

THE GROWTH OF KNOWLEDGE

WHAT PROGRESS, DISRUPTION, AND AI MEAN FOR INVESTORS

“In this book I argue that all progress, both theoretical and practical, has resulted from a single human activity: the quest for what I call good explanations.”

David Deutsch, The Beginning of Infinity

This paper draws heavily on David Deutsch’s The Beginning of Infinity and Karl Popper’s theory of knowledge and applies their ideas to progress, business, and investing. Any errors are my own.

I have always been curious about what causes progress. In school, I remember learning about the American colonies and wondering how that world became the one we live in today, with skyscrapers, computers, and spaceships that can land on the Moon. Yet for most of human history, progress was extremely slow. With America celebrating its 250th anniversary, I thought it was a good time to dive deeper into the question: why did progress suddenly take off?

The best explanation I have found is the one David Deutsch describes in *The Beginning of Infinity*: progress occurs when people create new knowledge by guessing solutions to problems, criticizing those solutions, and replacing worse ideas with better ones. This results in a growth of knowledge. Societies differ in how well their cultures allow that process to occur. Those differences help explain why progress has flourished in some places but stagnated in others.

This also relates to investing because businesses create value by applying knowledge to solve problems for customers. The knowledge that will shape future products, industries, and competition cannot be predicted in detail. If it could, we would already have it. Recent advances in artificial intelligence provide a timely example. Even after a new technology emerges, investors must still judge which businesses will benefit, which will be disrupted, and what expectations are already reflected in market prices. How can investors make sound decisions when a business’s future value cannot be known in advance?

This paper explores how societies create the conditions for knowledge to grow, how businesses apply that knowledge to create and retain value, and how investors can make decisions under uncertainty, especially during periods of technological change.

AMERICA AND THE CONDITIONS FOR SUSTAINED PROGRESS

It is remarkable that America has existed as an independent country for only about three long human lifetimes. Someone living at the time of the founding could not have imagined the wealth and capabilities available to the average American today. In many areas of material life, that person had more in common with someone living in ancient Rome than with a modern American.

People have been capable of creating knowledge for hundreds of thousands of years, as the early controlled use of fire suggests. The recent acceleration of progress therefore cannot be explained by the sudden emergence of human creativity. Nor can it be explained by access to natural resources alone; materials become resources only when people possess the knowledge needed to put them to use.

The difference lies largely in culture, particularly in whether a society's shared ideas and traditions protect people's freedom to challenge existing ideas and propose new ones. Deutsch distinguishes between two broad types of society: static and dynamic. Static societies preserve established ways of life by suppressing criticism and discouraging innovations that challenge tradition. Dynamic societies, by contrast, can preserve useful knowledge and social order while allowing existing ideas and practices to be questioned, improved, or replaced.

Static societies can persist because their cultures faithfully reproduce entrenched ideas along with the behaviors, traditions, and ways of thinking that support them. Conformity is rewarded, while questioning established practices is discouraged or punished. A community dependent on keeping a central fire burning, for example, might treat the practices for maintaining it as sacred. That might preserve essential knowledge embodied in the tradition, but it could also make useful steps difficult to distinguish from arbitrary or even harmful ones. By insulating the tradition from criticism, the culture can prevent alternatives from being proposed or tested, whether for maintaining the fire or solving other problems.

Although static societies dominated most of human history, some cultures experienced periods of unusual progress. In *Peak Human*, Johan Norberg examines seven such golden ages, including ancient Athens, Abbasid Baghdad, Song China, and Renaissance Italy. He identifies a recurring pattern: openness to people, trade, and ideas from elsewhere allowed existing knowledge to spread, while criticism of prevailing beliefs and experimentation with new approaches enabled new knowledge to be created.

These periods of openness and rapid progress were fragile and eventually receded. Some were weakened from within as authorities imposed orthodoxy or punished dissent: an Athenian jury sentenced Socrates to death on charges of impiety, Abbasid rulers punished scholars who rejected state-imposed religious doctrine, and the Roman Inquisition placed Galileo under house arrest for defending heliocentrism. War and political upheaval could also erode openness, as the Peloponnesian War did in Athens, or interrupt progress, as the Mongol invasion and subsequent civil strife did in Song China.

One of the Enlightenment's key achievements was establishing a more durable tradition of criticism through which people could pursue better explanations. In England, common law, limits on royal power, Parliament, and scientific debate helped sustain that tradition. America inherited and extended it through a political system founded on the principles that people possess natural rights and that governments derive their legitimate authority from the consent of the governed rather than hereditary rule. Although applied imperfectly, those principles provided standards against which existing practices could be judged and improved.

In practice, this tradition operates through several mechanisms: open debate, competitive markets, and constitutional democracy. Free speech protects people's freedom to propose and criticize ideas. Free enterprise and markets allow people to try competing solutions, while customer choice and the resulting profits and losses provide feedback about which solutions create value. Constitutional democracy provides peaceful ways to challenge laws, constrain power, and replace political leaders. As Karl Popper argued, democracy's central virtue is not that it guarantees good rulers but that it allows bad ones to be removed without violence. Together, these mechanisms allow existing ideas, businesses, laws, and political leaders to be replaced when better alternatives emerge, without overturning the broader system.

A society's institutions embody accumulated knowledge about how people can coordinate, criticize ideas, and correct errors. Some of that knowledge is made explicit in constitutions and laws; much remains inexplicit, residing in how elections, courts, property rights, and markets operate and in the less visible norms and practices that sustain them. This helps explain why copying the formal features of American institutions elsewhere has not always produced the same results. Cultural qualities such as tolerance for dissent, respect for limits on coercive power, willingness to permit experimentation and failure, and openness to new ideas and competition are more difficult to reproduce. Formal rules can support these qualities, but their effectiveness ultimately depends on how people interpret and uphold them.

The value of America's tradition of criticism lies not in preventing mistakes, but in making sustained progress possible by allowing people to identify and correct them. Deutsch's principle of optimism captures the broader point: "All evils are caused by insufficient knowledge." Problems are inevitable, but they are soluble. Protecting the freedom to challenge existing ideas and pursue better ones is therefore not merely a source of prosperity. It is fundamental to creating the knowledge needed for it.

BUSINESSES IN A DYNAMIC SOCIETY: MOATS AND ADAPTABILITY

Like dynamic societies, businesses depend on continual problem solving and adaptation. They bring people together to preserve, apply, and create knowledge. At their best, businesses function as error-correcting institutions. In a competitive market, a business must continue creating enough value for customers, employees, and investors to choose to participate voluntarily. By bringing together people, financial capital, and physical resources, it can produce goods and services that would be difficult or impossible for individuals to create on their own. The knowledge behind those solutions is embodied in its products, processes, culture, relationships, and business model.

Competition and customer choice continually test a business's solution against alternatives, while profits and losses provide feedback about whether customers value its products and services more than the resources used to provide them. The same process leaves every business vulnerable: a competitor may develop a superior solution, or new knowledge may make the existing one obsolete. A durable business must therefore embody knowledge that competitors cannot easily reproduce while remaining capable of developing new solutions as the world changes.

Moats: Hard-to-Replicate Knowledge

Creating value for customers does not guarantee that a company can capture enough of it to earn attractive returns on capital. Airlines transformed travel, but broadly similar services leave little room for differentiation and make price competition intense. High returns attract capital and invite attempts to develop competing solutions. Sustaining attractive returns over time requires a moat: an advantage that makes a company's solution difficult to copy or replace.

The trucking industry illustrates how seemingly similar services can have very different underlying business models and economics. A full-truckload carrier typically moves one customer's shipment directly from its origin to its destination. This service does not require a dense terminal network, so barriers to entry are relatively low, competition is intense, and profitability is generally modest. A less-than-truckload (LTL) carrier, by contrast, combines shipments from many customers across a network of terminals and routes. Its advantage depends on shipment density, route efficiency, pricing knowledge, service reliability, and the coordination of thousands of daily decisions. The resulting barriers to entry tend to limit the number of viable competitors and support greater profitability for incumbents that have reached scale. A competitor is free to enter the market, but it cannot easily build a dense terminal network or reproduce the operating knowledge needed to run it efficiently.

The LTL network reflects a broader feature of durable businesses: much of the knowledge behind their solutions may be inexplicit. It may reside in accumulated routines, judgment, and practical know-how that competitors cannot easily acquire or reproduce. Recognizing an attractive opportunity does not provide that knowledge. Overcoming such a moat may therefore require creating a materially better solution rather than simply copying what already exists.

A moat earned through customer choice does not prevent competition; it makes the company difficult to displace. Customers can leave and rivals can offer better solutions, so the advantage survives only while the incumbent continues providing enough value to retain them. That differs from an advantage sustained by political privilege or coercive restrictions that prevent alternatives from being offered.

Even a moat earned through superior problem-solving is not permanent. Innovation can alter an industry's economics and turn the knowledge, assets, and practices that once protected an incumbent into liabilities.

Adaptability: Creating New Knowledge

Newspapers illustrate this vulnerability. For decades, a city's leading newspaper often held a dominant local position, supported by economies of scale in printing and distribution and network effects between readers and advertisers. The internet dramatically lowered the cost of distributing content and shifted advertising spending toward digital platforms. Newspapers retained much of their knowledge of journalism and local markets, but that knowledge was no longer enough to sustain the competitive position built around the old model.

Historical results can inform expectations about the future, but they need to be explained rather than simply extrapolated. The important question is whether the advantages that produced them will remain useful as conditions change.

Amazon provides a useful contrast. Jeff Bezos recognized that the internet could give people access to a much larger selection of products and make them easier to find and compare. Amazon's retail business expanded from books into other categories while remaining focused on enduring customer problems: limited selection, high prices, and slow delivery. Solving those problems has no obvious endpoint. They give Amazon a reason to keep investing in fulfillment, software, logistics, and new services while developing new knowledge about how to serve customers better. That culture of continual improvement does not make Amazon immune to disruption, but it has encouraged the company to revise or replace existing methods as it develops better solutions to those enduring problems.

Moats and adaptability address different but related risks: a moat protects existing earning power, while adaptability helps a company improve existing solutions or develop new ones. Warren Buffett has generally preferred businesses with durable moats that do not require continual reinvention. Berkshire's experience with newspapers shows, however, that even a genuine moat can erode when innovation changes the economics supporting it. The most enduring businesses therefore combine hard-to-reproduce knowledge with a culture that does not treat existing advantages as permanent.

For investors, a moat can often be assessed through current customer behavior and economics. Adaptability is harder to judge because it concerns problems not yet recognized and solutions not yet created. Investors can still ask whether a company's existing practices can be questioned, new approaches tested, mistakes acknowledged, and resources redirected. These qualities do not guarantee successful adaptation, but they improve a company's ability to keep solving customer problems as the world changes.

INVESTING IN A DYNAMIC SOCIETY: DECISIONS UNDER UNCERTAINTY

Dynamic societies give people the freedom to continually create new knowledge, but neither the content of that knowledge nor the changes it will bring can be predicted in detail. Investors must therefore allocate capital without knowing precisely how a business or its industry will evolve.

Conjecturing Investment Theses: Good and Bad Explanations

Every investment thesis is a conjecture, but not every conjecture is equally useful. Deutsch argues that a good explanation is hard to vary: its details are constrained by what it explains and cannot be altered arbitrarily without weakening it. A bad explanation can be changed freely while still seeming to account for almost any outcome.

The value of a business ultimately depends on the cash it can distribute to owners over its remaining life. A thesis that does not connect the price paid to those future cash flows is speculation, as I define it. At its simplest, speculation depends primarily on the hope of selling an asset to someone else at a higher price, while investing involves owning a business for the cash it can ultimately produce.

There is nothing inherently wrong with speculating or, for that matter, gambling. The important thing is recognizing which activity you are pursuing. Some examples of speculation include buying stocks with money needed soon and therefore depending on a favorable near-term sale price, relying on other investors to become more enthusiastic and pay a higher valuation multiple, or expecting a historical price pattern to repeat. A historical chart pattern alone does not explain why a price relationship should persist, and a thesis that changes its pattern, time period, or metric to fit a desired conclusion is easy to vary. Without an explanation for why one relationship should matter more than another, there is no basis for choosing among them.

If the intent is to invest rather than speculate, there is no need to guess where share prices will move in the near term. A useful filter is to ask: "If I bought shares in this company and had to lock them in a vault for ten years, unable to sell them, would I still want to own the business?" This shifts attention from price movements to what a good investment thesis must explain. I generally place theses that depend on correctly predicting the timing and effects of Federal Reserve policy, recessions, or military conflicts in my "too hard" pile. Those events can affect the intrinsic values of businesses, but their timing and effects depend partly on future choices and knowledge that has not yet been created. Even if I could predict the events themselves, I would still need to determine how they would change the attractiveness of a particular investment relative to other available uses of capital.

The vault thought experiment also helps explain why I favor businesses whose long-term cash generation rests on hard-to-replicate advantages. Commodity-like businesses may not look so cheap, even at low valuation multiples, when the thesis must rely on the cash they can return to owners over time. Rapid growth alone does not solve this problem. Growth eventually slows, and without a moat, high returns on capital attract competition that tends to push those returns toward more ordinary levels. Businesses in fast-changing technology markets present a different problem: their business models and apparent advantages may not have been tested enough to judge whether they will endure.

A good investment thesis uses explanations to form expectations about future cash generation while making clear what those expectations depend on and what could undermine them. It does not require predicting every development in the business or its industry. It explains how the business creates and retains value: the problem it solves for customers, why customers choose its solution over alternatives, what makes that solution difficult to replicate, and what could strengthen or weaken its position as competition, technology, and customer needs change. It then connects these factors to the economics of the business, including its opportunities to scale and reinvest, the capital required to do so, the cash it can ultimately generate, and how management is likely to allocate it.

Buying a stock because it appears undervalued means judging that the present value of the cash it can ultimately distribute to owners exceeds the price being asked. This is the contrarian element of the decision: the investor considers their assessment of the business more persuasive than the assumptions implied by the market price. Since that judgment remains conjectural, a thesis's key assumptions must be explicit enough to be criticized as new evidence and competing explanations emerge.

Criticizing Investment Theses: Explanations and Evidence

Criticism begins with the conjecture itself. Is it internally consistent? Does it conflict with relevant facts or other explanations that have survived criticism? Are important assumptions arbitrary or easy to vary? Is there a competing explanation that accounts for the same observations at least as well? These questions can expose weaknesses before any new evidence is gathered.

Evidence provides another source of criticism. Historical growth, margins, market share, and other business results can reveal problems with a thesis, but they are not the thesis itself. They describe what happened, not why it happened or whether the factors that produced those results will persist. Further, the same facts can be consistent with different explanations.

When two competing explanations survive those initial criticisms and appear to account for the same observations equally well, additional evidence can help distinguish between them. Consider a company that repeatedly lowers prices. One explanation is that competition is forcing it to cut prices because it lacks pricing power. Another is that its scale lowers unit costs, allowing it to pass some of those savings to customers. The price cuts alone are consistent with both explanations.

The next step is to identify what each explanation would lead us to expect. If sharing the benefits of scale gives customers a stronger reason to choose the business over competitors, lower prices should increase demand and further reinforce its scale and cost advantage. If customer adoption and volumes rise, unit costs fall, and returns on capital remain attractive, the scale-advantage explanation survives an important test. If price cuts fail to generate enough additional volume to lower unit costs while returns on capital deteriorate, the lack-of-pricing-power explanation may better account for what is happening.

Even then, a period of better- or worse-than-expected performance does not automatically prove or disprove a thesis. That does not shield the thesis from criticism. Whether an outcome undermines it depends on what the thesis claimed and why the results differed from expectations. Businesses operate within complex, dynamic economies, and even the most successful rarely produce results that move smoothly up and to the right. Worse-than-expected performance nevertheless creates a new problem: why did this happen, and what does it reveal about the thesis?

The discrepancy may reflect temporary circumstances, incomplete data, or a mistaken interpretation, but any such explanation must remain open to criticism and account for the evidence better than the alternatives. A claim that a setback is temporary should also explain what caused it, why the thesis's central claims remain intact, and what should happen when the condition passes. In other cases, the result may expose an important error or make a competing explanation more persuasive. A thesis cannot be altered after every disappointment merely to preserve the original conclusion. The goal is not to defend it, but to improve or replace it when a better explanation emerges.

Changes in stock price should be considered separately from evidence about the underlying business. A rising share price does not validate the investment thesis, just as a falling price does not invalidate it. What changes directly is the prospective return available at the new price. A large price movement may prompt further investigation because it could reflect information I have missed, but the movement itself does not explain what changed.

When company results are weaker than expected and the share price also falls, I ask two questions: How much should the new information change the thesis and my estimate of future owner cash flows? After making that adjustment, how much has the lower price changed the prospective return? A business can become less valuable while its stock becomes more attractive if its price falls by more than the estimated decline in value. The reverse can happen when a business performs well but the stock appreciates enough to leave little room for an attractive return.

This approach to investing is a continuing process of problem solving: developing explanations for how businesses create and retain value, exposing those explanations to criticism and testing them against evidence, comparing the estimated value of each business with its market price, and revising decisions as new problems emerge.

INVESTING THROUGH TECHNOLOGICAL CHANGE: ARTIFICIAL INTELLIGENCE

This philosophy is especially useful for evaluating investment opportunities amid the rapid technological change that dynamic societies make possible. Recognizing that a new technology may transform society is not enough to identify a good investment. Which businesses ultimately succeed, what advantages they develop, and how much value they capture will depend partly on knowledge that has not yet been created. That limits what investors can reasonably assess today.

Warren Buffett illustrated this challenge in a [1999 *Fortune* article](#) published near the height of the dot-com exuberance. He noted that at least 2,000 companies had entered the automobile business in the United States, yet by the 1990s only three U.S. car companies remained. The paths leading to those eventual survivors were far from straightforward. Henry Ford's first automobile company failed. General Motors' rapid acquisition spree left it financially strained and cost founder Billy Durant control of the company in 1910. Chrysler emerged from the reorganization of the troubled Maxwell Motor Company in 1925. Automobiles transformed society, but recognizing their importance was far easier than identifying in advance which companies would survive or generate attractive returns.

Artificial intelligence presents the same challenge today. Both the technology and the surrounding industry are changing so rapidly that it is difficult to predict where either is headed. Today's AI emerged through a series of innovations that built on earlier advances in ways that were difficult to foresee. NVIDIA developed GPUs for video game graphics in the late 1990s and later introduced CUDA, which allowed developers to use those GPUs for general-purpose computing. AlexNet demonstrated the value of GPUs for training deep neural networks, then Google researchers introduced the transformer architecture, and OpenAI used that architecture to create increasingly capable large language models.

That progression looks more straightforward in hindsight than it did as it unfolded. Few people anticipated that chips originally designed for video game graphics would ultimately become central to training large AI models, let alone the range of tasks those models would eventually be able to perform. Nor did many expect ChatGPT, released in November 2022, to bring AI to a mass audience and help drive a surge in demand for computing infrastructure.

Uncertainty about where the technology is headed, combined with the rapid improvement and apparent intelligence of current AI systems, has led to dramatic predictions, ranging from widespread job losses and economic disruption to superintelligent systems escaping human control.

On the fear about jobs, new technologies created by people have always changed the type of work people do by taking over tasks that can be mechanized or automated. AI, in this sense, is no different from any other technology. Automating existing tasks does not mean running out of problems worth solving. With the help of new and better technologies, people are better able to devote more of their time and energy solving new and more interesting problems that require further creativity.

That brings us to the other fear: could AI advance to the point that it will be able to create new explanatory knowledge and therefore become artificial general intelligence (AGI)? [Deutsch has argued](#) that AGI must be physically possible, but that creating it will require understanding how creativity works, not merely improving tasks that use existing knowledge. For example, a system given only the knowledge available before Darwin or Einstein would need to be capable of conjecturing new explanations, such as natural selection or relativity, rather than reproducing theories that already exist. The unresolved problem in creating AGI is how to write a program with the capacity for creativity. [Deutsch has also argued](#) that AI is actually moving in the opposite direction of AGI because its outputs are becoming increasingly specialized at prescribed tasks, when creativity requires open-ended, undefined outputs that were not previously anticipated by the original programmer.

Whatever the path to AGI, AI does not need to cross that threshold to be economically transformative. By making existing knowledge easier and cheaper to apply, it can lower the cost of producing many goods and services and expand what people can accomplish. Like electricity or the internet, it may also enable businesses to develop products and services that are difficult to imagine today. The harder question for investors is how the resulting economic value will be divided among customers, companies supplying the technology, and businesses applying it.

Although I remain fascinated by AI, I have found it difficult to form well-grounded expectations about what many businesses built around it will look like in ten or twenty years. It is unclear to me which business models will endure or what AI capabilities will develop. The same questions I ask of any investment opportunity still apply: What problem does the company solve? How does AI improve its solution? What makes that solution difficult to replicate? Who captures the resulting value? What expectations are already reflected in its stock price?

NVIDIA illustrates how those questions can be examined through knowledge and competitive advantages that already exist. Its hardware, CUDA software ecosystem, and relationships with developers embody knowledge accumulated and tested over decades. Those advantages help explain why NVIDIA has captured substantial value from the growth of AI it has helped enable. Of course, the key for investors was recognizing those advantages and the value NVIDIA could capture before they were fully reflected in its share price. Any current thesis must still address whether alternative chips and computing architectures could weaken its position and whether its expected future earning power offers an attractive return at today's price.

The more a thesis depends on capabilities, products, or industry structures that do not yet exist, the more important it is to distinguish what can be explained using existing knowledge from what requires discoveries that have not yet been made. Investors' ability to form useful expectations depends on how well they can explain where future cash flows will come from and what could prevent them.

A U.S. Treasury bond contractually specifies its payments in advance, making the nominal cash flows relatively predictable if held to maturity. With a business like Coca-Cola, investors must assess why customers will continue finding its products a better solution to their problems than the alternatives, and how serving those customers will generate cash that can ultimately be returned to owners. A startup with a promising idea may still need to develop a working product, attract customers, and establish that it can serve them profitably. These differences in what investors can reasonably explain about future cash flows influence whether to invest, the price to pay, and the amount of capital to commit.

Early in a technology's development, companies are still discovering which products and business models will work and what durable advantages will emerge. Many will fail. Venture capital portfolios are structured for this risk, spreading capital across many companies before their products and business models have been extensively tested. Public-market investors can wait until customer adoption, competitive advantages, unit economics, and cash generation become easier to evaluate.

Fortunately, investing does not require predicting the future of every company or identifying the winners of every new technology. Investors only need to find a few businesses whose prospects they understand well and whose shares can be purchased at attractive prices relative to those prospects.

WHAT THIS MEANS FOR INVESTORS

People create wealth by developing explanatory knowledge and applying it to solve problems. Dynamic societies accelerate that process by preserving the freedom to criticize existing ideas, experiment with alternatives, and correct errors peacefully. Businesses apply useful knowledge to solve problems for customers. Moats allow them to retain some of the value they create, while adaptability enables them to preserve what works and improve or replace what does not.

For the Saga Portfolio, this means looking for businesses that solve important customer problems in ways competitors cannot easily replicate, can adapt as conditions change, and are priced attractively relative to the cash they may ultimately generate for owners. The explanations for owning them remain open to criticism and may need to change as new problems and evidence emerge.

AI does not overturn this framework. Its economic consequences will depend on the problems it solves, which businesses use it effectively, and who retains the value created. Investment returns will also depend on what expectations are already reflected in market prices. The future cannot be predicted in detail because it will be shaped by knowledge that has not yet been created. That uncertainty does not prevent sound investing. It makes good explanations, attractive prices, and a willingness to correct mistakes all the more important.