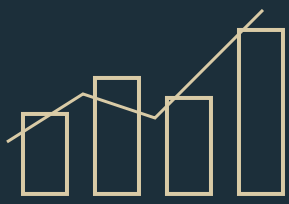
INDUSTRIES OF INDIA

THE STOCK EXCHANGE

A Market for Promises



KETINENI RAMARAO

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The Stock Exchange: A Market for Promises
An Industries of India study
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All charts in this book are original data graphics prepared for this study; the data sources are named in the captions and listed in the source companion. The order book in Figure 2 uses made-up prices and is marked as an illustration.

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This book is research and history. It is not investment advice.

Contents

A Hundred Guilders 5

PART ONE: The Idea 8
The Problem a Share Solves 9
Inns, Squares and Bills 13
The First Continuous Market 16
Coffeehouses and Bubbles 19

PART TWO: The Room 23
Twenty-Four Men and a Tree 24
Wires 27
The Panic Machine 30
Many Rooms, One Idea 33

PART THREE: How a Trade Works 37
Anatomy of an Order 38
After the Trade 42
The Rules of the Room 45

PART FOUR: The Idea of a Price 48
What a Price Knows 49
A Number for the Whole Room 53
Two Peaks, Remembered 56

PART FIVE: The Machine 59
The Screen 60
Screens Across the Channel 64
Milliseconds 67
The Week the Plumbing Showed 72
Futures Learn Finance 75
The Other Rooms 78

PART SIX: The Business and the World 81
Who Owns the Room 82
The Map Today 85
What the Exchange Feeds 89
What Holds It Back 92
What Comes Next 95
Back to the Ledger 98

Reference 99
A Timeline of the Exchange 100
Glossary 102

A Hundred Guilders

In August 1602 a notary in Amsterdam opened a ledger at the house of a merchant named Dirck van Os and started writing down names. The company he was collecting money for did not yet have an office. It had a charter, dated 20 March, and a plan to send ships to Asia. For a month, anyone who wanted to put money in could walk in and do it.

The charter was unusually open about this. Article 10 said that all the residents of these lands may buy shares in the company. There was no minimum and no maximum. Posters announced the offering. The directors themselves signed first. Six of them put in 12,000 guilders each. [1]

People came all month. On the last day, 31 August, the register closed at midnight with a total, for the Amsterdam branch, of 3,674,945 guilders. The notary wrote that he and his two witnesses had checked the tally and that not a nickel or dime had been paid in after twelve o'clock. In all, 1,143 investors had signed. [2]

The second to last name belonged to Neeltgen Cornelis. She was Dirck van Os's maid. She had spent the month opening the door to merchants, and she subscribed a hundred guilders, an amount she had worked long and hard to save.

That ledger is a good place to begin a book about the stock exchange, because it holds, in one month and one house, almost every problem the institution has been trying to solve ever since. A company needs money from strangers. Strangers need some reason to trust it. They also need a way out, because nobody wants to lock up a hundred guilders for a

decade. The charter promised an accounting after ten years. Then the directors, who understood their customers, added a line on the first page of the register: shares could be transferred. [3]

That line is the stock exchange in embryo. A share you cannot sell is a gamble you are stuck with. A share you can sell, to a stranger, at a price both of you accept, is something else: a claim on the future that can change hands in an afternoon. The market that makes this possible is the subject of this book.

It is a strange object to study as an industry, because most of what it produces cannot be touched. An exchange makes prices, and it makes them under rules. It lets a buyer find a seller. It guarantees, as far as anything can, that the stock arrives and the money arrives. It publishes the result so that a farmer in one country and a pension fund in another can both see what a company in a third is worth, right now, according to people who are willing to risk their own money on the answer.

Seen as a material industry, though, the exchange has a body. It has rooms, first an inn and a courtyard, then a hall with a floor, then buildings full of servers in New Jersey. It has wires: the telegraph, the ticker tape, the fibre-optic cable straight as a ruler between two cities. It has machines that match orders and machines that remember them. It has paper and later pixels. It has people whose work is to stand between a buyer and a seller and take a small amount for the trouble. And it has a long, repeating history of failure, because a market made of people tends to inherit what people do when they are frightened or greedy.

This book follows that body through time and around the world. It starts with the idea, and with the inns and squares where it first got a place to live. It walks through the first great manias, the building of the modern exchange in New York and elsewhere, and the invention of the wire that turned a local market into a national one. It then opens the machine: how an order becomes a trade, how a trade becomes ownership, what rules keep the whole thing honest, and what theories economists built to explain what a price knows. It follows the exchange onto screens and into data centers, through the days when the machines misbehaved, and

out into the world of businesses, regulators and households that depend on it. It ends with the questions the institution faces now, and with what is likely to stay the same.

A word on method. The numbers in this book come from named public sources: exchange operators' own reports, regulators' staff reports, central archives, the Nobel Prize committee's descriptions of the work it honoured, and historians of the periods in question. Where a figure is from a particular year, the year is given. Where a source is a retelling of a legend, the book says so. The separate source companion lists every source and the claims it supports.

Nothing here is investment advice, and nothing here predicts a price. The aim is to understand the thing that makes prices.

PART ONE: The Idea

The Problem a Share Solves

Start with a ship. Suppose a captain needs a ship, a crew, trade goods and provisions for a voyage that will take two years and may not come back. He does not have the money. A wealthy merchant could lend it, but one merchant putting everything into one hull is taking a risk few can afford. So the captain finds several backers, each putting up a part, and each getting a part of whatever comes home. If the ship returns, the backers share the profit. If it sinks, they lose their stakes.

This is the arrangement that existed in the Netherlands before 1602, and it had a limit built in. According to the Dutch exchange historians, a small group of moneylenders could take part in financing a single voyage, and when the voyage ended, so did the partnership. The next voyage needed a fresh round of fundraising, fresh haggling and a fresh list of backers. [4]

The Dutch East India Company, the VOC, changed the arrangement in one respect that mattered more than any other. It was meant to go on. The money was not for one voyage but for a company that intended to exist for many years, with ships coming and going, and with investors from all layers of society allowed to take part. Exchange historians describe it as the first company to issue shares to a broad public and one of the earliest to have many of the features of a modern public limited company.

A problem followed at once. If the company lives for years, the investor's money is locked for years. The charter tried to ease this. After ten years, in 1612, a general balance would be drawn up, the company would disclose how it was doing, and shareholders would be able to ask

for their money back. The directors, as the previous pages showed, then noticed that ten years was still a long time to ask someone to wait, and wrote the transfer provision into the register. [5]

Liquidity, in plain words

Economists give this property a name: liquidity. An asset is liquid when you can turn it into cash quickly without giving up much of its value. A bank deposit is liquid. A house is not. A share in a company is only as liquid as the market it trades in. [6]

Liquidity is not a side benefit of the stock exchange. It is the thing the exchange exists to produce. Investors accept lower returns on assets they can sell easily and demand higher returns on assets they cannot. A company that can offer shares people can sell tomorrow can raise money more cheaply than one that cannot. The same logic applies to the whole economy. If long projects, from ships to railways to semiconductor plants, can be financed by short-term savers who may want their money back at any time, then more long projects get built. The exchange performs this trick by letting each investor's exit be another investor's entry.

For that to work, the market needs a few things that a ledger alone does not provide. It needs a place where buyers and sellers can find each other. It needs a price that both sides can see. It needs a rule about how the sale is finalised, so that the buyer knows the share is his and the seller knows the money is hers. And it needs enough trust in the company that the share is worth buying at all. The rest of this book is, in one way or another, about those four needs: meeting, price, finality and trust.

What a share is

A share is a legal claim, not a physical thing. In 1602 it was an entry in a register; later it became a printed certificate; now it is, for most investors, an electronic record held on someone's behalf. What it represents is a fraction of ownership in a company, with a right to a proportional part of the profits the company chooses to pay out and, in general, a say in who runs the company. The holder is not responsible

for the company's debts beyond what he put in, which is a feature that took time to be fully worked out in law and without which few would invest.

The VOC's share was a strange hybrid by modern standards. The initial capital was not a stock issue in the way a modern initial public offering is, a point the historians behind the VOC research website are careful to make. Its structure, its duration and its relationship to the Dutch state all differ from a modern corporation. But the key move was already present: the claim could pass to someone else.

Six chambers, one company

The VOC was not one pool of money. It was six semi-independent branches, called chambers, each with its own subscription. The total raised in August 1602 was almost 6.5 million guilders. Amsterdam provided 57 percent. Middelburg provided 20 percent. Enkhuizen contributed 8 percent, Hoorn 7 percent, Delft 4 percent and Rotterdam 3 percent. The six figures add up to 99 because the source rounds each share. [7]

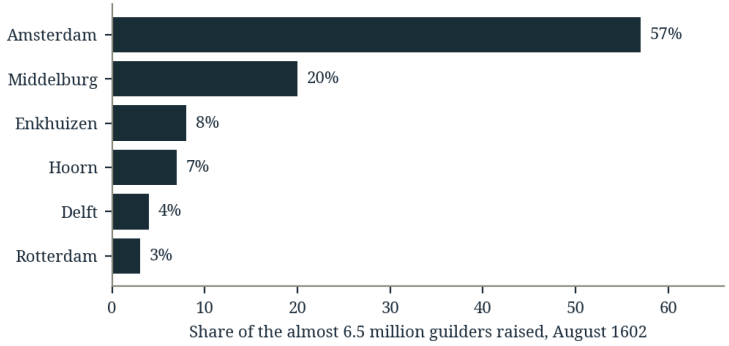


Figure 1. How the almost 6.5 million guilders subscribed in August 1602 were divided among the six chambers of the VOC. Data: worldsfirststockexchange.com (see source companion).

The first investors were not all rich. Part of what made the offering historic was its range, from the directors with their 12,000 guilders to the maid with her hundred. How much of the money came from large investors compared with small ones is a question the surviving ledgers

can answer in detail, and historians have spent careers doing so. For this book, what matters is the principle that anyone could buy, in any amount.

The darker ledger

A study of material industry that stays honest has to say what the VOC was besides a financial innovation. It was a conglomerate that traded spices and other Asian commodities across a wide area centred on what is now Jakarta, and it gained a dominant position in the spice trade by force. The research site that holds the most detailed account of its early shares states plainly that the company committed genocide on the Banda Islands, used forced labour, and actively traded enslaved people. Exchange historians in the Netherlands, who celebrate the VOC's role in the history of the stock market, say in the same breath that its darker side is rightly receiving increasing attention. [8]

This book keeps both facts in view. The first stock market was a way to pool money for a trading enterprise, and some of what the enterprise did was violent. That does not make the invention less real, and the invention does not make the violence less real. A market is a tool, and what it funds depends on who is using it and under what rules.

Inns, Squares and Bills

The Amsterdam ledger did not appear from nothing. Merchants had been meeting to trade promises long before anyone sold a share, and the places where they met left their mark on the language.

The inn that gave a name

The word bourse, used across continental Europe for a stock exchange, is commonly traced to a family. In the Flemish city of Bruges, a house known as Huis ter Beurze belonged to the van der Beurze family, whose coat of arms showed three purses. Foreign merchants gathered near it to trade and to exchange money, and the corner is still known as the Oude Beursplein, the old exchange square. Genoa, Florence and Venice kept permanent commercial houses nearby, called nation houses, a few of which can still be identified in the street today. [9, 10]

A caution belongs here. The story of the purse and the family is repeated in tourist guides, museum pages and encyclopedias, and it is commonly said rather than proven. What is solid is that Bruges was, in the Middle Ages, a centre of financial trade for the Burgundian Netherlands, that the name of the house and the family spread, and that "bourse" came to mean an organised place of exchange. The legend may be tidier than the history. The shape of the institution it points to is real.

Antwerp builds a room

In the sixteenth century the trade moved. Antwerp took over from Bruges as the prime trading centre of the region, and in 1531 the city opened a building made for the purpose: the Handelsbeurs, designed in a Flamboyant Gothic style by the architect Domien de Waghemakere. It

has been described as the world's first purpose-built commodity exchange. Its name borrowed from the inn in Bruges, a reminder that institutions often carry the names of the accidents that preceded them. [11]

The Antwerp bourse was not a stock exchange in the later sense. By the early sixteenth century, merchants were trading less in physical goods and more in notes recording promises from one person to lend money to another, and this is what the new building served. It did not trade shares in permanent companies. But it held the conditions that make an exchange possible: a fixed place, fixed hours, merchants of many nations in one room, and a reputation for trustworthy dealing. The architects of the Royal Exchange in London are said to have drawn on its Flemish style.

The invention of the bill

Behind both inn and building stands a financial device that deserves a paragraph of its own: the bill of exchange. In its medieval form it was an informal letter in which one merchant ordered an agent or banker in another city to pay a sum to a third party there. It let a merchant settle accounts abroad in local currency without carrying coins across borders. The early bill was not a tradable asset. It was held until its due date, because selling it before then meant accepting less than its face value, and a discount of that kind looked too much like the interest that the Church banned as usury. Economic historians date the change to the Low Countries: an Antwerp merchant court ruling in 1506 gave the holder of a commercial bill the right to claim payment, and the earliest known case of discounting a bill, also at Antwerp, falls in 1536. Once a bill could be sold at a discount, the discount became a price, and it depended on how far the buyer trusted the party who would eventually have to pay. Here, before shares, is the basic mechanism of a market: trust turned into a number that moves. [12]

Rice in Osaka

Europe did not have a monopoly on the idea. Across the world, in Tokugawa Japan, the shogunate and local lords collected taxes in rice. Osaka had the largest rice market in the country. Lords stored their rice

in warehouses in the city and sold it at auctions. The winning bidders did not receive rice. They received certificates, each redeemable for a set quantity of rice at the issuer's warehouse before a stated date.

Those certificates traded. Merchants bought and sold them as they would any other asset, and in Dojima, a district of Osaka, a market grew around them. In 1730 the shogunate formally authorised a spot market for rice bills and a futures market for representative brands of rice, an event the Japan Exchange Group's own history marks as the beginning of an official futures market there. [13]

The politics behind that permission are instructive. For years the government had banned trading in rice bills for future delivery, regarding it as gambling that pushed rice prices up. Then, in the late 1720s, rice prices fell to record lows. Samurai, whose income was tied to the value of rice, lost ground to the merchant class, and the authorities, alarmed, eased their stance. A market that had been condemned as speculation was legalised because it was thought it might help hold prices up.

The Dojima story shows something that recurs throughout this book. Governments do not just tolerate or ban markets on principle. They do so according to what the markets seem to be doing to the people whose interests they care about at that moment.

What the old markets had, and what they lacked

Compare these early arrangements with what came next. Bruges had a meeting place and a reputation. Antwerp had a building and set hours. Osaka had standardised certificates and a futures market. What none of them had was a permanent, widely held, freely transferable share in a company meant to outlive its founders, and a daily market in that share. That combination, the exchange as we know it, first appeared in Amsterdam.

The First Continuous Market

Once the VOC's shares existed, they traded. Exchange historians describe the volume as growing rapidly after 1602, and the trading drew on the habits Amsterdam's merchants already had from dealing in goods and bills. The Beurs of Hendrick de Keyser, the first municipal merchants' exchange in the city, was built between 1608 and 1611, though shares changed hands long before and in the surrounding streets as much as in any building. [14, 15]

A bear raid in 1609

The early market quickly produced a story that would be at home in any decade. One of the VOC's original directors and largest shareholders, Isaac Le Maire, was forced to resign in 1605 after accusations of embezzlement. Four years later, in February 1609, he and a group of partners began to speculate against the company, selling shares they did not hold in the expectation that the price would fall, so that they could buy them back cheaper to deliver. [16]

The raid ran for a year. In March 1610 the company surprised the market with a dividend, and the short sellers were squeezed. The episode has fascinated economic historians since the late nineteenth century. It shows that in the first decade of the first stock market, there were already investors betting on a decline, a company that could move the price by announcing a payment, and a conflict between the two that drew the attention of the authorities. Regulation of short selling is a debate with a four-hundred-year history.

A book about confusion

In 1688 a Sephardic writer named Joseph Penso de la Vega, born in Spain around 1650 into a family that had moved to the Netherlands, published in Amsterdam a work called *Confusión de Confusiones*. It is regarded as the first book about the stock trade. He lived in the city until his death in 1692. [17]

The book is written as a series of dialogues among three characters: a merchant, a philosopher and a share trader. The merchant and the philosopher have heard about the trade and sometimes watch the traders on the exchange, but they do not understand it and are afraid to join in. The trader teaches them, and mocks them, and warns them.

One passage stands out for what it shows about the early market. The merchant tells of his first dealing, when he asked what the premium would be for an option to be supplied with a VOC share on a certain day at a certain price. One of the traders answered, he says, that he would not commit himself to a rate but guessed the premium at 20 percent. The merchant offered 15 percent, and the trader accepted, saying he would take the risk as a favour. The merchant was grateful, until the share trader scolded him for being cheated.

The scene tells us several things at once. In 1688 Amsterdam, there was a market in options. Price was a matter of bargaining, with no screen to consult. Newcomers were fleeced by insiders. And someone found the whole spectacle important enough to turn into a dialogue. Researchers writing in a behavioural finance journal have argued that Vega should be treated as a precursor of that field, because the book describes excessive trading, overreaction and underreaction, a reluctance to sell at a loss, herding, overconfidence and regret. The Financial Times included the book in a 1995 list of the ten best books on investment, though the historian who runs the world's-first-stock-exchange research site asks a fair question about whether a seventeenth-century satire can guide a modern investor. [18]

What made Amsterdam work

Amsterdam's exchange rested on a set of ingredients that were each necessary. A large, well-informed merchant community meant plenty of people able to judge a trading company. A long-lived company with transferable shares provided the thing to trade. Custom and the city's authorities provided a rudimentary order. And a deep habit of dealing in paper promises, from bills to forward contracts, meant that the new instrument slotted into a familiar world.

What it did not yet have was the machinery we now take for granted. There was no central counterparty guaranteeing trades, no continuous electronic order book, no regulator publishing rules about disclosure. It ran on reputation, on the courts, and on the willingness of traders to honour their word, backed by the knowledge that a trader who defaulted would not be welcome at the next day's market. That kind of trust works in a small community. It becomes harder to sustain as the market grows, and much of the later history of exchanges is the search for substitutes: rules, clearing houses, surveillance, regulators.

A city in a hurry

It is worth picturing the market itself. Merchants stood in the open air or in covered courtyards. Information arrived by ship, by letter and by word of mouth. Prices were shouted, haggled over and remembered. A rumour about a fleet's safe return or loss could swing a price within hours, because the fleet's fate was the company's profit. There was no press release and no regulator to check whether the rumour was true.

The most useful way to understand the early exchange is as a community that had built a technology out of social habits. That technology could move money across a city in a morning, but it depended on face-to-face dealing, which limited its reach to the people who could stand in the same square. The next three centuries were largely about breaking that limit.

Coffeehouses and Bubbles

London's version of the early market grew in a different setting. Merchants and brokers gathered around the Royal Exchange and in the narrow lanes beside it, and many of their deals were made in coffeehouses, which supplied newspapers, warmth and a room for talk. Jonathan's Coffee House and others became central to the development of what was formally established as the London Stock Exchange in 1801. The Library of Congress guide to Wall Street's history records the sequence plainly: coffeehouses first, an organised exchange later. [19]

The coffeehouse is a good symbol of a market in its second phase. It was more regular than a street but less formal than a hall. Prices were exchanged along with gossip. The rules were whatever the regulars would tolerate. And because the room was open to anyone with the price of a cup of coffee and a bit of money, it let in more of the public than a guild of merchants would have.

The year of three bubbles

By the second decade of the eighteenth century, Europe's powers were racing for control of trade routes and colonies, and wars were expensive. Governments needed money. Joint-stock companies offered a way to convert state debt into company shares and to hand investors a stake in distant profit. Three of these schemes reached their peaks and collapsed within the same period, 1719 to 1720: the French Mississippi Company, the British South Sea Company, and, in the background, the long-established English East India Company, whose share price rose and fell alongside. [20]

The Mississippi Company. The Scottish financier John Law built a structure in Paris in which a trading company with claims on Louisiana absorbed one royal monopoly after another, while a bank he controlled issued notes to finance purchases of its shares. The price signalled optimism. Shares began at around 500 livres in January 1719 and reached about 10,000 livres by December, an increase of some 1,900 percent in under a year, according to the Mississippi Department of Archives and History. Crowds gathered on the Rue Quincampoix, the Paris street where the market operated. Soldiers were sent in at night to maintain order. Buying on credit was rampant, and the word millionaire is said to have been coined to describe those who grew rich on the paper.

The South Sea Company. In London the South Sea Company had been formed in 1711 to take advantage of a government-granted monopoly for trade with Spain's Latin American colonies, which Britain won in the Treaty of Utrecht in the form of the Assiento, a contract for the import of enslaved Africans into Spanish America. The trade it promised never materialised in the amounts imagined. Instead, the company turned increasingly into a financial intermediary, lending to potential buyers of its own stock. In 1720 it took on a large block of government debt in exchange for new shares. Stock was sold to a public that, by one contemporary's account, included nobility, ladies, brokers and footmen scrambling as equals in the alley. More than the available stock was sold, as new money kept coming in.

When the price turned, the damage spread. William Stukeley wrote in September 1720 that the world was in utter distraction and thousands of families ruined. Even the Royal Society lost £600 through a subscription, he wrote.

Newton and the price

The most famous investor associated with the South Sea collapse is Isaac Newton, and the story is usually told as a neat parable about brilliant men and market madness. The historians at the Oxford project on Newton and the Mint are more careful. It is likely, they write, that Newton lost some money, but the evidence is inconclusive. He held a

considerable block of South Sea stock before the bubble, as shown by his instructions to the company to pay him a dividend on 2,500 of South Sea stock in 1713. Whether he sold, bought back in at higher prices and then lost is partly reconstruction. A popular version puts his loss at £20,000, which a financial newspaper converted to millions in modern money. The Oxford historians stop short of such a figure. [21]

The honest conclusion is a modest one. The market in 1720 humbled many people who were not fools, and it is difficult now to be sure how much any individual lost.

What the inquiries found

The South Sea Bubble has often been told as a tale of folly, gambling fever, corruption and the cruelty of capitalism. The reality seems to have been more mixed. Those who profited from the scheme were called vultures in the press. Public outrage forced a parliamentary enquiry, which found evidence of insider trading and bribery. Several company directors were punished. The English East India Company's share price and the French company's price, plotted day by day across the same months from 21 August 1719 to 6 December 1720, show the same arc as the South Sea shares: climb, peak, collapse. A common mood moved prices in three countries at once, which suggests that the market for shares was already an international one, carried by letters, ships and merchants in each capital reading the other's prices. [22]

The lesson the era left behind

The bubbles taught lasting lessons, though not always the intended ones. They led, over time, to the idea that markets need guardrails: disclosure of what a company is and does, limits on lending against a company's own shares, and penalties for insiders who profit from what others do not know. These lessons were learned and unlearned repeatedly. What the eighteenth century left was a vocabulary, an instinct that crowds and credit together can produce dangerous prices, and a body of law that grew slowly in response.

It also left behind something harder to measure: a public that had learned how to buy shares. For the first time, many people outside the merchant class had been through the experience of watching a price move against them. They did not stop investing. They came back, in each generation, with new companies, new rumours and new reasons.

PART TWO: The Room

Twenty-Four Men and a Tree

On the other side of the Atlantic, a new country had a problem. After the Revolution, the United States was deeply in debt, and its first Treasury Secretary, Alexander Hamilton, needed to persuade his colleagues in the first Congress that debt could be a valuable commodity, something that could be bought and sold. His plan to fund the national debt created a large supply of government securities. Securities need a market. Brokers in New York and Philadelphia supplied it.

Philadelphia moved first. In 1790 the brokers there organised themselves as the Board of Brokers of Philadelphia, which became the Philadelphia Stock Exchange. Two years later New York followed. [23]

The agreement

On 17 May 1792, twenty-four stockbrokers signed an agreement outside 68 Wall Street. According to legend, the signing took place under a buttonwood tree where their earliest transactions had occurred. One modern account corrects the picture: the document was named for the brokers' traditional meeting place under the tree, not because it was signed there, and in March 1792 the twenty-four had met in secret at a hotel to discuss how to bring order to the securities business. There were too many brokers to meet under a tree anyway. Business was done in offices and coffeehouses, and by 1793 they had coordinated their trading inside the Tontine Coffee House at the corner of Wall and Water streets. The New York Stock Exchange celebrates that date as its founding. The Buttonwood Agreement is short, and in brief it had two provisions. The brokers would deal only with each other, which cut out the auctioneers, and they would charge commissions of at least a

quarter of one percent. The signers pledged to each other that they would not buy or sell public stock for any person at a lesser rate, and that they would give preference to each other in their negotiations. In other words, it created a club with a rule: members would deal among themselves and would not undercut each other. [24, 25]

That rule, small as it seems, is the template for a very common structure in the history of exchanges. A group of intermediaries bands together, limits access and sets terms, so that those inside can trust each other and share the profits of the business. The arrangement can be defended on the grounds that it makes trading more reliable. It can be attacked on the grounds that it keeps others out and fixes prices for the benefit of members. Both arguments have been made about the New York exchange, and about almost every exchange, for more than two centuries.

The New-York Historical Society's exhibition on the origins of the NYSE emphasises that the agreement regulated aspects of trading rather than merely recording a gathering. Before it, trading had been done on the street and in places like the Tontine Coffee House, an engraving of which from 1796 survives. After it, there was a body with an identity that could outlive any individual broker.

What was traded

In the early years, what traded was mostly government debt and a few bank shares. Company shares in the modern sense, for large industrial corporations, came later. This detail matters because it shows that the New York exchange was born not from industry but from state finance. The nation's first big market asset was the government's own promise to pay.

From club to institution

Between the signing under the tree and the large, ornate exchange building of later decades, the club slowly formalised. It acquired a constitution, rules about who could be a member, rules about disputes, and a space of its own. The membership was limited, and a seat on the

exchange became a valuable thing that could be bought and sold, a feature that remained until the exchange changed its structure in 2006. A seat was both a licence to trade and a share in the club's business.

The lesson for the long story of the exchange is that the institution grew in layers. First there was a habit: brokers meeting in the street. Then a coffeehouse. Then an agreement among a few men. Then a body with rules and a building. Each layer made the market more dependable and, at the same time, made it a thing that could be owned and governed.

Wires

Until the middle of the nineteenth century, a stock price was a local fact. If you stood in the exchange, you knew it. If you were in another town, you waited for a letter, a newspaper or a messenger. That delay was money. A trader who could learn a price early had an edge over everyone who learned it late.

The telegraph removed the delay between cities, but it did not yet solve the problem inside them. A broker's office a few streets from the exchange still needed someone to run back and forth with prices. The solution was a machine.

The ticker

In 1867, a telegrapher named Edward Calahan, working in Manhattan, devised the first stock ticker for the Gold and Stock Telegraph Company. The Library of Congress records a patent of 1868 for what Calahan called an improvement in telegraphic indicators. His own patent text states the need plainly: in most commercial cities there was a want of a cheap and reliable indicator for telegraphing, from the centres of trade to distant business firms, the fluctuations in the prices of gold, stocks and merchandise. Existing machines, he wrote, were costly and difficult to manage. [26]

Thomas Edison did not invent the stock ticker, though he is often credited with it. What he did, according to the Edison papers at Rutgers, was improve it. His Universal Stock Printer of 1871 built on his knowledge of printing telegraphs. His most significant contribution was a mechanism that kept all the tickers on one line synchronised, so that

they printed the same information. Before it, the printers frequently fell behind the transmitter by one or more letters, which was a constant nuisance for the companies that ran the lines. [27]

What the tape did

The effect of the ticker was larger than its mechanism suggests. A ticker was a machine that produced a continuous stream of prices on a paper tape. Anyone with a ticker in a broker's office, hotel or club could watch the market without being in it. Pricing was now almost simultaneous across a city and, through the telegraph lines, across a nation.

This changed three things. It made the exchange's prices public goods of a sort: the quotation on the tape was the price, wherever you read it. It created a market for information as a product, since the exchange and the telegraph companies could now sell the stream. And it widened the community of people able to follow, and to take part. A merchant in a distant city who could read the tape could place an order through his broker and have it executed in minutes.

It also changed what a broker was. A man who had once added value by knowing local people and local news now added value by being connected: to the wire, to the floor, to the customer. The sector began to value speed, and it has done so ever since. A line can be drawn from the ticker to the fibre cable of the twenty-first century, and the story of that line is told in later chapters.

The telephone and the floor

By one account, by 1878 the exchange had installed telephones, which gave investors a direct link to traders on the floor. The floor itself became a theatre. Specialists stood at fixed posts, each responsible for a stock, and brokers moved among them executing orders for clients. Information flowed through shouting, hand signals and paper slips. The visible activity gave exchanges their public image: noise, crowds, men in jackets, a bell at the opening and closing. [28]

The image was deceptive in one respect. The floor was never merely chaotic. It was a highly structured social system with rules about who could speak to whom, how an offer should be made, and what counted

as a deal. The rules had grown by trial and error in dozens of crises, and they carried an enormous amount of tacit knowledge. When the floor was replaced by computers, much of that knowledge had to be written down as code.

Information as an industry

The wire created an industry that has lasted. Today the sale of market data is a large part of the revenue of the world's main exchange operators, a subject taken up in a later chapter. The roots of that business are in the nineteenth-century ticker companies, which sold the right to receive prices and understood that the information was worth more to those who got it first.

The Panic Machine

A market that runs on credit has a weak joint, and the weak joint in early twentieth-century New York was a loan most people never saw.

Call money

Brokers who bought stock for themselves or their clients rarely paid in full. They borrowed. A broker would obtain a loan from a trust company, use the stock as collateral to take a call loan from a bank, and use that money to pay for the shares. A call loan could be recalled at any time, which made it a flexible tool in good times and a trap in bad. The interest rate on these overnight loans, the call money rate, was among the first signals of distress, as the history of the Panic of 1907 shows.

The panic itself began away from the exchange. On 16 October 1907, two speculators, F. Augustus Heinze and Charles W. Morse, suffered large losses in a failed attempt to corner the stock of United Copper, traded on the curb market. Banks tied to them faced runs. The New York Clearing House stepped in, then the run spread to the trust companies. When Knickerbocker Trust suspended payments on 22 October after a run, the annualised call money rate jumped from 9.5 percent to 70 percent, then higher still. Borrowing to buy stock had become punishingly expensive. The financier J. P. Morgan and the Clearing House banks eventually organised support, and the worst passed. [29]

What matters for this book is the chain. A cornering attempt in a copper stock led to bank runs, which led to a squeeze in the short-term loans that support the stock exchange, which led to a general crisis. The stock exchange was not the origin, but it was connected by credit to everything else. The Federal Reserve's own history notes that the crisis

spurred the monetary reform movement that led to the creation of the Federal Reserve System. An exchange cannot be understood apart from the system that finances it.

Boom and wreck

The 1929 crash ended an eight-year bull market fuelled by speculation and stock manipulation, in the words of the Securities and Exchange Commission's historical society. By mid-1932, stocks listed on the New York Stock Exchange had lost 83 percent of their pre-crash value. That number is the one that sticks. It is not a one-day fall, but a slide over almost three years, and it destroyed the trust that earlier decades had built.

The U.S. Senate Banking Committee held hearings to find out how such a thing could happen. They were called the Pecora hearings after the committee's counsel, Ferdinand Pecora, and they captivated the public at the depth of the Depression. The hearings exposed suspicious practices at banks and their affiliates, according to the National Archives, and inspired legislation to clean up Wall Street through tighter regulation.

Two laws and an agency

The Securities Act of 1933, enacted on 27 May, was the first general federal law to regulate the issuance of securities. It required issuers to register offerings and provide a prospectus to investors. It rests on a simple principle that remains the foundation of securities regulation: those who sell securities to the public must tell the truth about them, and must tell it in a standard form that buyers can read.

A second law, in 1934, extended oversight from the issue of securities to their trading, and created the Securities and Exchange Commission. The aims were to supervise the exchanges, to police fraud and manipulation, and to require companies with publicly traded stock to keep disclosing information. An earlier layer of law existed at the state level, starting with the Kansas Securities Act of 1911, and New York's Martin Act of 1921, but the federal laws gave the country a uniform baseline. [30, 31]

Felix Frankfurter, then a Harvard law professor, was brought to Washington to draft the 1933 law with help from James Landis, Benjamin Cohen and Thomas Corcoran. Landis later became chairman of the SEC. The act's drafters wanted to avoid a system in which a government agency judged whether a security was a good investment. They chose a different path: make companies disclose, and let investors decide.

The deal behind the rules

The bargain at the centre of securities law is worth stating because it recurs. In return for access to the public's money, a company accepts a duty to disclose. Investors, in return for protection against fraud, accept that the price can fall. The exchange sits in the middle: it lists companies that meet its standards, runs the market under rules, and supervises its members. That arrangement gave the exchange a second job, beyond matching buyers and sellers. It became a gatekeeper and an enforcer.

Insider trading law, which developed under this framework, shows how rules adapt. In 2000 the SEC adopted rules that addressed the selective disclosure of material non-public information by companies, clarified when trading while in possession of such information creates liability, and described when a breach of a family or other non-business relationship may amount to misappropriation. Regulation FD, as the selective-disclosure rule is known, was a response to the practice of companies telling favoured analysts and investors things before telling the market. [32]

What did not change

The regulation of the 1930s did not end panics. It changed their shape. Crashes continued, from 1987 to the first years of the twenty-first century and beyond, and each exposed a new weak joint. What the law of the 1930s added was a permanent institution with the job of looking for such joints and asking whether more rules could close them. The pattern has been crisis, inquiry, rule, and then a new market that works around the rule until the next crisis.

Many Rooms, One Idea

The history so far has been a story of Amsterdam, London and New York. That is a result of the records, the languages and the habits of historians. The institution grew elsewhere at the same time, and its adoption across the world shows that it is an answer to a general problem rather than a Western accident.

Bombay, under a banyan

In the 1850s, stock trading in Bombay was done informally by a small group of five brokers, four Gujarati and one Parsi, who gathered under a banyan tree in front of the Town Hall. As their number grew they moved, finally settling under banyan trees at the junction of Meadows Street and Esplanade Road. Their crowds clogged the roads. By 1874 they decided to find a building of their own.

In 1875, twenty-five brokers each contributed one rupee to form the Native Share and Stock Brokers' Association. Business started on 9 July 1875 in a trading hall on Dalal Street. Its financing was shaky. According to one retelling, the brokers could not at first afford the monthly rent of a hundred rupees, and Dinshaw Maneckji Petit, founder of the first textile mill in India, came to their rescue. What began as a meeting under a tree became what a business publication calls Asia's oldest stock exchange. [33]

A century later the exchange's neighbourhood name, Dalal Street, became shorthand for the Indian market, much as Wall Street did for New York.

Tokyo and the end of the samurai

When the samurai era ended in 1868, the new government began to pay former warriors a yearly stipend. Soon after, the stipends were replaced with a one-off payment in government bonds. Trading those bonds was a driving force behind the opening of the Tokyo Stock Exchange in Kabutocho in 1878, according to Tokyo's metropolitan government. Kabutocho, the district, is now used as shorthand for Japan's securities industry, in the way Wall Street is for the American one. The exchange began as a market for the debts of a state that had just dismantled its feudal order. [34]

Hong Kong and Shanghai

Hong Kong's first formal exchange was the Association of Stockbrokers in Hong Kong, formed in 1891 and renamed the Hong Kong Stock Exchange in 1914. A second exchange appeared in 1921, and the two merged in 1947. [35]

Shanghai's story has a gap. Securities trading there had a long history, and in 1946 the Shanghai Chinese Security Exchange was renamed the Shanghai Securities Exchange. In 1949 all securities trading venues were closed down. The market was reborn in the 1980s as China's reforms resumed the issuing of treasury bonds in 1981 and stocks and enterprise bonds in 1984 in Shanghai and other regions. The modern Shanghai Stock Exchange was established on 26 November 1990 and started formal operation on 19 December of the same year. The People's Bank of China, according to a history from Goldman Sachs, authorised the exchange as the lack of securities laws had greatly limited the size of stock and bond markets. [36]

Chicago: the market for what has not been grown

Not every exchange trades shares. The Chicago Board of Trade was founded on 3 April 1848 as a cash market for grain, and forward or "to-arrive" contracts began trading there almost immediately. In 1858 standard terms were created for forward contracts. In 1859 the Illinois legislature chartered the exchange with self-regulatory authority over

its members, standard grades of grain, and inspectors whose decisions were binding. The exchange introduced standardised futures contracts in 1865, centrally cleared and secured by the payment of margin. [37]

A central grain exchange allowed farmers and grain producers to sell their crops at set prices through the months between harvests, and let buyers purchase at transparent prices through the year. The idea is the same as Osaka's rice bills, rediscovered independently in a different continent: if the thing you depend on varies in price, you will pay to know the price in advance.

Futures belong in a book about stock exchanges because the two grew together, and because today the biggest exchange operators run both. The mechanics of margin and central clearing, which began with grain in Chicago, are the same ones that protect trades in shares.

An exchange built in code: India's NSE

The National Stock Exchange of India was incorporated in 1992, was recognised as a stock exchange by the securities regulator SEBI in April 1993, and began operations in 1994 with a wholesale debt market, followed shortly by a cash market. It started with electronic, screen-based trading in place of the open outcry that had been usual. Because it was electronic from the start, participants anywhere in the country could see a single order book and trade in real time. [38]

NSE's choice is one of the cleanest examples of how a late starter can leapfrog. It did not have to retire a trading floor. Today the scale of that bet is visible in the World Federation of Exchanges' 2024 report. It calls stock index options by far the most traded category of derivatives contract and says 97.7 percent of that trading takes place on NSE. The same exchange accounts for 94.5 percent of the currency options market. In the same report the CME Group, the heir of the Chicago exchanges, holds 60.6 percent of global interest rate options volume.

What the cases share

Looking across these exchanges, a pattern is clear. Each began with brokers meeting in the open air or in a coffeehouse, usually after a state had issued debt. Each moved indoors when the crowd grew too large.

Each acquired a rulebook. And each, at a certain moment, was tied to a government's need: for funding, for modernisation, for controlling the price of a staple. The idea turns up wherever people have savings, a need for capital, and a reason to trade. The differences lie in the details of law, culture and timing, not in the basic design.

PART THREE: How a Trade Works

Anatomy of an Order

Strip away the floor, the ticker and the screens, and the exchange's central job is simple to state. It collects offers to buy and offers to sell, and it pairs them off by a rule that everyone agrees to in advance. The rule is the product.

The book

An investor who wants to buy a share sends an order through a broker. The broker routes it to an exchange. At the exchange, the order enters the order book, a list of every standing offer for that share. On one side are bids, the prices at which people will buy. On the other are asks, the prices at which people will sell. The best bid is the highest price a buyer will pay, and the best ask is the lowest price a seller will take. The gap between them is the spread.

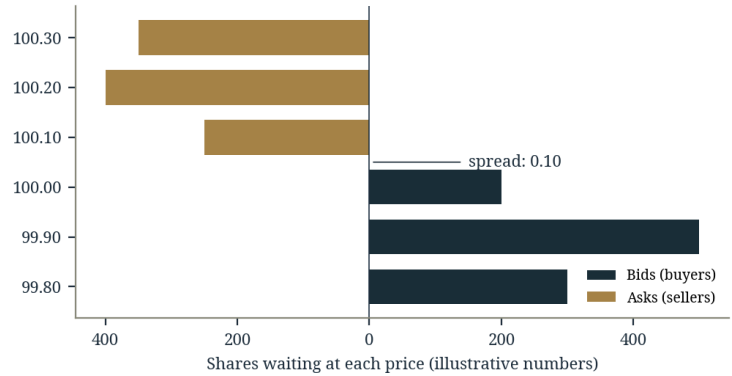


Figure 2. An order book with made-up prices, to show how bids, asks and the spread relate. Illustration only; not a record of any stock.

The figure above uses made-up prices to show a book in the simplest case. It is an illustration of the mechanism, not a record of any stock. A buyer who wants shares now, and is willing to pay the best ask, can take that offer immediately, and a trade occurs. This is a market order, and it buys certainty of execution at the cost of accepting whatever price is on offer. A buyer who is only willing to pay a lower price places a limit order, which joins the bid side of the book and waits. It may fill if sellers come down to the price, or it may never fill.

Price first, then time

When more than one order sits at the same price, the exchange needs a tie-break. The usual rule, used by exchanges in many countries, is price-time priority. Higher-priced buy orders are served ahead of lower-priced ones. Lower-priced sell orders go ahead of higher-priced ones. Orders at the same price are served in the order they arrived. Taiwan's futures exchange states the rule in these terms in its published matching principles, and the same logic runs through most order books. [39]

The rule has a quiet consequence. Because earlier orders at the same price get served first, being early is valuable. That makes speed a source of advantage, and an entire industry later grew out of that fact. The fairness of time priority can be defended: the first person in the queue gets served first. It is also an incentive to compete on milliseconds, as a later chapter shows.

The auction at the open and the close

Continuous matching is only half of the day. Many exchanges open and close the market with an auction. Taiwan's exchange, for example, uses call-auction matching at the open and continuous matching during the trading hours. Deutsche Börse's market model describes its opening auction as having a call phase, a price determination phase and an order-book balancing phase, run before continuous trading. All executable orders that are valid are matched in the opening auction, so that the book does not open crossed, which is the state where some buy orders are priced at or above some sell orders without having traded. [40]

An auction exists because the market's first and last prices are special. Overnight, news accumulates. A fund that tracks an index wants to trade at the closing price, because that is the price the index uses. An auction gathers all the interest into one moment and finds the single price at which the most volume can be done, rather than letting prices wander as individual orders trickle in.

The middleman who stays

Not every buyer meets a seller at the same moment. Someone has to stand ready to do the other side. That someone is a market maker, a firm or individual that continuously quotes both a bid and an ask and earns the spread between them. At the New York Stock Exchange the role was long held by specialists, members assigned to a stock who stood at a post on the floor and were responsible for keeping its market orderly. The exchange now uses designated market makers, a role with similar duties performed with much more technology. [41]

Market makers take risk. If they buy from a seller and the price falls before they can sell to a buyer, they lose. The spread pays them for that risk and for the capital they tie up. When spreads narrow, the cost to ordinary investors falls, and the market makers' margin shrinks with it.

What happened when the fractions went

For most of the twentieth century, American stock prices were quoted in fractions, down to sixteenths of a dollar. A sixteenth is 6.25 cents, so the smallest possible spread on a stock was large. In April 2001 the U.S. markets finished the move to decimals, pricing shares in dollars and cents like almost everything else in the economy. On the first Monday that all Nasdaq stocks traded in cents rather than fractions, according to a market research firm cited at the time, the spread on a sample of twenty-five stocks narrowed by an average of 63 percent compared with the previous five trading days. [42, 43]

The regulators who pushed the change hoped for lower trading costs, and in the narrow sense of the quoted spread, they got them. A narrower spread has a second effect, which is arithmetic rather than reported: the people who make markets earn less per share, which

pushes them toward higher volume, faster systems and different strategies. The change mattered, therefore, well beyond its effect on prices. It changed the economics of the whole business of standing between buyers and sellers.

One stock, many prices

Almost all of this describes one exchange's order book. In practice, a stock may trade on several. In the United States, the Securities and Exchange Commission's 2005 Regulation NMS, the rule set for the national market system, contained among its provisions an order protection rule, which seeks to ensure that a trade is not executed at a worse price on one venue when a better price is displayed on another. The SEC's own staff memo on the rule acknowledges the reason: where a stock trades in more than one place, order flow is dispersed, and without effective linkages the fragmentation of order flow can complicate brokers' efforts to obtain the best execution of investor orders. The next part of this book returns to the consequences. [44]

After the Trade

A trade on the exchange is a promise. It becomes a fact only when the buyer's money has gone to the seller and the seller's shares have gone to the buyer. The steps between are called clearing and settlement, and they are where the exchange's reliability is actually decided.

Why it matters

In the early exchanges, a failed trade was a problem for the two parties and their reputations. Today, millions of trades occur daily among firms that do not know each other and may never deal again. If one of them fails to deliver, the other has to be protected, or the market's trust breaks. The solution that grew up over the twentieth century is a clearing house that stands in the middle of every trade.

The central counterparty

In the United States, the National Securities Clearing Corporation, NSCC, a subsidiary of the Depository Trust & Clearing Corporation, DTCC, serves as the central counterparty for the clearance and settlement of virtually all broker-to-broker trades in equities, corporate bonds, municipal bonds and unit investment trusts. The legal device behind it is called novation: once a trade is matched, the clearing house becomes the buyer to every seller and the seller to every buyer. A buyer no longer relies on the particular seller on the other side. He relies on the clearing house, which is backed by the margin and the clearing fund contributed by its members. [45, 46]

DTCC describes its netting engine, called Continuous Net Settlement, as one that nets eligible transactions into a single daily position per security and member. A firm that bought a million shares of a stock in one set of trades and sold 900,000 in another, on the same day, does not need to deliver 900,000 and receive a million. It needs to receive 100,000. Netting reduces the volume of deliveries that actually have to happen. Without it, the world's securities markets would drown in their own paperwork.

DTCC's depository subsidiary, the Depository Trust Company or DTC, holds the securities and transfers them electronically from the selling firm's account to NSCC's account, and from NSCC's account to the buying firm's account. A registered clearing agency, a New York limited-purpose trust company and a member of the Federal Reserve System, DTC was designated in 2012 as a systemically important financial market utility. DTCC itself is described as a user-owned cooperative, which means that the firms that rely on it also own it. [47]

The days between

Until recently, the process took time. A trade made on a Monday settled on a Wednesday, a cycle written as T+2: trade date plus two business days. The delay existed for historical reasons, and it created risk. Between the trade and the settlement, the price could move, a firm could fail, and both sides were exposed.

On 28 May 2024 the United States moved to T+1 for cash equities, corporate debt and unit investment trusts. The SEC had announced the date in February 2023. DTCC reported that, after the transition, clearing fund requirements fell by 3.7 billion dollars compared with the previous quarter's average, and that same-day affirmation rates had risen by 30 percent in preparation. [48]

The numbers show why shortening the cycle is worth the work. The clearing fund exists to cover the risk that members fail during the settlement period. A shorter period means less risk, so less margin is needed, so firms can use their capital elsewhere. It also illustrates the cost: shortening the cycle compresses the time in which firms,

particularly those in other time zones, must match and finance trades. Operationally, the change is huge, which is why exchanges and clearing houses spent years preparing.

The thing no one sees

The post-trade system is quiet infrastructure. When it works, no one notices. Its weaknesses show up in a crisis. The 1987 crash revealed that stock, options and futures markets used different timelines for clearing and settlement, creating the potential for negative cash positions. The 2021 meme-stock episode, discussed in a later chapter, showed that a clearing house's margin demands can be the pressure that forces a broker to restrict customers' trading. [49]

Clearing houses, then, are the centre of an exchange's resilience. They are also a point of concentration. When a single entity becomes the counterparty to nearly every trade in a market, its failure could not be tolerated, and so its risk management is a matter of public policy. The regulators' designation of DTC as systemically important reflects that.

Safekeeping and the end of paper

For most of the twentieth century, a share was a certificate. The certificate had to be physically moved to complete a sale, which is why back offices sprawled and why the paperwork crisis of the late 1960s, which the SEC's historians call the back office crisis, hit the industry so hard. The depository model changed that: instead of moving certificates, the depository holds them and records changes of ownership electronically. Today, most investors never see a certificate and hold their shares through a broker in what the industry calls street name. [50]

The next stage is a fuller dematerialisation, often discussed as tokenization: representing the claim on a blockchain-style ledger so that settlement could in principle be instant. In December 2025 the SEC staff issued a no-action letter allowing DTC to offer a service to tokenize real-world assets that it holds in custody, in a controlled production environment. That is a limited and cautious step, and a later chapter returns to what it might mean. [51]

The Rules of the Room

An exchange makes two sets of rules. One governs how trades are done. The other governs who can be in the market, in what condition, and what they must tell the public. Both are part of what the exchange sells.

The listing

A company that wants its shares to trade on an exchange applies to be listed. The exchange sets conditions: a minimum size or profit history, a minimum number of public shareholders, corporate governance standards, and a duty to file regular reports. In return the company gets access to the exchange's pool of investors and a visible stamp of seriousness.

Listing is a source of revenue for the exchange and a source of competition between exchanges. Companies choose where to list, and each exchange markets itself on liquidity, the profile of the investors who trade there, the prestige of the name, and the fees. The leading American exchanges compete directly for the biggest initial public offerings.

The World Federation of Exchanges' figures show how this plays out in numbers. At the end of 2024, Nasdaq's U.S. market had 3,289 listed companies, of which 864 were foreign, and the NYSE had 2,132, of which 548 were foreign. The foreign listings are a measure of the pull of the American venues on companies from elsewhere. [52]

The initial public offering

The VOC's subscription in August 1602 was the world's first widely recognised initial public offering. Its modern descendant has a script. A company hires investment banks, which prepare a prospectus, test demand with institutional investors in what is called a roadshow, and set a price. The shares are allocated and then begin trading on the exchange. The exchange's role is to host the first trade and keep the market after it.

Global figures show the cycle. According to the World Federation of Exchanges, markets welcomed 1,133 IPOs in 2024, the lowest in the five-year period it reported, with the Americas up 52.4 percent from 2023 and Asia-Pacific and EMEA at their lowest levels. The consultancy EY, counting somewhat differently, put 2024 at 1,215 deals raising 121.2 billion dollars, down 10 percent in volume and 4 percent in proceeds, and reported that India had, for the first time, risen to first place globally by deal count. The two sources differ because they define an IPO differently and cover different periods, a reminder that exchange statistics are never as tidy as they look. [53]

Honest information

The most important rule in the room is that the information on which prices rest should be honest and shared. The principle has legal expression in the 1933 and 1934 laws described earlier, and in rules adopted since. Insider trading, meaning trading on material non-public information in breach of a duty, is prohibited. Selective disclosure, where a company tells some investors before others, is barred in the United States by Regulation FD. Exchanges themselves run surveillance: software that watches for patterns, such as a trader building a position just before a company announcement. [54]

The reasons for the rule are both moral and practical. Morally, it is unfair when a person can profit because of a position that others cannot reach. Practically, if investors believe that insiders always win, they stay out, and the market becomes thinner and the cost of capital goes up. The exchange's credibility is the sum of the market's trust in the rules and in their enforcement.

The brakes

A market that can fall fast needs ways to slow down. After the 1987 crash, in October 1988, the U.S. adopted market-wide circuit breakers: halts in trading across all exchange-listed securities when a broad index falls by a defined amount. After the May 2010 flash crash, discussed later, the SEC approved single-stock circuit breakers on a pilot basis. Those had a flaw: they triggered after a trade had occurred at or outside a threshold, so erroneous trades could themselves trip them. [55]

In May 2012 the SEC approved a replacement, the limit up-limit down mechanism. Instead of reacting after a bad trade, it prevents trades in individual stocks from occurring outside a price band set at a percentage above and below the stock's recent average price. It also updated the market-wide breakers. The change illustrates the pattern of exchange rulemaking. Each rule is a reaction to a particular failure, designed to prevent that failure, and it shapes the next.

The paradox of rules

A rule is a promise about how the market will behave, but it is also a map for those who want to exploit it. A price band can be used by a trader who knows the band will stop a fall, and can therefore trade more aggressively until it does. A rule requiring best execution across venues pushes brokers to connect to every venue, which makes speed more valuable. Exchange rulebooks are long because every rule creates a new edge case.

The better rulebooks are written with that in mind. They try to state purposes as well as procedures, and they rely on supervision by people who can make judgments about conduct that rules do not cover. That is why a stock exchange is also a regulator in the original sense of the word. It is not only a market but a self-governing institution, whatever the law above it says.

PART FOUR: The Idea of a Price

What a Price Knows

An exchange produces a number. The question that kept economists busy for a century is what that number means.

Bachelier's drunkard

In 1900 a French mathematician named Louis Bachelier submitted a doctoral thesis at the Sorbonne called *Théorie de la spéculation*. It argued that the mathematics of chance could describe how prices on the Paris Bourse moved. In its opening paragraph, as one economics paper later quoted him, Bachelier recognised that past, present and even discounted future events are reflected in market price, but often show no apparent relation to price changes. If the market does not predict its fluctuations, he wrote, it does assess them as more or less likely, and that likelihood can be evaluated mathematically.

He developed the mathematics of what is now called Brownian motion five years before Einstein, and concluded that the mathematical expectation of the speculator is zero. The thesis was ignored for decades. It is now treated as the origin of the modern mathematics of finance.

An earlier hint came in 1889, from George Gibson's book The Stock Markets of London, Paris and New York. Gibson wrote that when “shares become publicly known in an open market, the value which they acquire may be regarded as the judgment of the best intelligence concerning them.” A price, in this view, is a collective opinion with money behind it. [56]

Risk as something you can arrange

The next leap came in the 1950s and 1960s. The Nobel Prize committee describes the work in three stages. First, Harry Markowitz developed a theory of how households and firms should allocate their financial assets under uncertainty, called the theory of portfolio choice. It analyses how wealth can be placed across assets in the way that best trades off expected return against risk. A central lesson is that what matters is not each asset's risk alone but how the assets move together, which is why a mix can be safer than its parts.

Second, William Sharpe, using Markowitz's theory as a base, developed a theory of price formation for financial assets, the Capital Asset Pricing Model, which relates an asset's expected return to its sensitivity to the market as a whole. The committee honoured Markowitz, Sharpe and Merton Miller together in 1990. [57]

These theories gave investors and exchanges a vocabulary. Risk could be measured. Diversification could be justified mathematically. A portfolio of many stocks could be treated as a single object with a profile of its own. The index, the benchmark and the fund that tracks it all depend on this way of thinking.

The efficient market

In the 1960s, Eugene Fama and collaborators showed that stock prices are extremely difficult to predict in the short run and that new information is very quickly incorporated into prices, in the Nobel committee's summary of the work. The finding became known as the efficient market hypothesis. Its meaning is more modest than its name suggests. It does not say prices are always correct. It says that if prices already reflect available information, then no simple method of reading past prices will reliably beat the market. [58]

A very different finding came from Robert Shiller, who in the early 1980s showed that stock prices fluctuate much more than corporate dividends, and that the ratio of prices to dividends helps forecast returns over long periods. The committee, in awarding the 2013 prize jointly to Fama, Shiller and Lars Peter Hansen, put the apparent

contradiction crisply: there is no way to predict the price of stocks and bonds over the next few days or weeks, but it is quite possible to foresee the broad course of these prices over longer periods, such as the next three to five years. [59]

Both are found in the same market. Day to day, prices behave as if the crowd has already priced in what anyone can know. Over years, they swing with moods that the fundamentals do not explain. The exchange is where both facts show up.

The option formula

In 1973 Fischer Black and Myron Scholes published a formula for pricing stock options, and Robert Merton, working on the same problem, extended it. Merton and Scholes received the 1997 Nobel Prize for the work, with the committee noting that Black, who had died in 1995, would have shared in it. The formula showed that an option's value could be derived from the price of the underlying stock, its volatility, the time to expiry and the interest rate, without needing to know whether the stock would rise or fall. [60]

The significance for exchanges was practical. A formula for pricing options made it possible to trade them in standardised form, at scale, and to hedge their risk. The committee's description is that markets for options and other so-called derivatives redistribute risks toward those agents who are willing and able to assume them. A farmer worried about prices, a company worried about exchange rates and a pension fund worried about a crash can each buy protection from someone who wants to sell it. De la Vega's seventeenth-century merchant, bargaining over a premium of 15 or 20 percent, was doing by feel what the formula now does by calculation.

The index fund: a bet on the theory

Theory became a product on 31 August 1976, when John Bogle launched what is now the Vanguard 500 Index Fund, originally called First Index Investment Trust. It gave individual investors access to a strategy previously available mainly to institutions: owning the whole market at low cost rather than trying to beat it. The idea that passive management

could outperform most active managers was greeted with ridicule at the time, and the fund was referred to as Bogle's Folly. Vanguard's own history records that Bogle held the belief that most investors are better served by owning the whole stock market, at low cost, than by trying to beat it. [61]

Indexing now dominates a large part of equity investing. Its effect on exchanges is considerable. Many index-tracking funds aim to trade at closing prices, which is one reason the closing auction matters so much. They need a stock's price to be set by someone else's research, which links them to the active investors whose efforts keep prices informative. If everyone indexed, nobody would do the research that makes a price meaningful. An exchange's price has value only because some people still disagree.

The limit of the theory

The theories have a common feature. They treat the price as the output of a process that can be described, and they tell investors what to do with it. They do not tell an exchange how to run a market, and they do not guarantee that markets behave. The seventeenth-century dialogue in Amsterdam and the 2010 flash crash both involved people reacting to prices in ways no theory fully predicted.

Researchers who have drawn lines from de la Vega to modern behavioural finance argue that the book already described excessive trading, overreaction, herding, overconfidence and regret. What the twentieth-century theory added was a way to measure these things. It is better to see the economist and the trader as working on the same problem, one with equations and one with experience: what does a crowd of buyers and sellers know that none of them knows alone?

A Number for the Whole Room

A stock exchange lists thousands of prices. People want one number. The index is the answer, and its history is shorter and stranger than most people assume.

Charles Dow's peg

Charles Dow began calculating a daily average of twelve major industrial stocks in May 1896, as a companion to the transportation average he had introduced in 1884. He used the two together to watch broad market trends. Eight stocks were added in 1916 and ten more in 1928, bringing the total to thirty, where it remains. [62]

S&P Dow Jones Indices preserves a passage in which Dow explains the idea with a picture from the shore. A person watching the tide come in, who wants to know where the high tide stops, sets a stick in the sand at the point each wave reaches, until the stick sits where the waves no longer come, and the water recedes enough to show that the tide has turned. The average of stock prices, Dow says, is the peg which marks the height of the waves. [63]

The image is worth keeping in mind, because it describes what an index is for. It does not say what any one company is worth. It tells you which way the water is moving.

The weighting problem

The Dow's method has a quirk that surprises newcomers. It is a price-weighted average, so a stock with a high share price moves it more than a stock with a low one, whatever the companies' sizes. That was a

sensible shortcut when the arithmetic was done by hand. It is an odd choice for a benchmark that now stands in for the market.

Standard & Poor's got into the index business in the 1920s with its own composite indexes. On 4 March 1957 it launched the S&P 500, and on the following day the New York Times announced that it would publish the new index in its table of market averages. S&P's methodology weights the S&P 500 by float-adjusted market capitalisation, meaning the value of the shares available to public investors, so a larger company counts for more. S&P describes it as a proxy for the U.S. equity market. [64, 65]

How an index became a product

The index was first a thermometer. It became a thing you could buy. Bogle's fund in 1976, described earlier, gave individuals a way to hold an index. In 1982, as the next chapters describe, futures on stock indexes let institutions trade the index itself. Exchange-traded funds later put an index into a ticker symbol. Each step turned a measurement into a product, and each gave the index owner a licensing business: the company that owns the name earns a fee from every fund that tracks it.

This is a quiet source of power. The decision to add a company to a widely tracked index forces funds holding trillions of dollars to buy it, and the decision to remove one forces them to sell. The rules for who gets in are therefore a form of governance. They are set by committees at index companies, not by regulators or exchanges.

The index and the exchange

Index and exchange are separate businesses, but each feeds the other. The exchange supplies the prices from which an index is calculated and the market in which funds trade. The index supplies a benchmark that concentrates investor attention on certain stocks, which raises their trading volume. A company that joins an index gets more trading in its shares and more visibility, a benefit that listing venues take into account when competing for companies.

Closing prices are central. Because indexes are calculated from them, many funds that track an index aim to trade at the close, and exchanges compete to run the most credible closing auctions. The two ends of the

trading day, with their auctions, are where the index and the exchange most visibly meet.

Two Peaks, Remembered

A market can fall and then stay down for a very long time, and the clearest examples sit at opposite ends of the world.

Tokyo, 1989

On 29 December 1989, the last trading day of the year, Japan's Nikkei 225 index closed at 38,915.87, a record. The decade's boom in Japanese shares and property ended there. The index did not close above that level again for more than three decades. It finally did so on 22 February 2024, when it rose 836.52 points to close at 39,098.68, clearing 39,000 for the first time. It had taken 34 years and 2 months, according to Japan's Nippon.com data service. [66, 67]

The recovery had causes the sources identify. In 2013 the Bank of Japan's governor announced monetary easing on an unprecedented scale and the bank began buying large quantities of Japanese government bonds. By 2024, Reuters reported, cheap valuations and corporate reforms were attracting foreign money, at a time when investors were looking for alternatives to battered Chinese markets.

The Tokyo story is a useful correction to a comfortable belief: that stock markets always come back soon. They come back, and they take their time. An investor who bought the whole market at the peak, in 1989, had to wait until 2024 to be level on price. That is a statement about the index's price level, not about total returns including dividends, which the sources do not give.

Nasdaq, 2000

The dot-com bubble developed during the late 1990s and peaked on 10 March 2000, as the World Wide Web spread and investors bid up internet companies. The Nasdaq Composite closed that day at a record 5,048.62. After that it fell, by about 78 percent (1,114.11 is 22 percent of 5,048.62), to a low of 1,114.11 on 9 October 2002, as the Wall Street Journal recorded in 2015 when the index crossed 5,000 again, fifteen years after the peak. [68]

Between those two dates, the Journal noted, the iPod was introduced and the road back began. The index took fifteen years to return to its peak, though many of the companies that had led the boom had disappeared along the way, and some of those that survived grew far beyond anything the bubble's promoters had imagined. The bubble was in the prices and the promises, not in the underlying idea that the internet would change commerce.

What the two have in common

The two episodes share a pattern with the Mississippi and South Sea shares described earlier. A real change, here the rise of Japanese industry and the arrival of the internet, was priced as if it were certain and immediate. When the price outran what the businesses could earn, it fell, and the fall was larger and longer than most participants expected.

They also illustrate the two views of the market in the Nobel committee's 2013 summary. Day to day, nobody could predict the price. Over years, as Shiller found, prices swung far more than dividends justified, and the swing could be partly foreseen from valuations. The exchange makes both facts visible at once.

What the exchange did, and did not do

An exchange does not cause a bubble and cannot end one. In both 1989 and 2000 the exchanges worked as designed: they matched orders, published prices and settled trades. What they could not do, and were not built to do, was judge whether the price was right. That judgement belongs to the people trading. The exchange's contribution in a boom is

to make it easy to join, and in a bust to make it possible to leave. The second matters more than it sounds, because a market that stays open while prices fall lets people sell at a loss and move on. Markets that close, as the Chinese exchanges did after 1949, take that choice away.

PART FIVE: The Machine

The Screen

By the 1960s, the biggest over-the-counter market in the United States had no floor at all. About five thousand firms belonged to the National Association of Securities Dealers, two thirds of them working solely in the over-the-counter market. It was, as the SEC's historians put it, a virtual market from the start: no floor, no board, just an invisible network of broker-dealers linked by telephone and the daily printed lists known as the pink sheets, in which retail investors could find representative prices in their newspapers.

The pink sheets were the problem. They had to be compiled and printed, which meant they were out of date by the time anyone read them.

Nasdaq

In 1971, at the urging of the SEC, the NASD built an automated quotation system. It was called NASDAQ, short for NASD Automated Quotations, and it started in February of that year. Nasdaq marked the 50th anniversary of that launch in February 2021 and describes it as the moment computers entered the market and quote data began to be shared more widely. At first it was only a quotation system, not a trading system. Pushback from smaller brokers worried about narrowing spreads, and from NYSE members worried about losing business on the floor, meant it had no retail interface and listed no NYSE stocks.

It grew steadily. By 1980, Nasdaq was handling 63 percent of the volume of the NYSE, though the NYSE's own Rule 394 kept NYSE-listed blue chips off it. In 1984, sixteen years after the Pacific Coast Exchange introduced an earlier automated system, Nasdaq finally offered electronic

execution through its Small Order Execution System, SOES, which let market makers trade twenty-five issues in volumes under a thousand shares. It took a financial calamity for the system to be tested. [69]

1987

On Monday 19 October 1987, the Dow Jones Industrial Average fell 22.6 percent in a single session, the largest one-day percentage decline in its history, according to the Federal Reserve's account. The slide began before that day. Between 13 and 19 October the Dow fell 31 percent, and nearly one trillion dollars of shareholder value vanished, as the SEC's historians count it. Before U.S. markets opened that Monday, stock markets in and around Asia were already falling. In the most severe case, New Zealand's stock market fell by 60 percent.

Regulators and economists identified several causes. International investors had become active in the preceding years. A new product known as portfolio insurance, a strategy of selling index futures as prices fell to limit losses, may have amplified selling. The strategy was developed by Mark Rubinstein and Hayne Leland in 1976. And the structure of the markets had flaws. Stock, options and futures markets used different timelines for clearing and settlement. Price discovery was happening in the futures pits rather than among equity market makers and specialists, according to the SEC's report on the market break. [70]

The Nasdaq part of the story is vivid. SOES had been voluntary. When prices began to plunge, market makers pulled out. The system lagged behind constantly changing orders, so quotes became locked or crossed. More broadly, there was a perception afterwards that computerisation had protected institutions while hurting retail investors, because trading volume swamped the humans: market makers stopped answering the phone and specialists were overwhelmed. Day traders nicknamed SOES Bandits learned to exploit the system by buying or selling ahead of market makers who were slow to update their prices. In 1990, Nasdaq introduced an improved execution system called SelectNet.

The electronic communication networks

The next stage was a set of private electronic markets that matched orders without a floor or a dealer. Archipelago, one of the first, was founded in 1996. In 2002 Archipelago and the Pacific Exchange created ArcaEx, the first open, all-electronic exchange. It went public in 2004 and was within a year trading 700 million shares a day, according to the SEC historical society.

The exchanges' reaction shows how fast the ground shifted. In April 2005 the NYSE announced a merger with ArcaEx. Two days later, Nasdaq announced it would buy Instinet, another electronic-trading pioneer. In March 2006, as part of the purchase of ArcaEx, the NYSE ceased to be a member-owned club and became a public company. After more than two centuries as a mutual organisation of seat holders, one of the world's oldest financial institutions was a for-profit corporation whose shares themselves traded on the exchange it ran. [71]

Why exchanges changed their ownership

The trend toward demutualisation was not unique to New York. The International Organization of Securities Commissions notes in a paper that traditionally stock exchanges have been non-profit mutual or membership organisations, in which members who trade control the exchange. The model has been changing. The reasons are not mysterious. An exchange owned by its trading members has an incentive to protect the members' business, including their commissions and floor jobs, even when technology makes that business obsolete. An exchange owned by outside shareholders is free to invest in technology that undercuts members, and to compete across borders. [72]

Fragmentation

At the same time, regulation pulled in the same direction. Regulation NMS, adopted by the SEC in 2005, included an order protection rule and rules on market data, with the aim of linking the competing markets. The result was a national market made up of many venues: the exchanges themselves, several owned by the same operators, plus alternative trading systems. The SEC staff acknowledged the trade-off in

a memo. Where a stock trades on many venues, order flow is dispersed, and fragmentation can complicate brokers' efforts to obtain best execution unless the venues are well linked. [73]

The consequence is that the "stock exchange" of the twenty-first century is less a single place than a network, bound by rules about prices, data and routing. The old NYSE floor still exists as a place and a ceremony. Most trading happens elsewhere, in data centers, between machines.

Screens Across the Channel

Europe's exchanges followed a different route to the same machine. Two events frame it: a London morning in 1986 and a merger in 2000.

The morning of 27 October 1986

In the late 1970s the London Stock Exchange came under pressure to reform its structure and practices. In 1986 it changed its rules in ways that, taken together, were called Big Bang, a name that referred to the immediate increase in market activity that the changes were expected to generate. The Exchange's own account puts the date at 27 October 1986, and describes a single day on which trading floors gave way to screens. [74]

The reforms included several things at once. Minimum fixed commission rates were replaced by negotiated rates. Banks and other financial institutions were allowed to join the Exchange and to run broking firms, and many existing firms were bought by UK and overseas banks. All firms became broker-dealers, able to act as agents or to register as market makers buying and selling for their own account. A Bank of England bulletin of 1987 traces the package to a July 1983 agreement between the Exchange and the government, in return for which a case against the Exchange in the Restrictive Practices Court had been withdrawn.

Electronic trading ran on a new computer system that at first operated alongside the floor. The system turned out so successful that, according to the British tax authority's background note, trading on the floor was abandoned after a few weeks.

Look at what changed. Fixed commissions were a cartel, much like the quarter-percent rule of the Buttonwood Agreement two centuries earlier. Restrictions on who could be a member kept the club small. Big Bang opened the club, ended the fixed price and moved the market to screens in the same stroke. In New York the same changes arrived in pieces over decades. In London they arrived in a day, under legal pressure from the government.

A cross-border exchange

Continental Europe had its own history. Euronext traces its origins to the first bourses of Bruges, Antwerp and Amsterdam, which it dates to 1285, 1485 and 1602, and to the Paris Bourse of 1724. The first date, as earlier pages said, is a matter of tradition rather than hard evidence.

On 22 September 2000, the exchanges of Amsterdam, Brussels and Paris combined to create Euronext, described as the first genuinely cross-border exchange in Europe. It used a federal model with unified rules and a single order book on the same electronic trading platform. In 2007 Euronext signed an agreement to merge with the New York Stock Exchange; after the Intercontinental Exchange acquired NYSE Euronext in November 2013, ICE spun off the continental operations, which listed publicly as an independent Euronext in 2014. [75]

It is a long way from the Beurs of Amsterdam to a company whose shares trade on the exchange that it operates. The same city that hosted the first share sale in 1602 now hosts one market of a continental exchange group listing over 1,800 issuers.

Why Europe's story matters

The European path differs from the American one in an instructive way. Europe had many national exchanges, each tied to a state, and consolidation had to cross borders, currencies and legal systems. The United States had one federal securities regulator and a single currency but many competing venues. Europe's exchanges merged; America's multiplied. Each outcome is a response to a different starting position,

and each has costs. The merged exchange gets scale and a single rulebook but concentrates risk. The fragmented one gets competition but pays for it in complexity.

Milliseconds

When trading moved to machines, the competition that had always existed among brokers, to be first with the information and the order, moved to a new time scale. It also found a new machine to run on.

A straight line

In 2010, a company called Spread Networks finished building a fibre-optic cable between the financial markets of New York and Chicago. Earlier connections between the two centres zigzagged along railroad tracks and around mountains. The new cable was dug in a nearly straight line. Construction costs were estimated at 300 million dollars. The payoff, according to the economists who studied it, was that the round-trip communication time between the two cities fell from about 16 milliseconds to 13. [76]

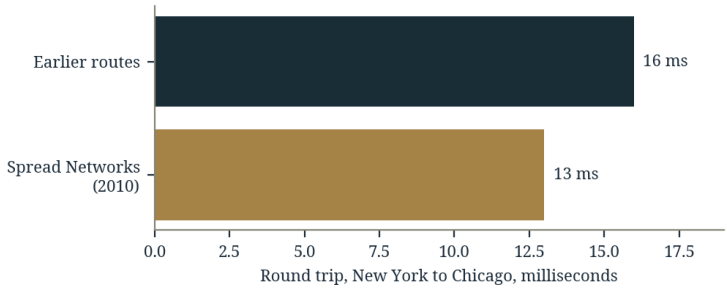


Figure 3. Round-trip time between New York and Chicago before and after the 2010 Spread Networks cable. Data: Budish, Cramton and Shim, NBER conference paper (see source companion).

Three milliseconds is a tiny fraction of a blink. It was worth hundreds of millions of dollars because of what happens in those three milliseconds. A price in one city moves, and a trader at the other end who learns of it first can trade against those who have not yet seen it. The race is not for a better view of the future. It is for the right to act on the present a fraction before others do.

The economists Eric Budish, Peter Cramton and John Shim, in a paper presented at a National Bureau of Economic Research conference, argued that this arms race was a consequence of how markets match orders in continuous time, one order at a time. In a market where the first to arrive at a price gets served, a tiny edge is worth a great deal, and no one can afford to be slower than the rest. They proposed instead running frequent batch auctions, where orders gathered over a short interval are matched together at a single price, which would remove the reward for being a millisecond ahead. The proposal remains debated, and the continuous order book is still the norm. [77]

Colocation

If speed is valuable, distance is expensive. Firms that trade quickly want their computers as close as possible to the exchange's matching engine. Exchange operators responded by selling space in their own data centers, known as colocation. The NYSE's data center is in Mahwah, New Jersey. Nasdaq's NY11 data center is in Carteret, New Jersey, and in a regulatory filing Nasdaq proposed expanding it to provide, in its words, additional and upgraded colocation services. Both sit in the New Jersey suburbs, a short drive from lower Manhattan, where the exchanges' names and some ceremonial functions remain. [78]

Colocation is a business and a controversy. For the operators it is revenue: firms pay for rack space, power and connectivity. For critics it is a tiered system in which those who pay more get a faster view of the market. Regulators require the exchanges to offer access on a fair and non-discriminatory basis and to file their fees. In the proceeding on the Carteret expansion, outside commenters filed letters, and Nasdaq answered them. The dispute shows the fault line: speed is a product, and its price is a matter of regulation.

In the world of machinery, this part of the exchange industry has taken on the look of industrial real estate. The buildings need power, cooling, security and carrier-neutral networks. A network provider, Hudson Fiber Network, announced a fibre route connecting the NYSE's Mahwah center to four other New Jersey sites that each host a major exchange's infrastructure, so that customers could reach them all through one carrier-neutral path. The matching engine that was once a person at a post has become a rack in a locked room. [79]

The flash crash

On 6 May 2010, the prices of many U.S. equity products fell with extraordinary speed and recovered almost as quickly. Major indices in both the futures and securities markets, already down more than 4 percent from the previous close, plummeted a further 5 to 6 percent within minutes, then rebounded. Of the almost 8,000 individual equity securities and exchange-traded funds trading that day, many saw prices fall 5, 10 or 15 percent and recover, according to the joint report of the SEC and the Commodity Futures Trading Commission. Some traded at absurd prices, in both directions. [80]

The two agencies' report found no single culprit, a conclusion a CFTC commissioner, Bart Chilton, repeated in his statement. The markets had been nervous all day because of worsening economic news from Europe, with high volume and volatility. By mid-afternoon, liquidity was draining and sellers were having difficulty finding buyers. Then one institutional firm used an algorithmic program to sell 75,000 contracts valued at more than 4 billion dollars. The markets, in his words, went into shock. As the sell orders hit one market, arbitrageurs moved to other venues, and within minutes the disruption was widespread. The interrelatedness of the markets, he said, exacerbated the problem and was a major lesson of the day.

The rules that came out of it, the single-stock circuit breakers and then the limit up-limit down mechanism, are described earlier. The deeper lesson is about structure. A market that is split across many venues,

populated by machines that are each programmed to step back when conditions look dangerous, can lose its liquidity all at once because every machine reaches the same conclusion at the same moment.

Knight Capital

Two years later, a smaller but sharper event occurred. On 1 August 2012, Knight Capital Americas, a major market maker and broker, installed new trading software. Because of an error in its automated routing system for equity orders, called SMARS, it routed millions of orders into the market over 45 minutes while processing only 212 small retail orders. The system obtained more than four million executions in 154 stocks for more than 397 million shares, according to the SEC's order. By the time Knight stopped it, the firm had a net long position of roughly 3.5 billion dollars in 80 stocks and a net short position of roughly 3.15 billion dollars in 74 stocks. Knight lost more than 460 million dollars on the unwanted positions. [81]

The SEC found that Knight lacked adequate safeguards to limit the risks of its access to the markets and failed to conduct adequate reviews of the effectiveness of its controls. It agreed to pay 12 million dollars in 2013 to settle the charges. Knight's own press statement the day after said the problem related to the installation of trading software at the open and that the software had been removed.

The Knight episode is the opposite of the flash crash. There was no market-wide panic, no structural fault. A single firm's code did something it was not supposed to, and the market, running at machine speed, gave it no time to stop. The lesson, which the SEC's market access rule embodied, was that a firm connected to the market has to have its own brakes. An exchange can protect against many things, but it cannot catch a firm's mistakes before they happen.

What the machine changed

The new machinery narrowed spreads and lowered the cost of ordinary trading. It also altered who provides liquidity, replacing a few specialists with many firms competing on speed, which is a different kind of competition with a different kind of risk. The exchange as a human

institution had relied on judgement: a specialist could step in when something looked wrong. The exchange as a machine relies on rules written in advance. When something outside the rules happens, there is often no one with the authority to say stop. The brakes the regulators added are an attempt to put that authority back.

The Week the Plumbing Showed

In January 2021, a video-game retailer's stock became the centre of a financial event that was, in important ways, about the parts of the exchange system that nobody sees.

The setup

GameStop, with other so-called meme stocks such as AMC Entertainment, became extraordinarily popular on social media going into January 2021. Institutional investors had bet against the stocks by selling them short, predicting a fall. Retail traders took the opposite side, buying in large numbers. The staff of the U.S. House Financial Services Committee, in its report on the episode, describes the result as a trading frenzy that drove historic market volatility. By its measure, on 28 January the gross market value of GameStop cleared in the stock market was 21,318 percent greater than on 4 January. [82, 83]

Why did buying drive the price up so far? The SEC's own staff report on the episode points to short interest, the number of shares sold short. Stocks that parts of the market see as overvalued tend to show significant short interest, and the high short interest in GameStop made a coordinated short squeeze possible. A short seller who must buy back shares to close a position adds to the buying when the price rises, which pushes it up further. The report also notes that some commentators characterised the trading as an act of rebellion intended to humble professional short sellers.

The pause

On 28 January 2021, the retail brokerage Robinhood restricted customers' ability to buy GameStop and other stocks. The restriction caused anger, accusations and a congressional hearing. What the official reports explain is the mechanism behind it, which lay in the clearing system described earlier.

When a customer buys a stock through a broker, the trade settles after a delay, then T+2. In that gap, the broker is exposed, and the clearing house, NSCC, requires members to post collateral against that exposure. The requirement rises with the volume and volatility of the trades. According to the House committee's report, on the morning of 28 January Robinhood had around 696 million dollars of collateral deposited with NSCC, and faced a requirement that left it with a deficit of about 3 billion dollars, which it needed to post or risk breaching NSCC's rules and potentially losing its ability to clear trades for customers at all. [84]

The SEC's staff report puts it in more general terms. The risk management mechanisms of the clearing agencies, it says, effectively led others in the transaction chain, such as retail broker-dealers, to pause and manage the risk exposure that arose as the rate of transactions accelerated. Both NSCC and the Options Clearing Corporation experienced record volumes cleared on 27 January. After the events of late January, the clearing agencies' margin requirements returned to normal.

What it showed

The public saw a broker blocking buyers. The structure underneath was a chain of obligations. A retail customer clicks buy. A broker takes the other side of a settlement promise. A clearing house guarantees that promise and charges the broker for the risk. A broker with too little capital cannot pay. Its only option is to stop taking more risk, which means stopping customers.

This is not a defence of the broker or a condemnation of it. Congress's staff criticised the firm's risk management and the gamification of its app, and the SEC staff's report examined short selling, options and market structure. The point for this book is that the episode revealed a part of the exchange system that normally runs invisibly: the cost of the promise to deliver. The move to T+1 settlement in May 2024 pushes in the direction of that lesson: a shorter delay means a smaller exposure and, as DTCC's figures on clearing fund requirements show, a smaller collateral call.

Who the market is for

The episode also showed a changed investing public. Smartphone apps with no commission fees brought in younger investors with smaller accounts. The SEC report notes that brokers reported younger investors and smaller accounts as notable sources of new account openings, with one large broker saying that individual customers aged 40 and under, with balances below 100,000 dollars, were driving a greater share of trading volume than before. The exchange of 1602 had a maid with a hundred guilders and the exchange of 2021 had a young investor with a phone. Both were allowed in. The question that recurs is what the institution owes them when the market turns. [85]

Futures Learn Finance

Futures began as a farmer's tool, a way to fix the price of grain before the harvest. In the 1970s they became a financial tool, and the change was fast.

The currency pit

On 16 May 1972, the Chicago Mercantile Exchange launched seven currency futures contracts: British pounds, Canadian dollars, Deutsche marks, French francs, Japanese yen, Mexican pesos and Swiss francs. The CME's own history marks it as the start of financial futures. In the middle and late 1970s and early 1980s, the CME and the Chicago Board of Trade added futures on interest-rate products such as Treasury bonds and bills and Eurodollar deposits. [86]

The CME's list of new contracts shows the pace: foreign currencies in 1972, gold and mortgage-backed GNMA certificates in 1975, 90-day Treasury bills in 1976, bonds in 1977, heating oil in 1978, certificates of deposit in 1980, cash-settled Eurodollars and gasoline in 1981, the S&P 500 stock index and options on futures in 1982, crude oil in 1983 and natural gas in 1990. Each new contract was a standardised promise to buy or sell something at a stated price on a stated date, backed by margin and cleared centrally, on the template that the Chicago grain traders had set in 1865. [87]

Betting on the whole market

In early 1982, stock index futures were created when the Kansas City Board of Trade launched futures contracts on the Value Line Index. A few weeks later, the CME launched futures on the S&P 500. Both had

respectable starts, but the Value Line contract faced a stiff headwind, which was a tailwind for the S&P 500. Much of the equity world was benchmarked to the S&P 500, so its futures drew far more activity, while little money was benchmarked to the Value Line. The Value Line contract's activity dwindled and it was eventually delisted. The CME says the S&P 500 futures complex now trades about two million contracts per day. [88]

The episode is a small lesson in how networks win. Two contracts, both reasonable, appeared within weeks of each other. The one linked to what the money was already measured against survived and the other did not. Liquidity attracts liquidity.

What stock index futures changed

A fund manager who wants to reduce exposure to the market no longer has to sell hundreds of stocks. She can sell a futures contract, which is faster and cheaper. A manager who has just received a large inflow can buy futures while deciding which stocks to buy. The price of the future and the price of the stocks it represents tend to move together, because traders can profit from gaps between them, a practice called index arbitrage.

The link had a dark side in 1987. The SEC report on the market break noted that price discovery was occurring in the futures pit rather than among equity specialists and market makers, and that portfolio insurance programmes, which sold index futures as prices fell, may have amplified the decline. Futures made the stock market more connected, and connection speeds the transmission of shocks as well as of information. [89, 90]

Options on futures and the new risk business

The 1982 introduction of options on futures extended the structure. The Black-Scholes formula of 1973 meant these products could be priced, and exchanges built whole markets around them. The result was a set of financial services, from airline fuel hedges to pension portfolios that

protect against a market fall, that did not exist in the era of De la Vega's Amsterdam. Futures and options took the old idea of paying someone else to hold a risk and made it routine.

The two businesses grow together

Today the largest exchange groups run both stock and derivatives markets. The reason is that the two share infrastructure and customers: the same funds trade shares, index futures and options, and a clearing house that handles both can net positions across them, which lowers the margin each firm must post. The World Federation of Exchanges notes in its 2024 figures that the CME Group holds 60.6 percent of global interest rate options volume and 49 percent of interest rate futures. The Chicago grain pits of 1848 turned into the world's largest market in the price of money. [91]

The Other Rooms

An exchange, in the sense this book has used, is the lit market: a public venue that displays its orders. In the United States today it is only one of several places where a stock can trade. This chapter looks at the others, and at the people who now use all of them.

Volume and the retail share

According to a market-structure compendium published by the Securities Industry and Financial Markets Association, SIFMA, U.S. equity volume averaged 12.2 billion shares a day in 2024, up 10.2 percent from the year before. Retail investors accounted for 17.9 percent of total volume, a share that had settled around 18 percent for the last three years, up from about 10 percent historically. After-hours trading was 10.8 percent of total equity volume, with 5.5 percent in the half hour from 4:00 to 4:30 p.m., right after the market closes. [92]

The figures describe a market that is both bigger and different in its users. A share of trading close to a fifth is now done by individuals, many through smartphone apps. A tenth of the day's volume happens outside the regular session. The planned Nasdaq 23-hour week described in the last chapter is, in this light, a response to behaviour that has already moved.

How a retail order is filled

When someone presses buy in an app, the order does not necessarily go to an exchange. Many brokers route retail orders to firms that fill them directly, often called wholesalers or electronic market makers, which pay the broker for the privilege. The practice is known as payment for

order flow. Supporters argue that wholesalers often fill orders at prices slightly better than the public quote and that it allows zero-commission trading. Critics argue that it creates a conflict of interest between a broker and its customers. [93]

The U.S. regulator has acted on the disclosure side. In December 2020 the SEC charged the brokerage Robinhood with repeated misstatements that failed to disclose its receipt of payments from trading firms for routing customer orders to them, and with failing to meet its duty to seek the best reasonably available terms to execute customer orders. Robinhood agreed to pay 65 million dollars to settle. According to the SEC's order, the misstatements ran between 2015 and late 2018. The SEC's order describes the trading firms as principal trading firms, also known as electronic market makers. [94]

Why other rooms exist

Competition between venues is a design choice. The Regulation NMS framework of 2005 encouraged it. Different venues offer different features: lower fees, particular order types, anonymity for large orders, or price improvement for small ones. A large pension fund selling a big block of shares does not want to display the order to the whole market, since showing it would push the price down. It wants a place where it can find a buyer quietly. An alternative trading system serves that need. A retail broker, by contrast, wants its customers to get a fast fill at a good price and may prefer to sell the order flow.

The result is a layered market. Public exchanges publish the best prices and set the benchmark. Other venues, which may be run by exchange operators themselves, trade against that benchmark. The exchange's price is the reference that everything else leans on, which gives the lit market a role in setting prices even when it does not host every trade.

Why the lit market still matters

If much of the volume trades elsewhere, why does the exchange matter? There are three answers. First, price discovery: the public quotes and closing auctions are where the market's views are revealed to everyone, and other venues use them as reference points. Second, listing: the

exchange confers the status of a listed company, with its disclosure rules and standards, on the firms it lists. Third, the closing auction, which sets the price at which index funds trade and from which indexes are calculated. A market in which everyone traded off-exchange would have no public price to trade against, so the free ride on the public price has limits. That is the structure of the argument over how much trading should be required to go through public venues, which regulators keep revisiting.

Who the market serves

The user of 1602 was a merchant. The user of 1792 was a broker. The user of 2024 is as likely to be a person with a phone who has never heard of an order book. The institution's job is the same, and its audience has changed beyond recognition. Whether an exchange serves such users by providing a fair price to the market as a whole, or by providing a clean interface to a group of brokers, is a question about its purpose that law, competition and technology will keep answering in different ways.

PART SIX: The Business and the World

Who Owns the Room

An exchange operator is a strange kind of company. Its product is a rulebook and a network. Its customers are also its suppliers, since the firms that trade supply the orders that make the market worth trading in. And its largest asset is a thing it cannot easily show on a balance sheet: the trust of people who put money through it.

How an exchange makes money

Exchange revenue in the modern era comes from a handful of sources. Trading fees are charged on each transaction, often a tiny amount per share or contract. Listing fees are charged to companies that list their shares, at the start and annually. Market data is sold to firms that want the prices, in real time or as history, which goes back to the ticker companies of the nineteenth century. Technology and connectivity services include colocation. Clearing fees come from the clearing house if the exchange operator owns one. Index licensing lets financial companies use the exchange's index names for funds and derivatives.

The mix has been shifting. Intercontinental Exchange, which owns the NYSE, reported full-year 2024 consolidated net revenues of 9.3 billion dollars, up 16 percent, of which exchange net revenues were 5.0 billion, fixed income and data services 2.3 billion and mortgage technology 2.0 billion. Its adjusted operating margin was 59 percent. Nasdaq reported 2024 net revenues of 4.6 billion dollars, an increase of 19 percent over 2023, with a large portion from what it calls Solutions, such as technology and data, and annualised recurring revenue of 2.8 billion dollars. Both companies, in different words, tell the same story: the

business of an exchange operator is less and less about the act of matching trades and more about data, technology and the services that surround the market. [95, 96]

Consolidation

The history of the operators is one of mergers. The NYSE combined with ArcaEx in 2006 to form the NYSE Group, then with Euronext, which had been formed in 2000 from the exchanges of Amsterdam, Brussels and Paris, to form NYSE Euronext in 2007. In 2013, Intercontinental Exchange acquired NYSE Euronext, and Euronext was later spun off as a separate company. Euronext today describes itself as the leading European capital market infrastructure, with over 1,800 issuers representing six trillion euros of aggregate market capitalisation on a single stock market covering seven countries, and welcomed 53 new listings in 2024. Amsterdam, where the first shares traded, is one of its markets. [97]

The logic of consolidation is simple. Trading is a network business: the more orders in a market, the better the prices, which attracts more orders. Technology has high fixed costs and low marginal costs, so larger operators spread them across more volume. And a group that runs equities, derivatives, clearing and data can sell customers a package.

The names

Several operators dominate the global picture, each with its own character. Intercontinental Exchange, based in Atlanta, owns the NYSE and other exchanges and clearing houses. Nasdaq, based in New York, operates markets in the Nordic and Baltic countries and, by its own account, supplies technology to more than 135 marketplaces and regulators in more than 55 countries. CME Group, the descendant of the Chicago exchanges of the nineteenth century, dominates interest rate derivatives. The Japan Exchange Group in Tokyo, Hong Kong Exchanges and Clearing, the Shanghai and Shenzhen exchanges, the National Stock Exchange of India and the Bombay Stock Exchange are among Asia's large markets. Deutsche Börse in Frankfurt and the London Stock

Exchange Group are other large European operators alongside Euronext. DTCC, which is not an exchange but a cooperative owned by its users, sits underneath the American ones. [98]

None of these is a household name outside finance. All of them influence the cost of capital for the companies listed on them, the cost of saving for the people who invest, and the flow of information that tells everyone else what things are worth.

Who owns the owners

An old question follows each of these arrangements: who should own the market? A mutual exchange is owned by its members, which can mean cosy rules and resistance to change. A listed exchange is owned by shareholders who may care more about profit than about the integrity of the market. A state-owned exchange can serve policy goals and can be used for them. Each design has produced failures and successes. There is no neutral structure. What the exchange owes the public has to be written into law and rulebooks, whatever the structure, because the incentives of owners alone will not do it.

The Map Today

The best single guide to the size of the world's exchanges is the World Federation of Exchanges, the industry body that collects statistics from the operators. Its 2024 figures show a market at a high.

The total

Global equity market capitalisation increased by 13.4 percent in 2024, to 125.71 trillion US dollars, according to the WFE's full-year highlights. More than 13 trillion dollars was added to stock markets worldwide. The Americas region reached its highest market capitalisation in the period the report covers, driven mostly by technology companies. Trading value rose 15.5 percent. In the Asia-Pacific region, the surge in value traded was largely due to the Shenzhen and Shanghai exchanges, the Japan Exchange Group, the National Stock Exchange of India, Hong Kong's HKEX and the Taiwan Stock Exchange. [99]

The largest rooms

This is a snapshot, not today's ranking. At the end of December 2024, the WFE's domestic equity market capitalisation figures, in millions of US dollars, put the world's largest exchanges in this order among the major operators it lists: the NYSE at about 31.6 trillion, Nasdaq's U.S. market at about 30.6 trillion, Shanghai at about 7.2 trillion, the Japan Exchange Group at about 6.6 trillion, the National Stock Exchange of India at about 5.7 trillion, Euronext at about 5.4 trillion, Hong Kong at about 4.5 trillion and Shenzhen at about 4.5 trillion. [100]

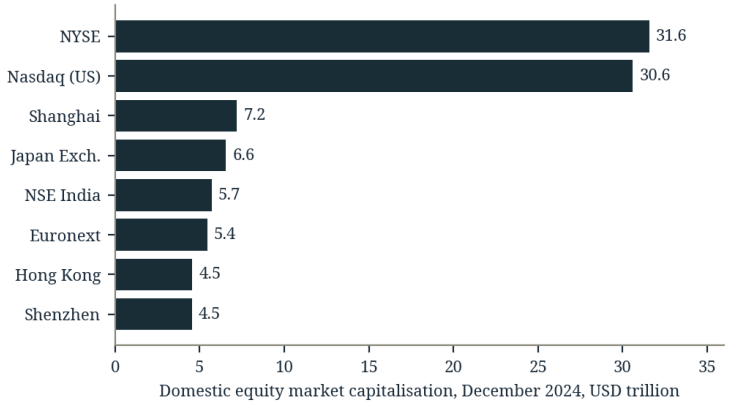


Figure 4. Domestic equity market capitalisation of the largest exchanges, December 2024. Data: World Federation of Exchanges, February 2025 market statistics (see source companion).

Two things are visible at once. The American exchanges dwarf the rest: the NYSE and Nasdaq together list around 62 trillion dollars of domestic companies, about half of the world's total. And the next tier is crowded and international: Asia holds five of the top eight, with Euronext as the European representative.

Number of companies versus size of companies

Market capitalisation measures value. A different measure counts the companies. At the end of 2024, Nasdaq's U.S. market had 3,289 listed companies and the NYSE 2,132, according to the WFE's listings table. By value they are the two largest. By count, they are not as dominant, because many exchanges around the world list large numbers of small companies. [101]

Fewer public companies

One of the most discussed facts about exchanges is that the number of listed companies in the United States has fallen over time. According to the National Bureau of Economic Research, in 1976 the United States had 4,943 firms listed on exchanges. By 2016 it had only 3,627. Because the population rose from 219 million to 324 million, the number of listed firms per million inhabitants fell from 23 to 11. [102]

A study from Dartmouth's Tuck School describes the graph of the number of public firms between 1980 and 2020 as showing a 50 percent decline after the peak in 1996, and points out that it is easy to read that as a sign that firms see less benefit in going public in the United States. The researchers argue that the picture is more complicated. For this book the fact stands as a puzzle: the market has grown enormously in value while the number of companies in it has shrunk. Fewer, bigger companies now carry more of the weight of the market. Index funds that hold the whole market hold a smaller number of businesses than they once did. [103]

How many IPOs

On new listings, the WFE counts 1,133 IPOs worldwide in 2024, the lowest in the five years of its report, and says that the average size of an IPO rose. In the second half of the year, nine IPOs raised more than a billion dollars each, in addition to seven in the first half. American markets welcomed 218 IPOs. EY, which counts differently, reports 1,215 deals raising 121.2 billion dollars, down 10 percent in number and 4 percent in proceeds, with the Americas and Europe, Middle East, India and Africa recovering while Asia-Pacific lagged, and with India taking first place by deal count for the first time. [104]

The point is not which number is right. It is that listing on an exchange, a thing the VOC pioneered in 1602, is today done by a little over a thousand companies in a year, in a world with over a hundred trillion dollars in listed equity. For a great many companies, a public listing is one option among several, not the default.

The gaps in the map

These statistics leave things out. They cover exchange-listed shares and not the large and growing world of private companies and private funds, where companies raise money from investors without a public listing. They do not capture over-the-counter trading. And they treat value and activity as if all exchanges were comparable, though

regulation, liquidity and openness to foreign investors differ widely. A reader should treat any single table as a photograph taken from one angle.

What the Exchange Feeds

Follow the price a stock exchange produces and you find it in places that have nothing to do with trading.

The household

In the 2022 Survey of Consumer Finances, run by the Federal Reserve, 58.0 percent of U.S. households held stocks, directly or indirectly, up from 52.6 percent in 2019. That is about 76.1 million households. Direct holdings are shares of individual companies; indirect holdings include stock mutual funds, retirement accounts invested in stock, and other managed assets with equity interest. The median value of holdings for those households was about 52,000 dollars in 2022 terms and the mean about 489,000 dollars. The gap between median and mean shows how unevenly the holdings are spread: a few households hold a great deal. [105]

Axios, reporting on the survey, noted that the share of American households owning stock, whether in mutual funds, retirement accounts or individual shares, hit a new high in 2022, and that the relatively large share with a stake in the market is a distinctive feature of American capitalism compared with other large advanced nations such as the United Kingdom, France, Germany and Canada, where equity participation is lower. [106]

This is an important change from 1602. Then the buyers were merchants and the occasional maid. Now a majority of households in the largest market are in it, mostly through accounts they hardly look at. Their retirement depends on a price they did not set, in an institution they have never visited.

The company

For a company, the exchange does at least four things. It raises money: the initial offering, and later sales of new shares. It provides a currency: a listed company can pay for acquisitions with its own shares, whose value is visible to everyone. It provides a way to pay and retain employees, through stock options and share grants whose value is set by the market. And it provides a scoreboard. The share price is read by customers, suppliers, lenders and rivals as a verdict, whether deserved or not.

The price also disciplines. A company whose share price is low relative to its assets becomes a takeover target, and a company whose price is high can raise money cheaply. The pressure shapes behaviour in ways that managers resent and economists debate.

The index and the fund

When a fund tracks an index, it holds the stocks in proportion to their weight in that index. The index, in turn, is built from the exchange's prices. This loop, from price to index to fund to buying and selling, is how a household's monthly retirement contribution flows into the market in proportion to company size. Since Bogle's first index fund in 1976, which began as a product for individual investors that many regarded as folly, that loop has become a significant mechanism in the pricing of the largest companies.

Derivatives and risk

From the stock price grows an entire family of products. Options let investors protect against or bet on a fall. Futures on stock indexes let a fund adjust its exposure to the whole market in one trade. Exchange-traded funds, which trade like shares but hold baskets of assets, put an entire index into a single ticker. The World Federation of Exchanges' 2024 report records peak volumes in single stock options, single stock futures, stock index options, ETF options and ETF futures. India's NSE accounts for 97.7 percent of stock index options trading in the report, and U.S. venues including Nasdaq and Cboe Global Markets appear in its rankings of options on single stocks and ETFs. [107]

Government

An exchange also serves government. Public debt can be traded on exchanges, as it was in Philadelphia and New York in the 1790s, and as the Tokyo exchange's first business, in 1878, was trading bonds issued to former samurai. [108]

Machinery and economies

The physical economy of the stock exchange is easy to forget because the product is abstract. It includes the data centers in New Jersey and their power and cooling; the fibre-optic cable between New York and Chicago that cost an estimated 300 million dollars to dig; and the technology firms, Nasdaq among them, that supply trading and surveillance systems to other marketplaces.

An exchange is, in the end, a piece of industrial infrastructure whose output is a number. The number is as much a product of machinery and law as a barrel of oil is, and, like oil, it flows into everything else.

What Holds It Back

Every industry has constraints. The stock exchange's are less visible than a mine's or a refinery's, but they are real.

Trust

The first constraint is the one the Amsterdam ledger started with: trust. A market without it shrinks. The history in this book is full of events that damaged it: bubbles in 1720, the panic of 1907, the crash of 1929, the day in 1987, the flash crash of 2010, the Knight incident of 2012, the meme-stock week of 2021. Each produced rules, and each rule was a patch over a lost confidence. The 1930s legislation, written when stocks listed on the NYSE had lost 83 percent of their pre-crash value, can be read as an attempt to rebuild a bridge of trust by forcing companies to disclose and by policing fraud. [109]

Trust is also limited by what regulators can see. A market that operates across many venues, at machine speed, with thousands of firms, is hard to supervise. The flash crash reports needed months of reconstruction by staff of two agencies to explain an event that played out in a short stretch of one afternoon.

Settlement and capital

A second constraint is the cost of the promise. The clearing system exists because trades involve risk between the agreement and the exchange of cash and shares, and it requires members to post collateral against that risk. This makes capital a bottleneck: when volatility rises, margin requirements rise with it, as the January 2021 clearing numbers show,

and a firm without enough capital must stop. T+1 reduces the problem by shortening the time at risk. Faster settlement, however, shortens the time available to fix errors and to move money across time zones.

Speed and geography

The third constraint is physical. Light in glass travels at about two thirds of its speed in a vacuum, and a cable cannot be shorter than the straight line. The Spread Networks cable cut the New York to Chicago round trip from about 16 to 13 milliseconds, at great cost, and later microwave links cut the round trip further, to about 8.5 milliseconds according to the authors of the batch-auction paper, which is not far above what physics allows. The cable's speed of light figure is general physics, about two thirds of the vacuum speed in silica fibre. The need to sit close to the matching engine means that the real centre of the American market is a set of warehouses in New Jersey, and any outage, power failure or attack there affects the whole system. Resilience requires duplicated facilities, tested failovers and disciplined software releases, as Knight's loss demonstrated in forty-five minutes. [110, 111]

Fragmentation

The fourth constraint is the one the regulators created on purpose. Competition between venues lowers costs and drives innovation, and it also splits liquidity, makes the best price harder to find and makes the market's behaviour in stress harder to predict. Rules such as the order protection rule try to hold the venues together. They also add complexity. The system cannot be simply simplified without giving up something its architects wanted.

The supply of companies

A fifth constraint is the supply of things to trade. If fewer companies list, as the American data show, the market has fewer choices, and more of the economy's growth happens before the public gets access to it. Companies that stay private longer can raise large sums from private investors, so the retail investor, whose main route to the economy is the

public market, may reach a company only after much of its growth has occurred. That is a limit on the exchange's ability to serve its widest audience.

Law and politics

The sixth constraint is that exchanges operate inside the legal systems of states, which can change what they may do. The Dojima exchange in Osaka was banned, then authorised, depending on whether the shogunate thought futures hurt or helped rice prices. The Shanghai market closed for decades after 1949 and re-opened in 1990. Rules on short selling, on foreign investment and on listing standards are political choices. An exchange cannot be understood as a purely technical object, because the permission to exist is political. [112]

The people

Last, the exchange depends on people. A matching engine can run without anyone watching, but someone has to decide when to halt trading, someone has to write the rules, someone has to catch the fraud and someone has to decide what to do when the unexpected happens. The institutions that survive are those that train such people and give them authority. Replacing the floor with software did not remove the need for judgement. It moved it earlier in time, to the people who write the rules and the code.

What Comes Next

Predicting a price is not the aim of this book, and predicting the exchange is not much easier. But several changes are already in motion, with dates attached.

Longer hours

Nasdaq's trading hours currently run from 9:30 a.m. to 4 p.m. Eastern Time, with extended sessions from 4 a.m. to 9:30 a.m. and 4 p.m. to 8 p.m. In April 2026 the SEC granted accelerated approval to a Nasdaq proposal to extend trading to 23 hours a day, five days a week. Nasdaq has announced a target start of Sunday 6 December 2026 at 9 p.m. Eastern Time, a date that depends on remaining regulatory sign-offs and industry readiness. Under the plan, the market would operate from Sunday evening through Friday evening at 8 p.m., with a one-hour maintenance pause between 8 and 9 p.m. [113]

The change is a reminder of the original limit on exchanges: hours were set by the people who stood on the floor. An exchange that runs nearly around the clock serves investors in Asia and Europe in their own daytime, and it requires clearing, data and risk systems that can handle a long session. Whether liquidity will be deep at three in the morning in New York is an open question that only experience will answer. The practical consequence is that the exchange will behave less like a place with a closing bell and more like a utility.

Tokens

In December 2025 the DTCC announced that its subsidiary DTC had received a no-action letter from the SEC staff to offer a service to tokenize real-world assets that DTC holds in custody, in a controlled production environment. DTC said it expected to begin the service later. Tokenization means representing the claim in a form that can be moved on a shared ledger, with the aim of faster, more flexible settlement. [114]

What this will achieve is uncertain. If a token can be exchanged for cash on the same ledger in a single step, the delay between trade and settlement could shrink toward zero, and with it much of the risk that the clearing system exists to manage. But clearing does more than speed things: it nets trades, so that firms need far less cash and fewer securities than if every trade settled one by one. Faster settlement of each trade can raise the amount of capital a firm needs to hold. The transition from T+2 to T+1 in 2024 was a modest step on the same road, and DTCC's numbers on reduced clearing fund requirements show the benefit of a shorter cycle. How far the road goes is a design choice, not a law of nature.

Who is listed

Fewer companies list on American exchanges than in the 1990s, and IPOs worldwide were at a five-year low in number in 2024, though larger on average. The WFE report records that the Americas region saw more IPOs and more capital raised than in the previous year. Exchanges compete for listings with private markets, and the contest has implications for the average investor, who can only buy what is public. [115]

Machines and rules

The machines will keep getting faster and the rules will keep reacting. The history in this book suggests a pattern: an innovation lowers cost and increases speed, a weakness emerges under stress, a crisis occurs, regulators patch, and the cycle continues at a higher level. The limit up-limit down mechanism and T+1 settlement are the patches of the last fifteen years. There will be others, and they will probably follow rather than prevent the next surprise.

What will not change

Some features of the exchange look stable across four hundred years. It needs a place, even if the place is a rack of servers. It needs a rule about who goes first. It needs a way to ensure the promise is kept. It needs a public that believes the price is not rigged. And it needs people willing to take the other side of a trade, since no market can exist where everyone wants to do the same thing at once.

The ledger in Dirck van Os's house did one thing a modern exchange does at a larger scale: it let strangers share a risk without knowing each other. Whether the strangers are a maid in Amsterdam, a pension fund in Ontario or a student with a phone, the institution works only when each believes that the next person to come along will honour the promise. That belief is the product.

Back to the Ledger

The register of the VOC's Amsterdam chamber survives in the national archives in The Hague, and its pages have been photographed. The first page carries the line that made the rest possible, the permission to transfer shares. The last page carries the notary's note about midnight.[116] Neeltgen Cornelis's hundred guilders are somewhere in it, the second to last entry in a book of 1,143 names. We do not know what she did with her shares. We do not know whether she sold them to someone in the street when she needed the money, or held them, or what they became. That is also the exchange: a record of a moment, and then a market in which the owner is free to leave.

Four centuries later, the picture has changed beyond what anyone in that house could have imagined. The ledger has become a matching engine, the street a network, the notary a regulator. A hundred guilders has become a click. But the exchange still rests on the same simple offer: you may buy a share of what others are building, and when you need your money, you may sell it to someone else.

Reference

A Timeline of the Exchange

- **13th to 15th centuries.** Merchants gather near the Huis ter Beurze in Bruges, and the name bourse spreads (the family-and-inn origin is commonly told, not fully documented).
- **1531.** The Handelsbeurs opens in Antwerp.
- **1602.** The VOC charter (20 March) and the August subscription; shares are made transferable.
- **1609 to 1610.** Isaac Le Maire's short-selling raid on VOC shares ends in a surprise dividend.
- **1688.** Joseph Penso de la Vega publishes *Confusión de Confusiones* in Amsterdam.
- **1719 to 1720.** The Mississippi and South Sea bubbles rise and collapse.
- **1730.** The shogunate authorises the Dojima rice futures market in Osaka.
- **1790.** The Board of Brokers of Philadelphia is founded.
- **1792.** Twenty-four brokers sign the Buttonwood Agreement in New York.
- **1801.** The London Stock Exchange is formally established.
- **1848.** The Chicago Board of Trade is founded.
- **1865.** The CBOT introduces standardised futures contracts.
- **1867.** Edward Calahan builds the first stock ticker.
- **1875.** The Native Share and Stock Brokers' Association starts business in Bombay.
- **1878.** The Tokyo Stock Exchange opens in Kabutocho.
- **1891.** The Association of Stockbrokers in Hong Kong is formed.
- **1900.** Bachelier submits *Théorie de la spéculation*.
- **1907.** The Panic of 1907.

- **1933 and 1934.** U.S. securities laws and the SEC follow the 1929 crash and the Pecora hearings.
- **1971.** NASDAQ launches as an automated quotation system.
- **1973.** The Black-Scholes option pricing formula is published.
- **1976.** The first index fund for individual investors is launched.
- **1987.** Black Monday: the Dow falls 22.6 percent in one day.
- **1990.** The Shanghai Stock Exchange is established and begins operation.
- **1994.** The National Stock Exchange of India begins operations.
- **2001.** U.S. stock prices move to decimals.
- **2005 to 2006.** Regulation NMS is adopted; the NYSE merges with ArcaEx and demutualises.
- **2010.** Spread Networks' cable opens; the flash crash of 6 May.
- **2012.** Knight Capital's software error (1 August); limit up-limit down approved.
- **2013.** Intercontinental Exchange acquires NYSE Euronext.
- **2021.** The meme-stock episode and its clearing-house collateral calls.
- **2024.** U.S. settlement moves to T+1 on 28 May.
- **2026.** Nasdaq's 23-hour, five-day trading week is targeted to begin on 6 December, subject to remaining approvals and industry readiness.

Glossary

Ask. The lowest price at which someone will sell.

Bid. The highest price at which someone will buy.

Bourse. A continental European term for an exchange.

Call auction. A matching method that gathers orders over a period and trades them together at one price.

Central counterparty. A clearing house that becomes the buyer to every seller and the seller to every buyer.

Clearing. The process of confirming and netting trades before settlement.

Colocation. Renting space in an exchange's data center to be near its matching engine.

Demutualisation. An exchange's change from member ownership to shareholder ownership.

Index fund. A fund that holds the stocks in an index in proportion to their weights.

Limit order. An order to buy or sell at a stated price or better.

Liquidity. How easily an asset can be turned into cash without a large loss of value.

Margin. Collateral posted against the risk of a trade or loan.

Market maker. A firm that continuously quotes both a bid and an ask.

Novation. The legal replacement of the original two parties to a trade by the clearing house.

Settlement. The final exchange of cash and securities.

Short selling. Selling a borrowed share in the hope of buying it back cheaper.

Spread. The gap between the best bid and the best ask.

T+1. Settlement one business day after the trade date.