuer to investors. Investors assume the risks of a specified catastrophe or event occurring in return for attractive rates of investment. If the qualifying catastrophe or event occurs, investors lose the principal they had invested and the issuer, often insurance or reinsurance companies, receives that money to cover their losses.

First implemented in 1995, the CAT bonds market really took off in 1997 when rating agencies started to rate CAT bond issues. They have since gained momentum as a financing vehicle in the insurance market, “replicating” a reinsurance contract and generally accounted as such. CAT

bonds, which can have a payoff tied to either an indemnity trigger or an index trigger, currently represent the dominant form of insurance-linked securities (ILSs). Consider that 15% of all insurance or reinsurance (insurance companies buying insurance) is now covered by alternative risk transfer tools. And here is where blockchain technology fits in, facilitating the growth of financial innovations.

As of the writing of this chapter in August 2017, a private CAT bond transaction was settled using the blockchain. Dom Re IC Limited issued \$14.8 million of notes, due in 2023, representing the securitization of a reinsurance contract to six investors, which are all ILS funds. The private blockchain, named “ILSBlockchain,” effectively replaced the role of a traditional settlement system, providing a peer-to-peer means to manage settlement of the note issuance. The underlying contract is related to US wind risk.

The issued notes now reside on the ILSBlockchain. That means that any secondary transactions would also have to be registered in the underlying distributed ledger technology. This distributed ledger could open the market for a wider array of participants, which could significantly impact the creation of a more robust and efficient market.

Fitting is the “match” between the blockchain’s distributed ledger capabilities that allow for settlement without an intermediary — and the “trigger” aspect of a CAT bond that triggers settlement without any claim. Settlement could take just seconds, and transparency would be increased at much lower transaction costs. It will be interesting to observe if this trend continues, or if it remains a one-off occurrence.

Blockchain applications might also help grow existing and new environmental markets. The role of emissions trading in combating climate change will substantially change. The same is true for mitigating the impacts of drought and unsafe water.

Let’s touch upon the concept of carbon offsets and the potential applications that blockchain could have in facilitating the participation of individuals, farmers, foresters, and other smaller participants in the carbon market. Because blockchain technology decentralizes the registration process, it can have huge implications for verification, registration, and trading of carbon credits worldwide. Allow me to echo the words of Tapscott:

“Blockchain may hold the key to changing human behavior on a mass scale, motivating people everywhere to integrate carbon reduction into their daily activities.”

Exciting are the prospects for blockchain and environmental finance to work together for the benefit of the planet.

While we have been discussing inchoate uses of blockchain in the insurance sector as well as a potential in environmental markets, major efforts in finance are already underway. They are so ubiquitous that they warranted a cover story in one of the world's most prestigious financial weeklies. Bitcoin and the blockchain technology are both the story of today — and of tomorrow. An article in Barron's recently featured these major efforts worldwide. Here is what was presented in the article:

ASX Australia

ASX, which runs the Australian Securities Exchange, is considering replacing its entire system for post-trade clearing and settlement with a blockchain-like system. It's in a unique position to do so. ASX is the primary equities exchange, and under a parliament-granted monopoly, operates the only clearinghouse in Australia. The first testing phase demonstrated the technology's security, speed, and reliability, and a lower cost of operation than traditional mechanisms. ASM will decide by the end of 2017 whether to commit to this technology. The system is also designed to be open to an additional clearing provider, should the ASX monopoly expire.

Bank of Canada

In a venture called Project Jasper, the Bank of Canada, Payments Canada and the seven largest banks in Canada demonstrated a system for transferring and settling central bank-held assets using a distributed ledger, the first blockchain research project undertaken by a central bank and private-sector institutions together. Banks deposit their cash collateral in an account held by the BoC and receive depository receipts, which are then exchanged on the platform and can be redeemed for cash. A white paper detailing the project's performance is set to be published shortly.

Bank of New York Mellon [BK]

Bank of New York Mellon has been using a blockchain-based system to create an independent backup ledger of US Treasuries transactions. The platform, called Broker Dealer Services 360, or BDS360m, only runs internally and is an inexpensive way of protecting transaction records in the event of a disruption to the system. The BDS360 platform has been in use since March 2016, putting BNY Mellon ahead of other banks in adopting blockchain technology.

Daimler (DAI Germany)

In late June [2017], Daimler and Landesbank Baden-Wuerttemberg launched a 100 million (need the euro symbol) one-year corporate loan, using blockchain technology to carry out and fulfill all parts of the transaction. According to Daimler, “The entire transaction — from the origination, distribution, allocation and execution of the *Schuldschein* [promissory note] loan agreement to the confirmation of repayment and of interest payments — was digitally carried out via blockchain technology.” Three other German banks also acted as lenders.

Northern Trust [NTRS]

In February 2017, Northern Trust created a blockchain to manage the administration of a private equity fund launched by Switzerland-based Unigestion, which manages \$20 billion in assets. Northern Trust partnered with IBM and Guernsey authorities to develop the blockchain, which records the transactions and other documentation associated with private equity deals — for example, investments by partners, capital calls and legal and administrative processes — and provides a central record of these transactions that fund managers, investors and administrators can access. There will be manual processing of transactions and more security, Northern Trust says.”

Now I'd like to walk you through this book and provide some food for thought.

This introduction trails my original attempt at an all-electronic exchange in 1969, even before personal computers existed. It includes the burying of the project for two decades, the emergence of a patent that was uncannily similar to my study, and some of the original articles that appeared then and 20 years later (Figures 1–3). The original Project CCARP Report Preliminary Design for an Electronic Market for the Pacific Commodities Exchange (1969) is reproduced in its entirety in Chapter 2.

As I mentioned earlier in this introduction, in Chapter 3, Don Wilson of DRW shares his personal story, with some big-picture ideas about how the markets have evolved over time and what new technologies and factors might have important impact on future market structure evolution. In his words: “Certainly the application of technology to drive greater efficiency in the markets is the boldest headline in the story about market structure evolution. The migration from open outcry to electronic futures markets was a critical — and often wrenching — transition, one I witnessed firsthand (and perhaps contributed to).” Wilson describes how things have changed

and what it's meant for the industry through the lens of his 28-year career, that started, as most did back then, in the pit.

In Chapter 4, Tapscott provides his perspective of blockchain, its origins and potential by examining cases in financial services, new business models, the Internet of Things, and peer-to-peer electronic trading. There is a reason why the book Tapscott co-authored with his son, Alex Tapscott, *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business and the World* was a bestseller. You will find this chapter most illuminating and exciting.

Tomorrow

Some final thoughts

As an economist, the study of inventive activity has always fascinated me. And innovation in finance must go hand in hand with lowering transaction costs. As Nobel Prize laureate Ronald Coase taught us in his concise but monumental article, *The Nature of the Firm* (1937), firms exist in their current form because of transaction costs. These costs can be thought of in three buckets: (1) Search; (2) Contracts and their negotiations; and (3) Coordination. The nature of exchanges requires a slightly different lens. There are four buckets here: (1) Enabling legislation; (2) Regulatory; (3) Designing new exchanges with new contracts or modification of existing contracts or new products on existing exchanges; and (4) Details of the specific contracts. The nature of the firm, and in my words, the nature of markets, is driven by minimizing transaction costs. Otherwise, no financial innovation can achieve success. The success of new markets or technologies is not instantaneous. Standard undergraduate textbooks often state, "Let's assume there is an efficient market for widgets," and follow that with a graph of supply and demand curves. This example is dictated by pedagogical reasons, not because the authors believe in the spontaneous combustion of markets. It generally takes decades to establish efficient markets. Financial innovations are just part of the economics profession's study of inventive activity.

A useful framework to understand the evolution of electronic trading and, more recently, blockchain is well accepted in the academic and real world.

According to Austrian economist Joseph Schumpeter, the process of inventive activity can be described in three stages: invention, innovation, and imitation or replication. The birth of a new product or process is termed

invention. Innovation is the commercialization stage, and imitation is when its use becomes prevalent and widely replicated.

In the case of electronic trading, “invention” was the realization that transactions that had required human interaction could be replaced by an electronic model. That invention was described in the Project CCARP, a blueprint for an all-electronic exchange. The study was followed by the Wagner Patent. The term for this inventive activity was about 12 years. Innovation, or the commercialization of the idea, occurred with the birth of Eurex some 7 years later. It took more than another decade before full-scale replication occurred. The entire cycle was about 35–40 years, from 1970 to 2010. A generation to invent and innovate, and then another generation to attain full-scale imitation. “Commercialization” of the idea lay dormant for another 20 years. In an ironic twist, the novelty was first implemented in Switzerland and Bermuda, places where legacy factors such as “open outcry” and the historical nature of the mutual form of organization were easier to overcome. On the other hand, these same factors were the reason that the US, with its long legacy of open outcry, was the last to fully embrace electronic trading. What does this example imply for the inventive cycle for blockchain?

We can apply the same framework to the blockchain. In the case of the invention, its origins are shrouded in mystery. We don’t even know if the inventor is truly who he/she/they claim/s to be. Is it an individual? A collaborative process? Whoever stands behind it, the innovation took the form of bitcoin and the blockchain. We know not the trajectory of its evolution. Was it a decade in the making? And as Don Tapscott illustrates in the last chapter of this book, we are now entering the innovation phase, where the idea is being used in numerous applications, including the environment and, of course, finance, and trading. Where and when will successful commercialization surface? In the exchange space, will it again happen first outside the United States? Will the pattern witnessed in electronic trading repeat itself? It appears that it will. Will it outpace the innovation and replication of electronic trading? I’d venture to say yes.

In addition to Don Tapscott, this book also brings together innovators and practitioners that have been involved in the intersections of finance, electronic trading, and now, blockchain. Blythe Masters, CEO of Digital Asset, has also been a trader in environmental and energy markets. She is incredibly capable, and it would not surprise me at all if she will be the one to lead this change. She articulates well the potential of blockchain in the preface:

“Secure, mutualized transaction processing can eliminate reconciliation, reduce errors, satisfy regulatory reporting requirements, speed up settlement, reduce margin and capital, and offer new business opportunities. These are not the characteristics of a technology looking for a problem, but of one that can solve urgent realworld issues. Rarely does a technology live up to its hype but I truly believe — after spending an entire career in financial markets — that blockchain offers a once-in-a-lifetime opportunity to rethink financial markets infrastructure.”

We get to walk through history via the chapter authored by Don Wilson, founder and CEO of DRW, who lived through the transition from open outcry to electronic markets. He was a first adopter in this space and shares his firsthand experience. Don Tapscott is morphing from a seer into a practitioner with his efforts in the carbon market. Others will follow suit. While the blockchain is a novel way to implement clearing and settlement, many of the challenges it will solve could have been done with the current digital technology. For example, 3-day settlement could have been shortened with current technology. It is important to recognize that sometimes a new technology can force the adoption of change that could have been accomplished without it. The lesson: never underestimate the impact of a new way of doing business to drive change that could have happened without it. The flow of human and financial capital may force the obvious. The replacement of legacy methods within an existing business is very difficult. Forty years as a financial innovator have taught me that people would rather see their institutions die than change. What, if any role, will cryptocurrencies play in the coming technological change? I for one eagerly await that change and wonder whether I will be an actor in that play, or will in some small way help create the play.

The success of bitcoin, as opposed to the blockchain, will further the adoption of the underlying technology.

Although this book has focused on the underlying technology, that does not mean that we do not recognize the revolution of the cryptocurrency itself. As I penned the final draft of my introduction in the late days of summer 2017, I called Casares, the “prophet of bitcoin,” to take his pulse on where we were. As of August 2017, there were 35 million users of bitcoin. A million or more new users trade or own cryptocurrencies. There are now hundreds of cryptocurrencies. Ethereum, launched in 2015, is the clear second. As Don Tapscott points out, “Ethereum and Bitcoins are not really direct competitors but rather amigos.” He further notes in

Chapter 4 that 2017 is becoming the year of Ethereum for the enterprise. Bitcoin, and other cryptocurrencies, continue to grow because of the unique nature of blockchain with its distributed ledger, trusted counterparties, and the breadth and depth of its network. The cryptocurrencies and their associated technologies seem like awkward teenagers getting ready to burst into early adulthood. In my view, it will be implemented more quickly than electronic trade.

During our conversation, Casares shared that he thought that there was a “bubble” going on in the bitcoin space. I felt the same. I thought a correction would take the form of a decline in prices. It would shake up the market by impacting individual cryptocurrencies. It would also affect the proliferation of exchanges in this space.

Having this conversation after vacationing on a ranch in the west, I could not help but think about the gold rush of the 49ers in the 19th century. Gold was found accidentally, and then it was “mined.” The price rose, fortunes were made, and millions of people were drawn to and gravitated to the riches of California. Eventually, many of those people failed; not everyone could find gold. The market became standardized, and only a handful of key miners remained; those that could do so more efficiently and on a larger scale. The value proposition became the associated services created by gold rush, rather than the mining itself. What stands out more in our memory nowadays are those that provided services to the industry, such as William Randolph Hearst or Levi Strauss. Interestingly, these same individuals laid the foundation for the establishment of the California System of State Universities. And thus we have come full circle back to the halls of Berkeley.

As I review the final galleys to this book and search for lessons learned, my mind reels at the amount of change since that dinner in Boca 2014 with Wences. According to CoinMarket there are now 1,519 cryptocurrencies with a market cap of US\$ 429 billion. Still only a fraction of the market cap of gold at 6 to 7 trillion dollars, but how will that change in the next 5 years? Will it be like automobiles where the 3,000 manufacturers in the United States in 1920 dwindled to three and only the technique of mass production survives? If you Google cryptocurrencies there are 18,000,000 citations. Even more on the blockchain.: 24,000,000. How will these numbers and content in these citations change in the future? There seems to be one conclusion that is safe to infer from the past. This current data on cryptocurrencies and the blockchain will become obsolete but the framework for studying inventive activity will likely remain.

As Blythe Masters and Don Wilson discuss in their respective contributions to this book, the switch from electronic trading didn't just mean a gain in efficiency and transparency. It also represented a major opportunity to invent, as in the case of new products in the environmental market space. The contributors seem to concur that the new frontier for blockchain will also unlock value in areas we may not yet have anticipated. Although some of this innovation may take place outside the United States, it would be foolhardy to "short" America's ability to innovate.

Finally, some food for thought. Even as this book goes to print, the pace of innovation in the cryptocurrency field in general and the blockchain, continues at a baffling pace. IOTA is another ledger system, an alternative technology to the traditional blockchain model called Tangle. It provides zero-fee transactions, as well as a unique verification process that is well-suited for large scale applications. As the secure communications and payments between machines — also known as the "Internet of Things" — become more prevalent, it could find more widespread adoption. Ripple, another cryptocurrency, connects financial institutions to make global payments. The list goes on and the field is still wide open. Sustainable invention and innovation often depend of academic research and teaching. Just as derivatives entered the curricula at universities so is the blockchain. I can't explain the joy and irony that the Haas School of Business at the University of California, Berkeley has introduced the blockchain into its curriculum (the course, "Blockchain, Cryptoeconomics, and the Future of Technology, Business and Law" will be offered in the Spring of 2018).

And as student of markets have seen before, many times the first product is not necessarily the most successful. Heating oil was supplanted by crude futures contracts, the first interest rate futures contract (GNMAs) was replaced by the long and the ten-year; the first stock index futures (Value Line) was supplanted by the S&P Futures. The list goes on. Perhaps this trend will be duplicated in the blockchain technology with new basic and improvement inventions. Simply put expect change. Surely the best is yet to come.

Around the world, electronic trading is now ubiquitous. All major exchanges are electronic. And for-profit. Transaction costs have come down dramatically, making markets more efficient and transparent. Yet the impact of the rise of electronic trading has been felt almost entirely on the trading side. Settlement and clearing are still done in the same way and it is here that we peer into the future with curiosity and hope. Blockchain can bridge this gap; it can provide an integrated system that can further lower

transaction costs and spur greater innovation. I know this innovation would have brought a great smile to my friend and mentor, Ronald Coase. While there has been great advancement in reducing transaction costs, that piece of the puzzle is as yet unknown. It is a genesis story whose future chapters are waiting to be written. Who knows what lies ahead? *The wheels are already in motion and I, for one, eagerly await the changes that are on the horizon because of some anonymous inventor. I wonder, did he/she/they felt/feel like I did after completing the first study of electronic trading? The journey ahead promises to be a great story of inventive activity. Out there in the digital universe there are fantastic minds working on and in this brave new world. I implore them to keep records and heavily guard against their going missing. Their history will benefit us all.*