

Technology Report 2023

Reset and Reinvent: The Thriving Landscape of Tech Innovation

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Reset and Reinvent: The Thriving Landscape of Tech Innovation

By David Crawford



Technology thrives on innovation, and today, the sector is in a period of renewal and reinvention. Tech is healthy, vibrant, and moving forward assertively, driven by strong global demand and broad interest in new technologies.

What looked like a slowdown was actually a reset. After the Covid-19 spending bubble, demand slowed, valuations fell, and profitability mattered again. The sector responded, cutting costs and laying off thousands, then bounced back quickly with market caps near peak levels again (*Figure 1*).

This rebound rides on optimism. Technology is increasingly central to everything we do—personally, professionally, and as a society. Even during periods of economic uncertainty, companies continue to invest in technology (*Figure 2*). Large language models and generative AI represent the most significant disruption since the Internet. The need for resilience in supply chains is creating capacity in new places. These are the investments that will propel and reshape the tech sector in the years ahead.

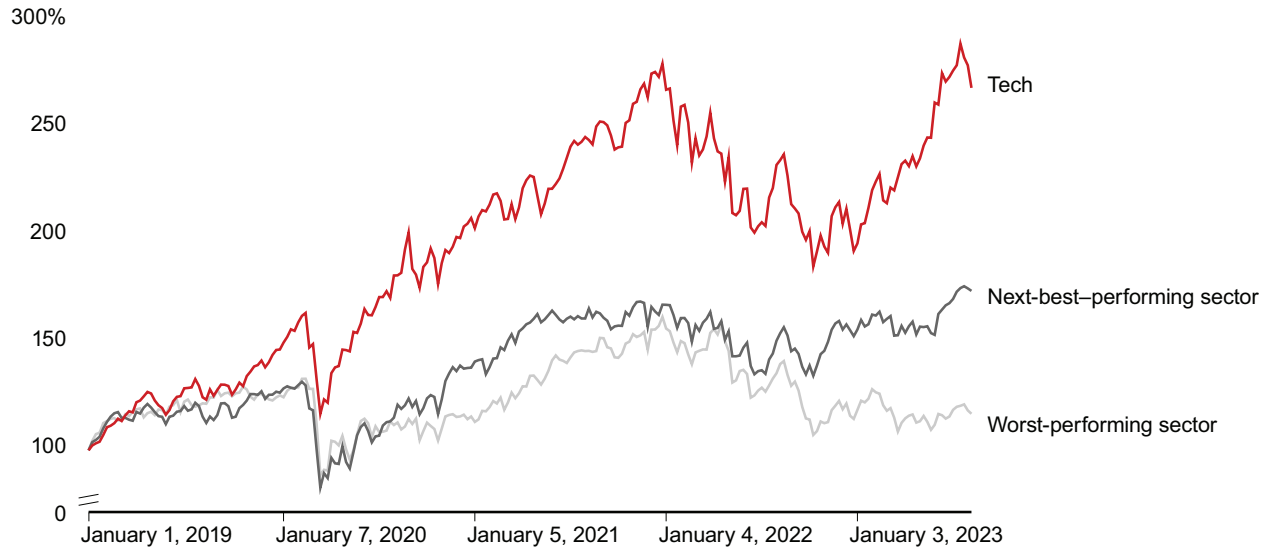
A handwritten signature in black ink, appearing to read 'David Crawford'.

David Crawford

Leader of Bain's Global Technology Practice

Figure 1: The technology sector bounces back

S&P 1500 aggregate market cap, weekly percentage change



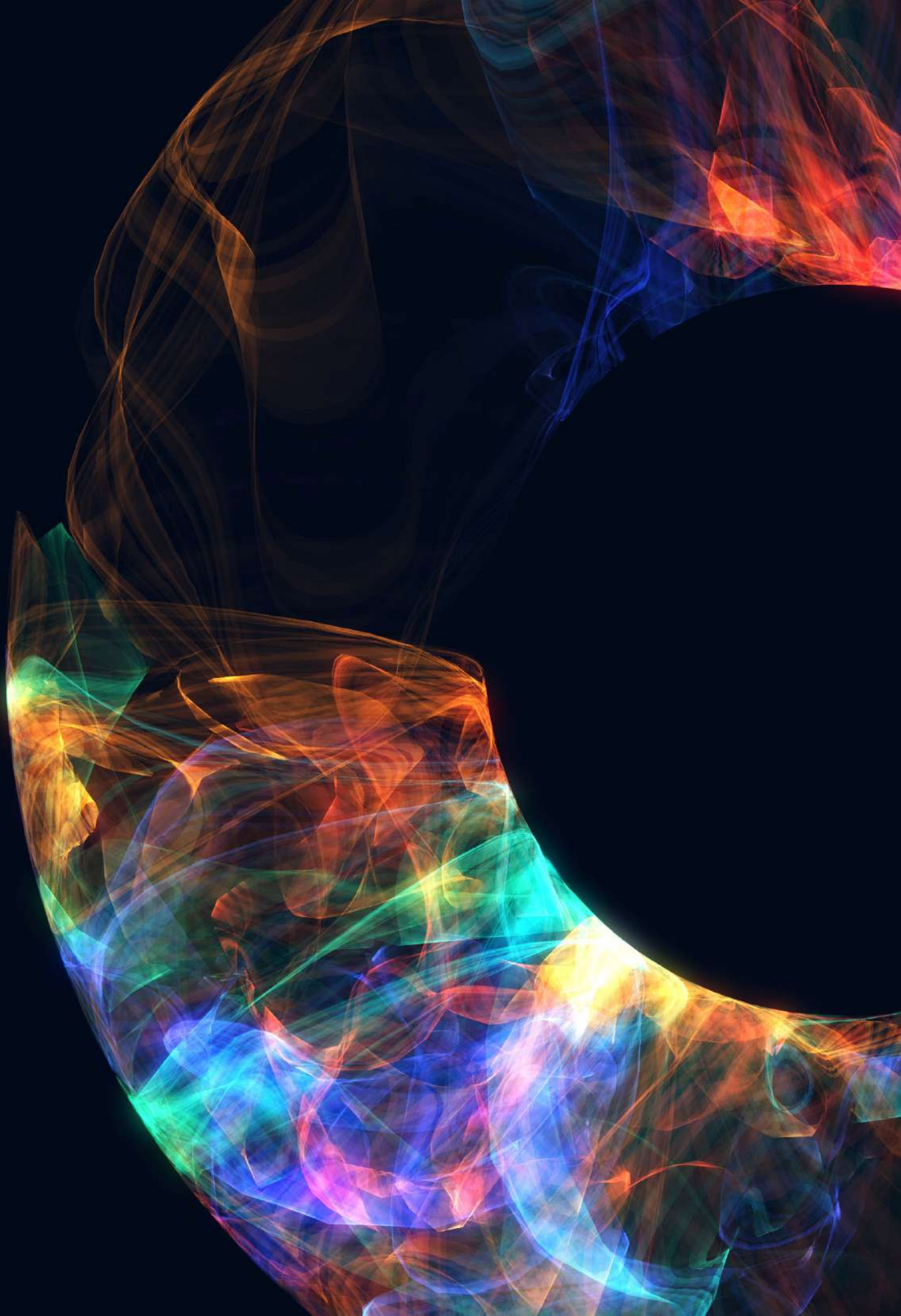
Note: Based on Wednesday closing prices
Sources: S&P 1500 composite sector data; Bain & Company

Figure 2: Most CIOs still aren't decreasing their budgets

Percentage of CIOs who say that their budgets are flat or increased



Source: Bain IT Decision Makers Survey (July 2021 n=150; August 2022 n=200; August 2023 n=151)



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Value Evolution

Creating Value in Tech Throughout the Life Cycle

Driving returns depends on how far down the road you are.

By David Crawford, Matthew Crupi, and JF Van Kerckhove

At a Glance

- ▶ In the tech sector, investors are attracted to young, disruptive companies based on their growth potential.
- ▶ As companies and their markets mature, investors expect a mix of growth and returns.
- ▶ Mature companies with a proven track record in stable markets can expect slower growth while their investors are closely focused on profitability and return on invested capital.
- ▶ Understanding where your company is in its life cycle and signaling expectations to the right group of investors is essential for attracting the capital that companies need to operate.

Over the past five years, as technology companies have navigated through volatile supply-and-demand shocks (Covid-19, supply chain constraints, recession, inflation) and uncertainty on financing (higher cost of capital, closed equity markets), many have focused on growth at any cost. Their attention is shaped by the common belief that, in tech, growth matters most in creating value for shareholders.

The truth is more nuanced: Shareholders reward tech companies differently based on a company's context and point in the life cycle. For more mature companies, their return on invested capital (ROIC) can matter much more. As markets mature, they also attract more conservative investors, who then pressure companies to turn toward more predictable, profitable opportunities. This then limits further growth and investment in the business and attracts a new breed of value investor who cares about stable revenue streams, reinforcing this cycle.

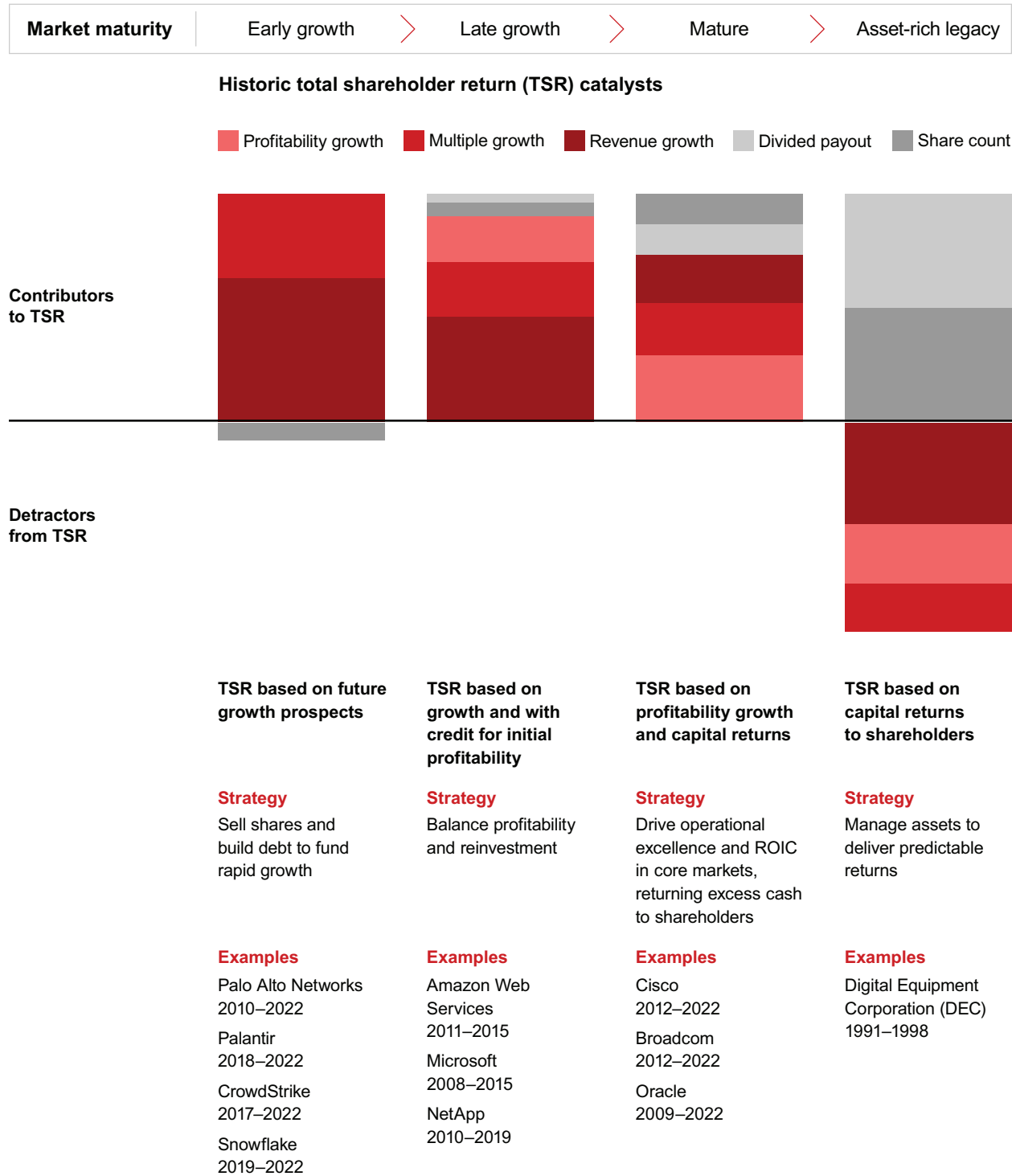
As markets mature, they also attract more conservative investors, who then pressure companies to turn toward more predictable, profitable opportunities.

When determining a company's value, investors often turn to total shareholder return (TSR), a financial metric that indicates the total amount an investor reaps for an investment. TSR has a few fundamental factors that measure strategy and operations (for example, revenue growth, profitability, and capital efficiency); investor sentiment (multiples); and capital structure (debt-to-equity ratio, buybacks, and dividends). The weight of these factors differs as companies and their markets pass through life stages with different growth rates (see *Figure 1*).

- Early-growth markets may be small, but they are growing fast, disrupting existing industries or creating new ones. Speed and innovation are essential for related businesses as they establish their market position. Revenue growth and future prospects drive TSR, creating value for venture investors who invest to scale new champions.
- Late-growth markets still benefit from robust growth as they expand and stabilize. TSR is based on growth, with credit for initial profitability as investors look for growing companies with proven economic viability and scalable profitability.
- Mature markets are relatively stable, with single-digit growth expectations. An incumbent's share position may vary by only a few basis points a year. Investors focus on profitability and ROIC. Growth is less important, valued only if it's efficiently funded.
- Asset-rich legacy markets may be fighting the gravitational pull of shifting customer needs. Investors expect highly predictable returns with low to no tolerance for risk.

Once a company is within a given stage of market maturity, it is important to maximize the sources of TSR specific to that phase. Although these phases seem logical, too many companies in late-growth and mature markets downplay the importance of profitability and ROIC. Growth still matters, but profitability and capital efficiency may create more value.

Figure 1: The catalysts for total shareholder returns differ according to a company's stage in the life cycle



Note: DEC start date is year of first reported annual loss, and end date is year of Compaq acquisition
 Sources: S&P Capital IQ; Bain analysis

Companies in late-growth and mature stages should be improving the efficiency of generating revenue by:

- rethinking which markets are most attractive;
- reducing portfolio complexity and adopting design-to-value principles to match customer needs;
- revisiting ways of working to improve productivity (including AI and automation);
- deploying new business models based on asset-light solutions;
- pursuing M&A where operational synergies are clear; and
- reinvigorating a lean core to ensure new growth.

Moving back upstream to higher-growth phases can be extremely difficult. Few tech companies, apart from Apple, have produced successful second acts in unrelated adjacencies, but Adobe, Microsoft, Nvidia, and others have renewed themselves with an upstream shift by reigniting and modernizing the core. Late-growth companies such as Amazon have also successfully unleashed Engine 2 catalysts, generating a second wave of growth.

Interest rate hikes have increased the cost of funding, so shareholders are watching returns on capital more carefully and rewarding companies that understand when to reinvest in the business, when to use capital more efficiently, and when to return capital.

As businesses grow, their investors and valuations tend to reflect the maturity of their core business. Sometimes, smaller, less mature businesses trapped within the bigger company are not properly valued by the market—a fact that’s often pointed out to boards by activist investors rather than management. Portfolio restructuring can unlock value and help match these businesses with the right investments.

Companies should be proactive in shaping their investor base, targeting the type of investors they want and tailoring communications to them. Amazon did this by signaling its intent to deprioritize profit in favor of continually reinvesting in the business. By clearly communicating these priorities, Amazon was able to set expectations and attract growth-oriented investors who supported this reinvestment rather than conservative investors who would not have rewarded this strategy.

To maximize value, strategies for growth, capital allocation, and investor relations should change over time as markets mature. Shaping the investor base and communicating clearly to set expectations are essential to ensure investor support, whether growing the core business, searching for a new engine of growth, unlocking hidden assets, or improving capital efficiency. Understanding the roles among market maturity, investor expectations, and sources of TSR is essential to deliver shareholder value at every step of the journey.



Value Evolution

Preparing for Exit: A Buyer's Market Is Coming for Tech Assets

A backlog of portfolio investments is likely to come to market when deal activity picks back up.

By Brian Kmet, David Lipman, Christopher Perry, Jen Smith, and Colleen von Eckartsberg

At a Glance

- ▶ Reduced exits, extended hold times, and steady dry powder reserves point toward an incoming wave of tech asset exits that will create a crowded, competitive buyer's market.
- ▶ Firms that have prepared to stand out will fare better than average, while others may struggle to sell mature assets in their portfolio.

The volume of technology deals has slowed since mid-2022 for a number of reasons, including limited debt availability amid rising interest rates and declines in asset values that have left buyers unable to meet sellers' asking prices. Successful deals have relied on greater equity contributions (with expectations to refinance later), partial equity sales to fund growth, and a greater proportion of add-ons rather than standalone or platform assets. Overall, the pace of tech deals since the third quarter of 2022 continues to be slow, in line with the broader deal market.

Exits are also down—on average, about \$20 billion per quarter in the first half of 2023 compared with \$107 billion per quarter in the first half of 2021 and \$75 billion per quarter in the first half of 2022. A growing backlog of deals, including more than \$700 billion of tech assets purchased between

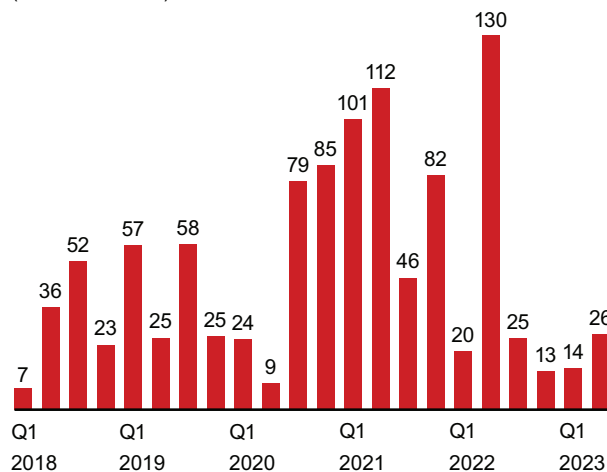
2018 and 2021 (see Figure 1), has led to longer hold times of tech portfolio companies. In 2023, nearly half of tech portfolio companies have been held for more than four years, and 15% have waited more than six years. For the first time since 2012, more than 40% of tech portfolio companies are being held for more than four years (see Figure 2). This backlog of long-held portfolio assets is growing more quickly than the mountainous level of dry powder that is holding steady, which will create a buyer’s market when activity picks up (for more, read Bain’s “Stuck in Place: Private Equity Midyear Report 2023”).

The backlog of long-held portfolio assets is growing more quickly than the mountainous level of dry powder that is holding steady, which will create a buyer’s market when activity picks up.

Figure 1: Tech deals have slowed over the past year, and a backlog of deals points to a coming buyer’s market

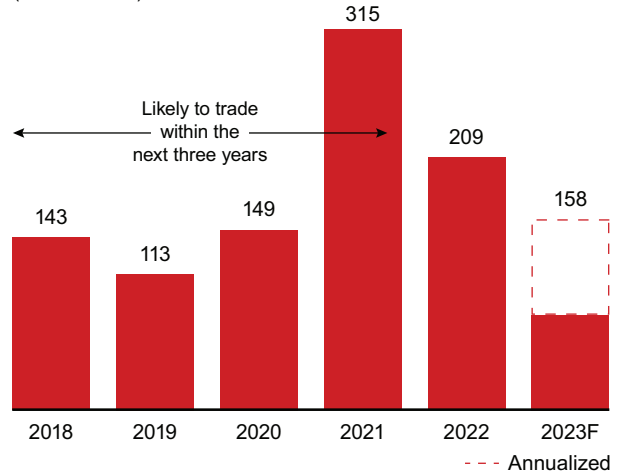
Following buyout frenzy in 2020–2021, exits have slowed

Global tech sector buyout exit value, in billions of US dollars (2018–2023YTD)



A backlog of deals will come to market when demand recovers, including more than \$700 billion of assets that traded between 2018 and 2021

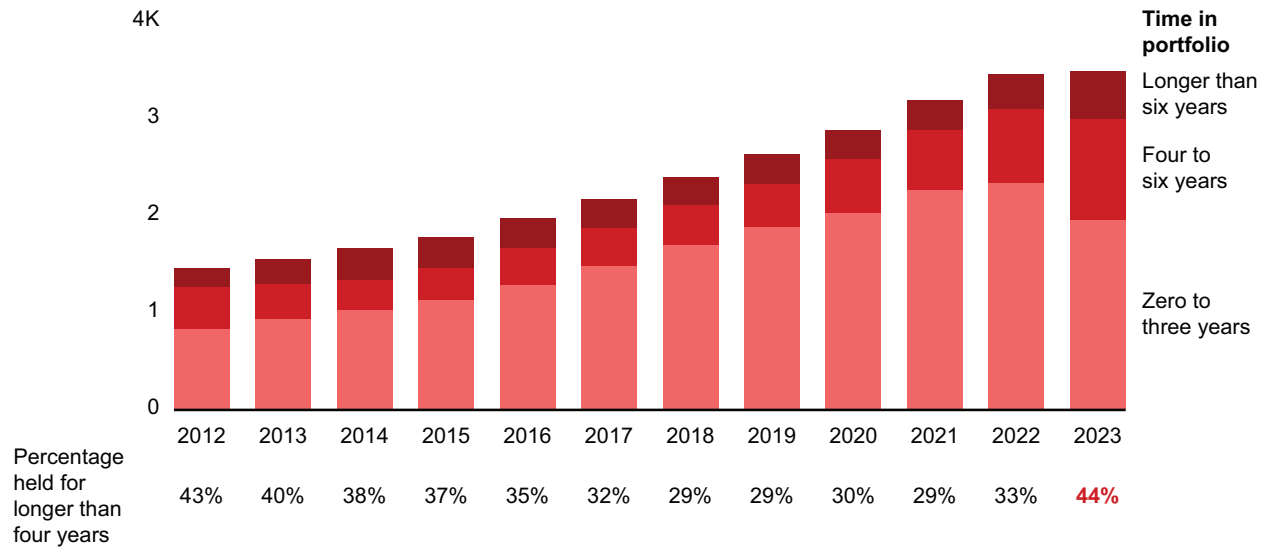
Global tech sector buyout deal value, in billions of US dollars (2018–2023F)



Notes: YTD after year stands for year-to-date; F after year stands for forecast
Source: Dealogic (as of July 5, 2023)

Figure 2: Nearly 45% of current tech portfolio companies have been held for longer than four years

Number of tech buyout-backed companies by time in portfolio (global)



Note: Data aggregated by year of investment and time in portfolio
 Source: PitchBook (as of March 31, 2023)

How to add value

With multiples trending downward and a competitive market on the horizon, investors should focus on adding value to existing assets by growing earnings, redefining operational processes that may have been ignored for a while, raising efficiency with new tools, and seeking new areas of growth. Within software, we see several interdependent trends.

- **Focus on margin improvement:** As market valuations have declined, investors have shifted focus from growth at any cost to rewarding profitability. To expand margins, companies need to build scale, increase automation, and boost productivity—all while managing the costs of growth. Operational metrics and benchmarks become more important as companies eliminate low-value work, automate less-complex tasks, and explore offshore opportunities.
- **Address weaknesses in the go-to-market model:** A slowing economy has renewed the focus on sales and marketing capabilities. By synchronizing sales, marketing, ops, and product functions, companies can design focused, repeatable sales plays. Additionally, the emergence of product-led growth lets software companies engage customers with a self-service model (for more, read the Bain Brief “What It Really Takes to Develop Product-Led Growth”).

- **Evaluate AI-driven disruption and efficiency improvements:** The recent boom in consumer AI usage and business-to-business applications has led to a variety of new use cases, specifically in two key areas: R&D and enablement tools. Portfolio companies are evaluating the potential of generative AI, and they are focusing their R&D efforts on areas of growth while pulling back on distractions (for more, see the related chapter in this report, “AI Investors: Act Fast, Act Wisely”).
- **Consider new growth vectors:** Companies are developing the next phase of their growth strategies, which should include adjacencies, new regions, and buy and build through M&A.

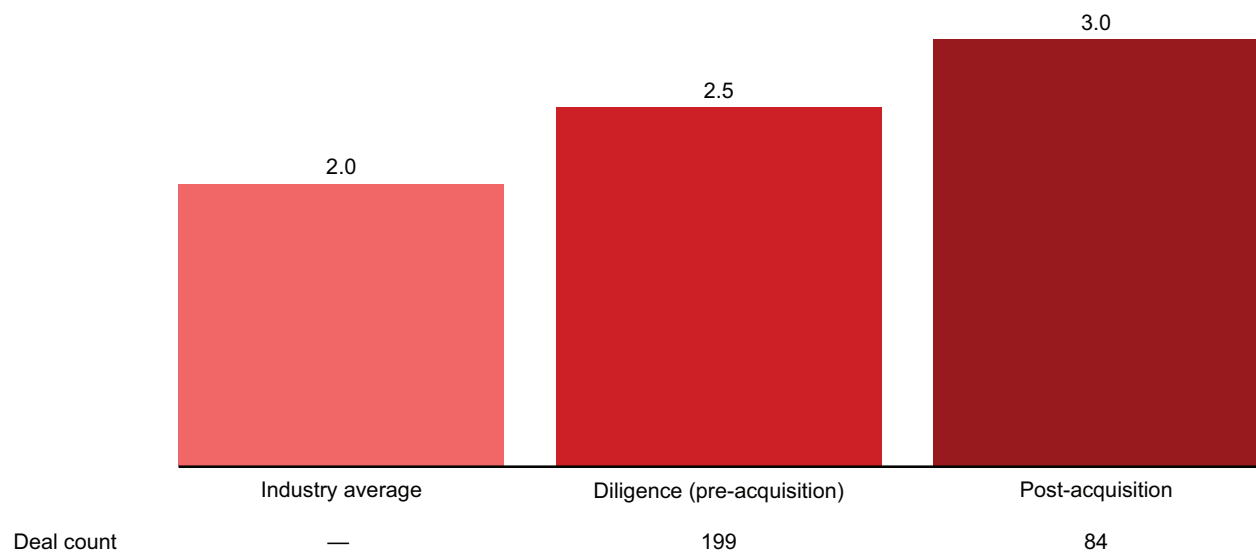
When to add value

Portfolio activism pays off at any point in the investment process, from early-stage due diligence to preparing for exit. We have seen better-than-average returns, up to three times multiple on invested capital (MOIC), with post-acquisition activism (see Figure 3).

The biggest returns come from engaging early, as close to day one as possible, as well as engaging later, with plans to move from good to great before an exit.

Figure 3: Post-acquisition portfolio actions can deliver up to a three times multiple on invested capital

Average multiple on invested capital for investments by type of effort



Sources: Bain coinvestment database; Bain Revenue System

- **Engage early to strengthen capabilities.** Setting strategy along with substantial support in capability-level execution can improve earnings and boost the exit price.

One example of adding value soon after acquisition comes from a software-as-a-service company offering critical data and communications IT software for business clients that wanted to develop a plan for efficient growth. The company started by identifying prospects and developing a channel strategy that shifted focus to its highest-priority accounts. Among other actions, the company diagnosed sales coverage, accelerated the sales pipeline, and assessed discounting and price increase practices in order to maximize revenue. A detailed diagnostic across marketing channels helped it differentiate its message and target the right audience. Online, it ran structured A/B tests and improved the way it measured lead tracking and revenue projections, using benchmarks from OPEXEngine to compare performance across industries. Through these actions, the company identified opportunities to raise earnings by about \$40 million, mostly through price increases and new market leads.

- **Engage later with targeted actions.** For companies already performing well, strategic investments that raise their game from good to great can deliver the greatest punch—on average, a 50% increase in MOIC within a year of targeted engagement, mostly from the work leading to a successful exit at an attractive price.

For example, one educational technology company, a leading provider of online test and assessment solutions, had already achieved significant organic growth based on the strength of its product. An inconsistent go-to-market approach that included investing too much in accounts unlikely to deliver the necessary returns, however, prevented the company from achieving its full potential.

The company improved its go-to-market strategy to capitalize on its strong product advantage and to gain market share before its sale. It assessed the competitive landscape and redefined M&A objectives to articulate a pathway to further growth. Pushing a faster execution helped the company get more out of its market traction and trajectory, which boosted equity value during the sales process.

These actions took an already remarkable 7 times MOIC at the start of the engagement and raised it to 14 times at exit. A new segmentation of customers offered clarity on service and buying behavior for 13,000 potential customers. The company crystallized its strategy, revisited ideas for adjacency and acquisitions, and improved competitive dynamics to create the right dialogue for exit. Within two years, the private equity owners completed a partial sale of the business, keeping a sizable chunk themselves given their newfound confidence in the business.

Investors and portfolio managers that don't add significant value to their software assets will struggle to sell among a growing slate of mature assets. Tech investors that have done the work necessary to improve earnings are more likely to succeed in the upcoming competitive buyer's market with assets that stand out.

Value Evolution

AI Investors: Act Fast, Act Wisely

Lower barriers to experimentation open the door to more disruption, but incumbents have advantages, too.

By Sanjin Bicanic, David Lipman, Christopher Perry, Gene Rapoport, and Jue Wang

At a Glance

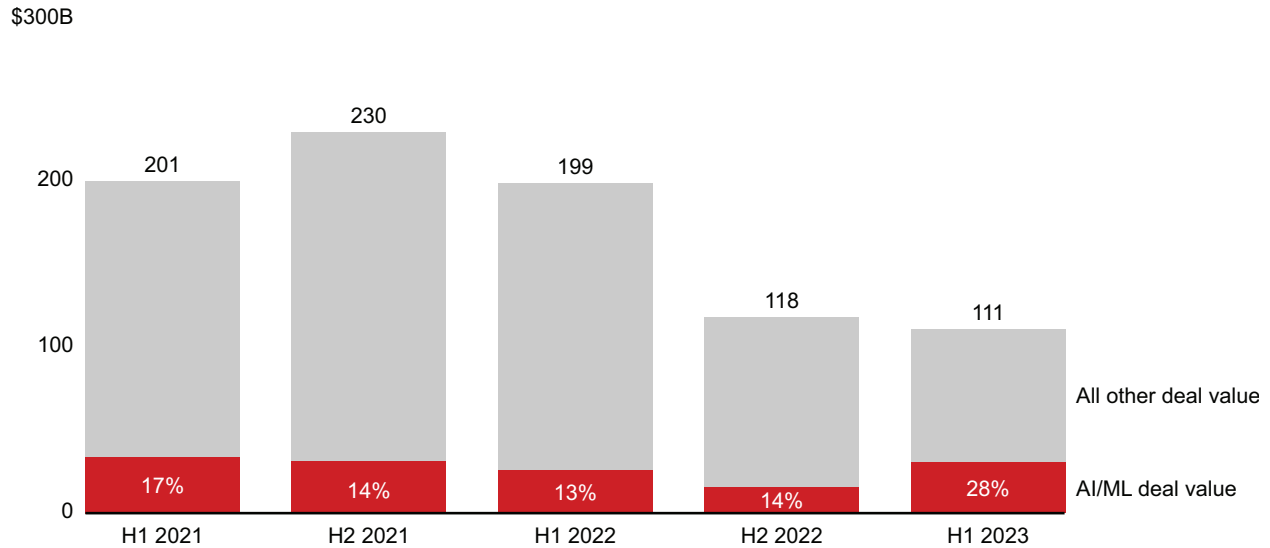
- ▶ Investors' enthusiasm for artificial intelligence is high, with AI and machine learning investments leading venture growth in the first half of 2023.
- ▶ Across industries, AI should increase the productivity of knowledge workers, and software companies already benefit from AI coding assistants.
- ▶ Investors should be assessing risks and opportunities across their portfolios, understanding where technology will create new advantages and where it might lead to share loss.

Investments in technology flocked to early-stage generative AI companies in the first half of 2023, led by Microsoft's \$10 billion investment in OpenAI (see *Figure 1*).

With the potential for sweeping changes to the tech sector, investors are rightly afraid of the ways that generative AI technologies can affect current and future tech assets. The excitement raises a number of possibly overwhelming choices for investors: How will AI affect our portfolio companies? Which business models will change, and what new opportunities will present themselves? How do we adjust diligence criteria for future investments? Are there ways we should deploy generative AI to improve our own internal operations?

Figure 1: Artificial intelligence and machine learning solutions led venture and growth funding in the first half of 2023

Quarterly capital investments in venture and growth stage deals, in billions of US dollars



Note: Data as of July 12, 2023; AI stands for artificial intelligence; ML stands for machine learning
Source: Pitchbook

“Software is eating the world, but AI is going to eat software.”

—Jensen Huang, CEO of Nvidia

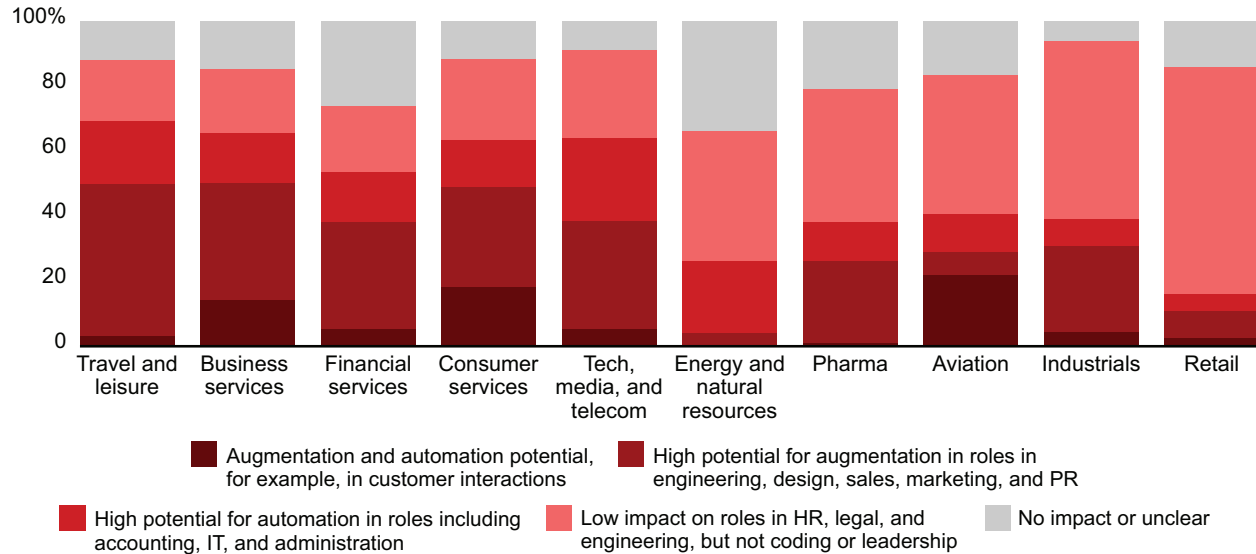
Broad impacts in software

As the nature of human-to-computer interactions evolves, customer expectations are growing. Generative AI-powered chat interfaces for applications and data simplify the user interface, increase the localization and personalization of content, and open new routes to market.

New products will emerge, many of which will automate and augment the work of people in specific roles across sectors (see Figure 2). Software developers, for example, will become more efficient as AI-coding assistants supplement their efforts. Workers in other roles, such as customer support, technical field services, and sales and marketing, could all be augmented by generative AI. Start-ups and other small companies with fewer resources may be able to deliver new products more rapidly when assisted by AI.

Figure 2: Generative AI will have differential impact, depending on the share of automatable and augmentative roles

Percentage of employees by function's level of automation/augmentation potential



Sources: Aura; Bain analysis

Experimentation also becomes easier, and barriers to entry are lower given reduced development costs and democratized foundation models at enterprise companies' disposal. With lower barriers to entry, cycle times come down, requiring incumbents to act quickly to capitalize on the advantages of differentiated data assets, entrenched customer access, and integration into user workflows.

Generative AI, however, introduces both opportunities and risks—for example, new AI features, such as a ChatUX, make it easier for users to engage with a company's product, but risks also emerge as users seek out other AI-enabled applications that might better address specific use cases, potentially reducing market share.

Competitive landscape implications

Although most investors agree that AI will have a significant effect on the tech sector, the evolution of the competitive landscape remains to be seen.

Tools and enablers. Large language models (LLMs) and other foundation model providers are likely to consolidate, forming a few winners in each category. Open-source models are likely to be part of the evolving landscape, too. We also expect more consolidation for tools supporting generative AI—including cloud providers, system integrators, and specialized semiconductors—as a result of the

rising R&D investment required to maintain the pace of innovation. Many of today's largest tech companies will benefit, and leaders, including cloud service providers, OpenAI, and Nvidia, are already seeing record-breaking growth.

For other generative AI tools and enablers (including data and systems and services that facilitate the use of AI), the story is more nuanced. With few incumbent or leading providers, a large number of early-stage companies are likely to arise to provide support for building LLM-based apps in categories such as data management, storage and process capabilities, and AI implementation services. These tools may eventually consolidate as larger platforms eventually provide these services in-house.

Software applications. Beyond tools and enablers, there will be winners and losers among software applications innovating on new and existing use cases. With broad and inexpensive access to democratized foundation models, a flurry of early-stage players will likely develop innovative use cases using existing foundation models. These will include vertical and horizontal applications for use cases that weren't previously possible.

With broad and inexpensive access to democratized foundation models, a flurry of early-stage players will likely develop innovative use cases using existing foundation models.

Among incumbents, software companies that learn to deploy generative AI technology in relevant markets are likely to emerge as winners. Unlike the transition to cloud, the benefits of AI can often be realized without investing in major overhauls of company platforms. On balance, this favors incumbent software providers that have access to data, customer relationships, and a track record of execution. Customer access and customer data protects incumbents from disruption by new competitors and start-ups, but sustained market leadership will depend on how incumbents adopt generative AI to make their products and operations better.

A healthcare IT company encountered this situation as it evaluated opportunities to use generative AI across its product suite. Larger competitors were quickly harnessing generative AI, potentially putting the healthcare IT company's areas of differentiation at risk. Its position as a specialized provider could be threatened as customers begin to use generative AI tools and consider a broader set of vendors with features that would make their daily operations more productive. To counter those risks, the company set out to rapidly embed generative AI features that would enhance the customer experience and further differentiate its products.

How can funds avoid disruption risks?

Top funds aren't waiting to see how generative AI changes this space. With shorter cycle times and lower barriers to entry, incumbent advantages will dissipate if they don't act now.

In assessing whether a market will face significant change from generative AI, investors must consider both disruption potential and structural barriers in the market. Does generative AI have the potential to replace or augment human effort, improve product quality, or reduce costs? What are the structural barriers to entry? Are there legal restrictions or sensitive data involved?

In assessing the company's ability to capitalize on these opportunities, investors must consider whether they own proprietary data that could enrich generative AI applications. Is the company's pricing model set up to capture value from generative AI, or will it face pricing pressure? Do you have the talent to execute—and if not, where can you find it? What defensible moats, such as customer stickiness and brand awareness, can you lean on?

By understanding the overall potential for change in markets from generative AI and the ability of assets to navigate that change, top funds are biasing toward action to capitalize on the potential of their incumbent software assets.



Value Evolution

Technology Enters Its Post-Globalization Era

How tech companies are relocating manufacturing, R&D, and talent for resilience.

By Karen Harris, Anne Hoecker, Christopher Schorling, Balaji Thirumalai, and Jue Wang

At a Glance

- ▶ Tech companies are diversifying their supply chains, R&D locations, and talent pools in order to build resilience against global shocks.
- ▶ The semiconductor industry, for example, is responding to government incentives to make large, long-term investments in fabs in the US, Japan, and Germany.
- ▶ These changes will create new technology hubs and shift the competitive landscape—partly as a result, the hiring of engineers is accelerating in India and Europe.
- ▶ A decade from now, the global footprint of the technology value chain is likely to look very different, but companies should be evaluating their options today.

The shocks of the past few years have awakened tech companies to the risks of restrictive policies and export controls. Most are now moving rapidly to build resilience into their supply chains, primarily by expanding their geographic footprints and creating more flexibility within their talent pools.

Investing in resilience is costly and could take decades. But the good news is that resilience doesn't mean 100% risk aversion—an approach that would be too expensive and inefficient. Practical resilience means diversifying the most critical aspects of your business while getting closer to end markets.

Beyond supply chains: Disentangling talent and R&D

The initial impulse to be closer to end markets, diversify geographically, and respond to pressures from local government and regulatory bodies led companies first to disentangle their supply chains. Now, they are extending those efforts to R&D, talent, and innovation centers.

The semiconductor industry is incentivizing the build-out of new fabs outside of historical locations, primarily targeted at newer chips at smaller node geometries, but new fabs take three to five years to come online and produce chips in volume.

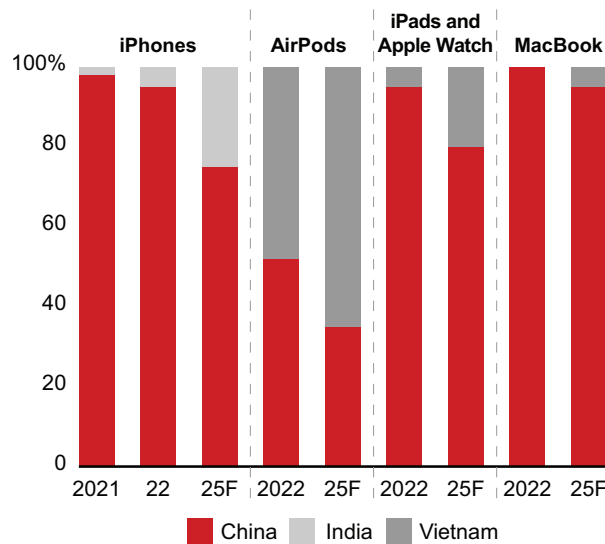
Relocating manufacturing and component suppliers. Tech manufacturers that have their facilities concentrated in one region or that sell to markets on the opposite side of the world are boosting resilience and improving efficiency by diversifying their manufacturing footprint to new locations in Asia, Europe, and North America. It will take time for companies to move production, and they will also need to balance the risk of oversupply as new sites come online. The semiconductor industry is incentivizing the build-out of new fabs outside of historical locations, primarily targeted at newer chips at smaller node geometries, but new fabs take three to five years to come online and produce chips in volume. Even downstream original equipment manufacturers and component suppliers that are moving production to new locations will require a few years to materialize and deliver the same standards as original factories.

Apple, for example, has started to diversify its manufacturing base outside of China—and India and Vietnam have been the biggest winners. India is expected to become a major manufacturer of iPhones soon. The percentage of iPhones produced in India grew from 2% in 2021 to about 5% in 2022, and this number is expected to grow to 25%. Several of Apple's contractors and component suppliers, including Foxconn and Foxlink, are also planning to invest in new capacity in India to support this expansion (see *Figure 1*).

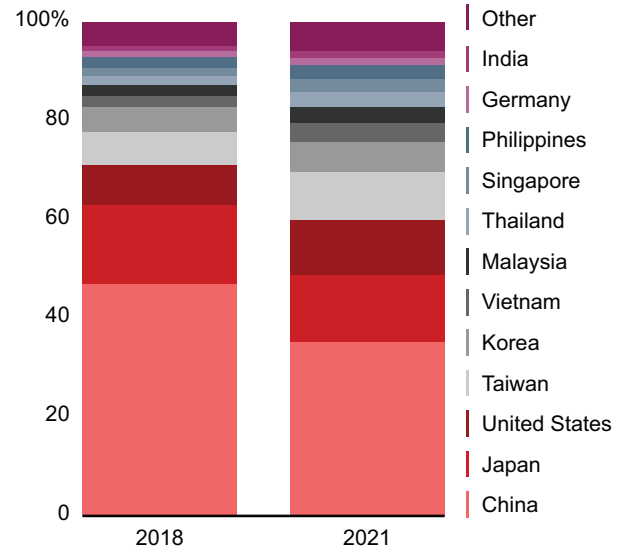
Chipmaker TSMC has also started to expand its production capacity outside of Taiwan, with announcements to build multiple fabs in the US, Japan, and Germany, investing close to \$65 billion. TSMC relies on local subsidies from recently passed legislation in those regions to cover 20% to 50% of the total cost.

Figure 1: Apple is assembling more iPhones outside of China and diversifying its supplier base

Apple final assembly volume by geography



Apple supplier number of locations



Notes: F after year stands for forecast; supplier locations reported for fiscal year 2021 and fiscal year 2018
 Sources: Company reports and filings; Apple 2022 annual report; Apple 2019 corporate social responsibility report

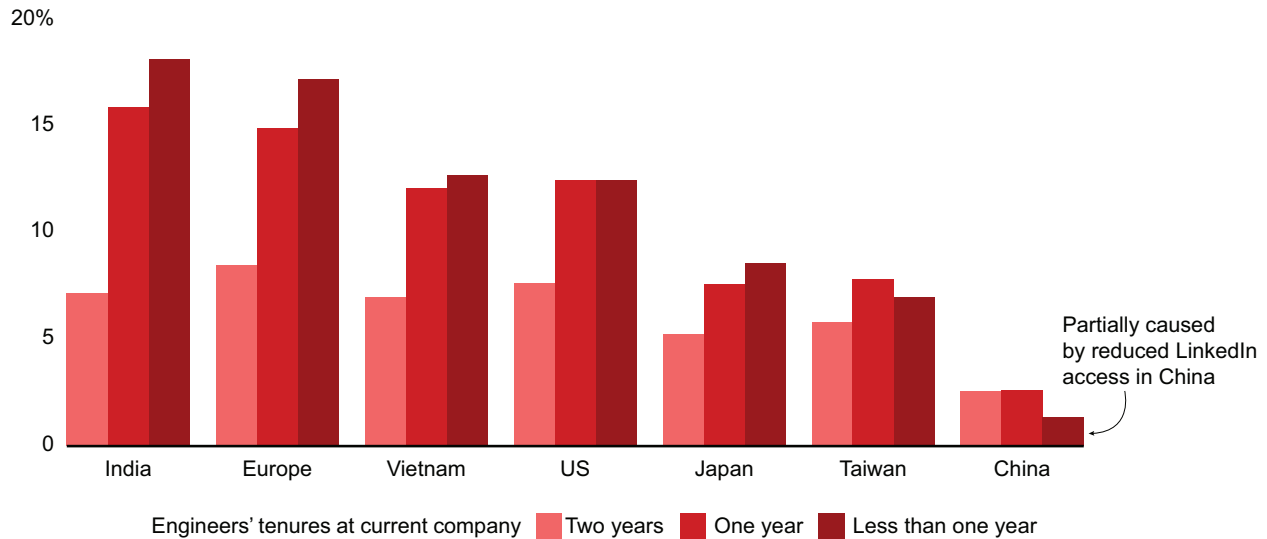
In 2021, Lenovo doubled its manufacturing footprint in Monterrey, Mexico, allowing the company to manufacture all data center products for North American customers within a Nafta country. This lets Lenovo manage its supply chain more effectively to better serve its North American customers.

Foreign direct investment in China has gone down, with the notable exception of Tesla, which recently announced that it will open a second factory in Shanghai in 2024 to produce the Megapack battery. This is in addition to its Gigafactory that started production in 2019, which was built to provide local manufacturing for the company’s second biggest market outside of the US. This helps Tesla serve its large customer base in China, avoid tariffs, and source parts locally to reduce costs.

Relocating R&D and talent. Restrictions moved faster than expected to impact talent and R&D. For example, in October 2022, the US Department of Commerce’s Bureau of Industry and Security added new rules restricting the ability of US persons to support the development or production of integrated circuits at certain fabs in China. Tech companies are avoiding single points of failure and tapping markets with concentrations of specific skills (see Figure 2). They are strategically relocating business-critical functions and roles to areas with lower geopolitical risk. Approaches include duplicating high-value capabilities in several locations, documenting at-risk processes in case they need to be replicated in new locations, and hiring more employees in safer geographies.

Figure 2: R&D relocation and nearshoring are accelerating the hiring of engineers in India and Europe

Percentage of engineering headcount that joined the current company over the past two years
(raw LinkedIn statistics)



Source: LinkedIn analysis includes headcount in engineering function in each location across computer hardware, software, networking, computer and network security, and semiconductors industries

Partly as a result of these strategies, India and Europe are seeing an acceleration in the hiring of engineers. India has become a thriving location for multinational companies to establish R&D centers in artificial intelligence (AI) because of its large talent pool, which offers vast potential for growth. Among other examples, Fujitsu launched a new AI R&D center, Fujitsu Research of India Private Limited, in 2022 as part of its global innovation strategy.

Implications for technology companies

Given the high cost and time commitment to build resilience, some companies are waiting on the sidelines as others take the first step. While it's not essential to be the first mover, it's certainly critical not to be the last to act. The key is to have a plan in place.

- **Identify critical risk areas.** Across the supply chain (manufacturing, component supplier, R&D, talent), companies should start by assessing which parts of the business are strategically most important and most susceptible to risks, along with identifying critical dependencies and where to build redundancy. Each business unit requires different types of resilience, with varying complexity and potential impact on earnings.

- **Evaluate options.** In assessing complexity, companies should consider locations where governments are making it easier to do business. Several countries and trading blocs are putting new rules in place and offering subsidies to encourage new, local technology supply chains that use government investment dollars and tax credits. For example, recent regulatory initiatives in India are creating favorable grounds for manufacturing and talent relocation, and in the US and EU, regulations are paving the way for more semiconductor investments.
- **Be ready to invest.** Tech companies will have to coinvest and share know-how to support the re-balancing of supply chains, aiding in the broader development of new local supplier ecosystems. Specifically, this could include helping key suppliers get approval to build sites in new countries as well as providing the talent, engineering, and management expertise needed to build products to the necessary standards.
- **Test the waters.** Companies can start with smaller, less important products to assess markets, avoiding the risk of being a late mover. They can move to core products after gaining a foothold in new locations.

A decade from now, the global footprint of the technology value chain will look very different. Today's investments in resilience are likely to create new hubs and ecosystems while shifting the competitive landscape. Industries may fragment, and new local heroes will emerge. Now is the time to begin making early investments to ensure the resilience of talent and supply chains.



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Strategic Battlegrounds

You're Out of Time to Wait and See on AI

Artificial intelligence is as much an economic revolution as a technological one.

By David Crawford, Arjun Dutt, Eric Sheng, and Jue Wang

At a Glance

- ▶ It's expensive to build the large foundation models that power generative AI, but once they exist, it's relatively inexpensive to experiment with these models.
- ▶ The current generation of AI tools and models could help companies speed up 20% of worker tasks without a loss in quality.
- ▶ Engineering teams are already deploying AI coding assistants, and 75% of executives told us that AI has already met or exceeded their expectations.
- ▶ Beyond taking current work and making it better, faster, and cheaper, the real value of AI is likely to come from new uses that weren't possible before.

Few technology revolutions have rolled out this quickly.

Five years ago, machine intelligence lagged far behind humans. But over the past year, general purpose foundation models have demonstrated capabilities rivaling a person's ability to perceive, understand, communicate, create, reason, and employ tools. The public release of ChatGPT late in

2022 made these models accessible to a large base that had no previous experience with artificial intelligence (AI). Two months after its public release, ChatGPT had gained more than 100 million users, an adoption rate five times faster than that of previous champ TikTok.

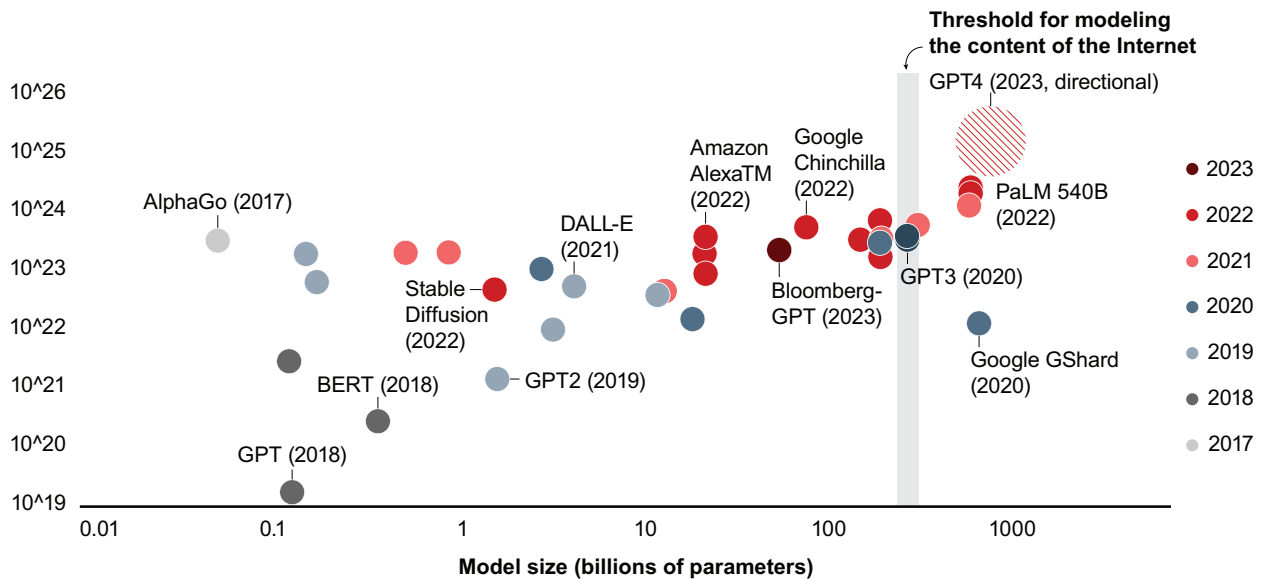
Of course, AI is an overnight success story decades in the making. We are still in the early days of one of the most important technology inflection points in history, but in this fast-moving environment, adopting a wait-and-see posture is as good as being left behind.

Most significantly for the enterprise, foundation models and AI represent much more than a technology revolution; there’s also an economic revolution underway. While the cost of building the foundation models is high and has increased as the models have grown larger (see Figure 1), their existence creates a relatively low bar for entry for companies to experiment with ways to use foundation models and generative AI in their business.

Until recently, AI work (and talent) has been concentrated among the big cloud service providers. Now, with the dramatic reduction in the economics of AI experimentation and application, it’s spilling over into a broader spectrum of industries and capabilities, where innovation is happening quickly and already creating new value.

Figure 1: Foundation models have grown in size and cost over the past six years

Model training (floating point operations)

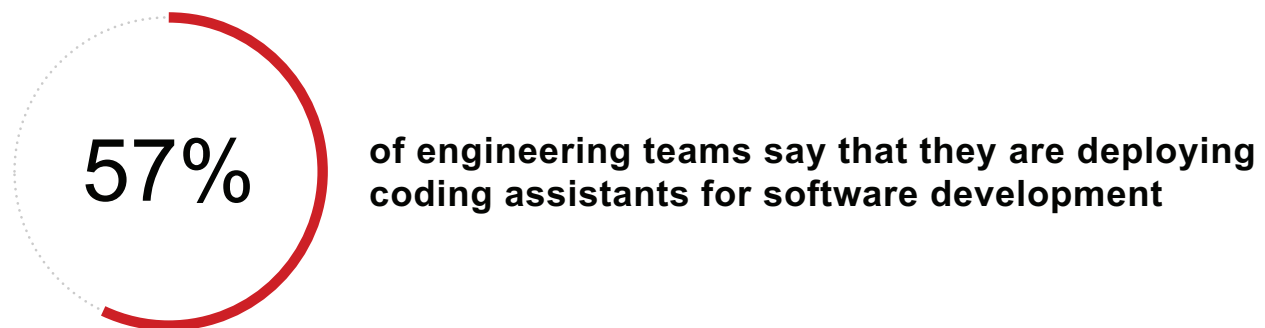


Note: Floating point operations show the computing power necessary to train the models and thus is also a proxy for cost
Source: Bain & Company

How are tech leaders assessing their opportunities in foundation models and generative AI? Bain's recent research reveals how technology executives are approaching this opportunity, where they're investing and experimenting, and what the most likely disruptive plays could be in the months ahead.

Assessing potential

The most recent foundation models improved dramatically over previous generations, demonstrating better language abilities and scoring higher on tests. This dramatic change in economics and performance to understand, reason, generate, and act on unstructured data is revolutionizing knowledge work in the enterprise. Bain research suggests that access to a large language model and AI tools could help companies speed up 20% of worker tasks without a loss in quality. Companies are already deploying foundation models and generative AI tools to reduce costs, increase productivity, and enhance quality—cheaper, faster, and better. (For more, see the Bain infographic “The Era of Enterprise AI Is Here.”)



Enterprises are seeing early results and productivity gains in applications, including sales and marketing, IT ticket resolution, HR talent acquisition and performance management, software development, and customer contact centers and help desks. For example, in Bain's recent research with software companies in the process of evaluating and rolling out generative AI-based coding assistants, 75% of executives said that AI met or exceeded their goals, 76% said it was speeding time to market, and 63% said it improved the quality of code. (For more, see the Bain infographic “AI Coding Assistants Are Already Living Up to Expectations.”) System integrators and IT services lead the pack in most disrupted industries and fastest adopters for activities such as writing code, supporting field services, and managing IT (see *Figure 2*).

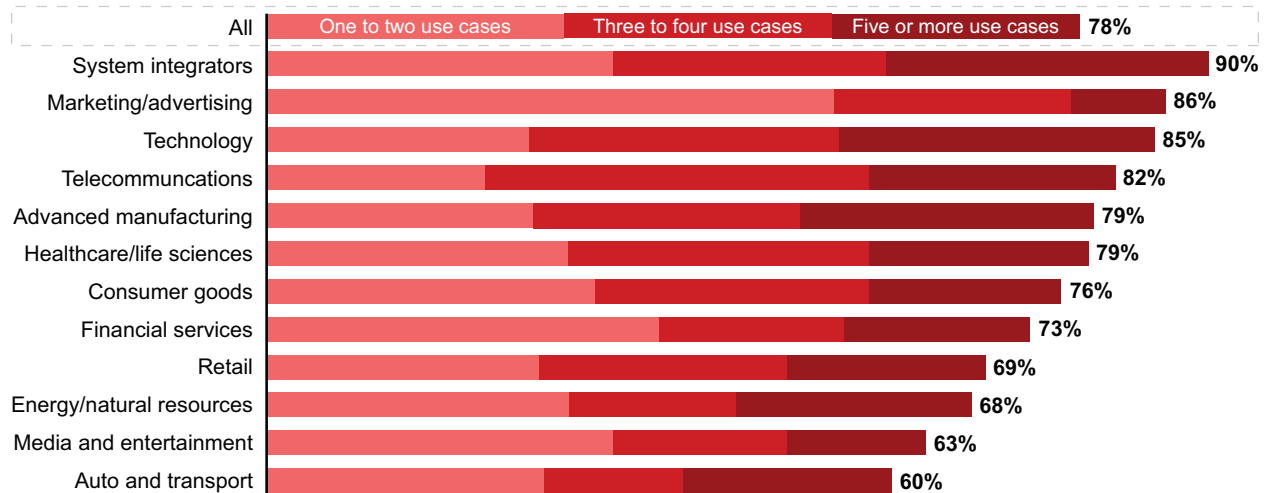
Beyond “cheaper, faster, and better,” foundation models and generative AI are already creating new value in cases that weren't possible before.

- **Rapid upskilling:** At one company, new customer service agents were able to reach productivity levels that normally take six months to attain in only two months because they were supported by generative AI models that suggested responses for them based on summaries of a vast database of answers.

Figure 2: IT system integrators lead the way in AI adoption, closely followed by companies in marketing, advertising, and technology

Adoption pace by industry

Percentage of respondents currently adopting or evaluating at least one of the top six foundation model use cases



Source: Bain AI Survey, 2023 (n=571)

- **Hyper-personalization and A/B testing at marginal cost:** For example, Khan Academy’s AI-powered guide Khanmigo helps students understand complex concepts by adapting to explain these concepts at various levels, depending on the students’ degree of understanding.
- **Redefining the customer experience:** Generative AI could fundamentally change how customers interact with software and data. For example, New Relic launched Grok, a feature aimed at allowing users responsible for monitoring applications and infrastructure to interrogate deep system telemetry data through natural language, aiming to dramatically simplify a typically sophisticated, complex user experience.
- **Reimagining the business definition:** Generative AI capabilities can expand the value of transactional apps by accessing more data about the user and relevant external data. For example, Carrefour introduced a shopping assistant called Hopla that does more than simply generate shopping lists and integrate with its website; it suggests new items and menu ideas based on budgets and diets.
- **Core product innovation:** Companies are using generative AI to radically reduce product development times and add new features to products. For example, pharmaceutical companies are using generative AI to speed up development times. Insilico Medicine, for example, deployed

the technology to help identify a molecule that a drug compound could target and bond with, helping it predict the outcome of clinical trials. The company said using generative AI allowed it to accomplish these tasks in one-third the time and for one-tenth the cost. In game development, Roblox recently announced the development of a platform to enable users to create sophisticated 3D content via voice, text, or touch prompts by using generative AI, dramatically simplifying and democratizing the creator experience.

Building momentum

For senior executives and boards of tech companies, the arrival of AI at scale presents enormous opportunities. Most are closely focused on understanding how AI can add value, but it's also important to tend to a range of technical and process issues that can support rapid deployment of AI solutions.

Among the technical aspects to consider:

- Are privacy and security mechanisms in place to ensure security for data and customers, as well as compliance with regulations?
- Do we have a solid build vs. buy strategy to ensure that we build only where it differentiates us while maintaining the right balance of vendor choices to avoid lock-in?
- Do we have the right machine learning operations (ML Ops) and engineering processes to test and maintain the quality and resilience of complex, non-deterministic models, as well as the quality of input data? And do we have a scalable architecture for reusable components and models?
- Do we have access to enough computing resources, including a wide spectrum of power and performance design points from the cloud to the edge?

Process questions include:

- Will our rapid experimentation in sandbox environments deliver quick wins that demonstrate potential value?
- Do we have a roadmap for scaling and change management that will help us capture the full potential value beyond the first experiments?
- Are we prepared to redesign business processes and redeploy labor as material innovations require?

The rapid uptake of AI over the past year and the many ways that it contributes to productivity and creativity have generated a broad wave of enthusiasm across the entire tech sector and beyond. Products and services seem likely to evolve quickly over the next six months, particularly since the establishment of large foundation models means that the cost for experimentation is relatively low. Waiting to see what competitors will do is tantamount to yielding the field. How will your company create new value with AI today?

Strategic Battlegrounds

How AI Is Recoding the Software Business Model

New features could accelerate growth, but changes in customer processes and job roles could disrupt established use cases and pricing models.

By **Simon Heap, Christopher Schorling, and Ted Shelton**

At a Glance

- ▶ Easy access to large language models has unleashed a torrent of experimentation in the software industry: Nearly 9 out of 10 developers are already using artificial intelligence (AI) in their products.
- ▶ Software vendors expect a step change in functionality, and those that move too slowly could lose competitive advantage.
- ▶ The rise of AI also poses some risks for software companies—for instance, AI tools could make it easier for customers to develop their own software instead of buying it.
- ▶ If AI reduces the number of roles in some job categories, software vendors that price on a per-seat basis may need to adjust their business models.

Over the past six months, nearly every software company has announced plans to apply generative artificial intelligence (AI) within their business. The ease of access to large language model (LLM) application programming interfaces (APIs) has made it relatively easy to demonstrate new AI-powered products. Bain's recent survey found that 89% of software companies are building AI into their products to differentiate them—15 percentage points higher than other sectors.

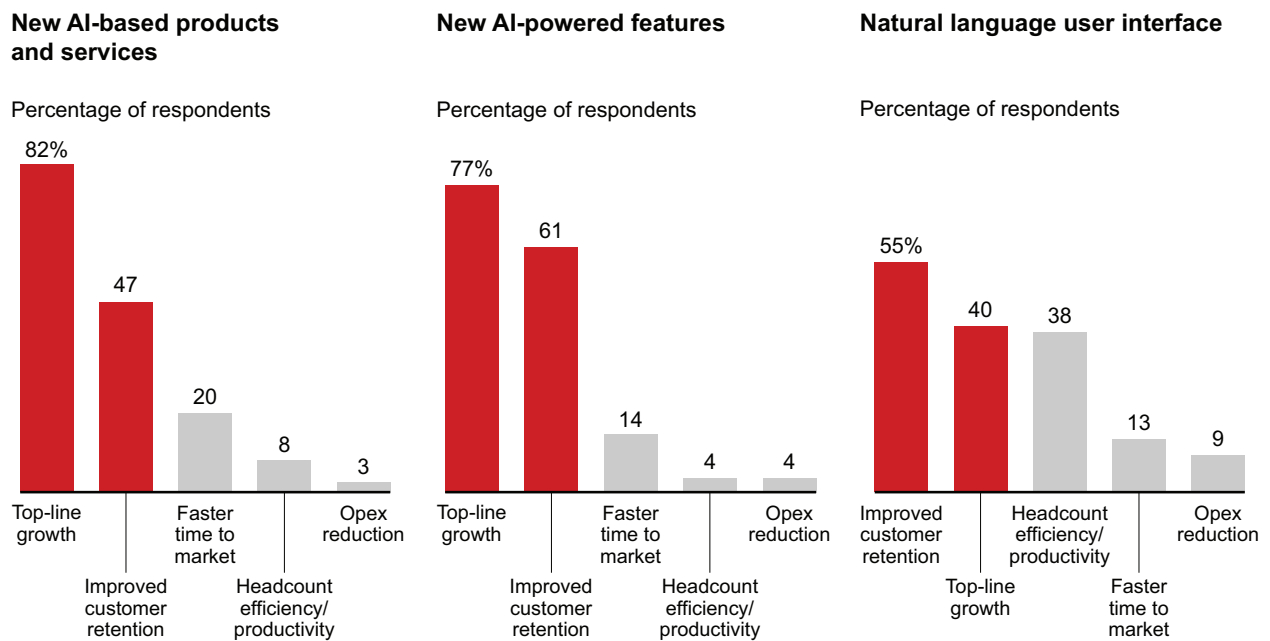
Innovation is happening quickly, and we’re still in early days. Three out of four software companies surveyed believe that early movers will have a sustained advantage that will not level off. Software leaders expect the technology to generate significant opportunities to increase top-line growth and customer retention (see Figure 1). All that can be certain is those that fail to start the journey will be left behind.

Opportunities and risks

Software companies also need to address how the adoption of generative AI by their customers and competitors can threaten their core business. Some software categories may face an existential threat as AI fundamentally changes the capabilities and economics of what can be done in areas such as low- or no-code application development and customer experience management. Most application categories will experience a step change in functionality and user experience, so vendors should prioritize their AI roadmaps to deliver their own capabilities where they will count the most.

As customers introduce AI into their own processes, job roles will change. This could lead to a dramatic fall in the number of end users, which would hurt segments that rely on seat-based pricing, such as service desks, engineering development, marketing and project management, and others

Figure 1: Software companies see benefits from new artificial intelligence products, features, and interfaces



Source: 2023 Bain AI Survey (overall n=571, enterprise software companies n=99)

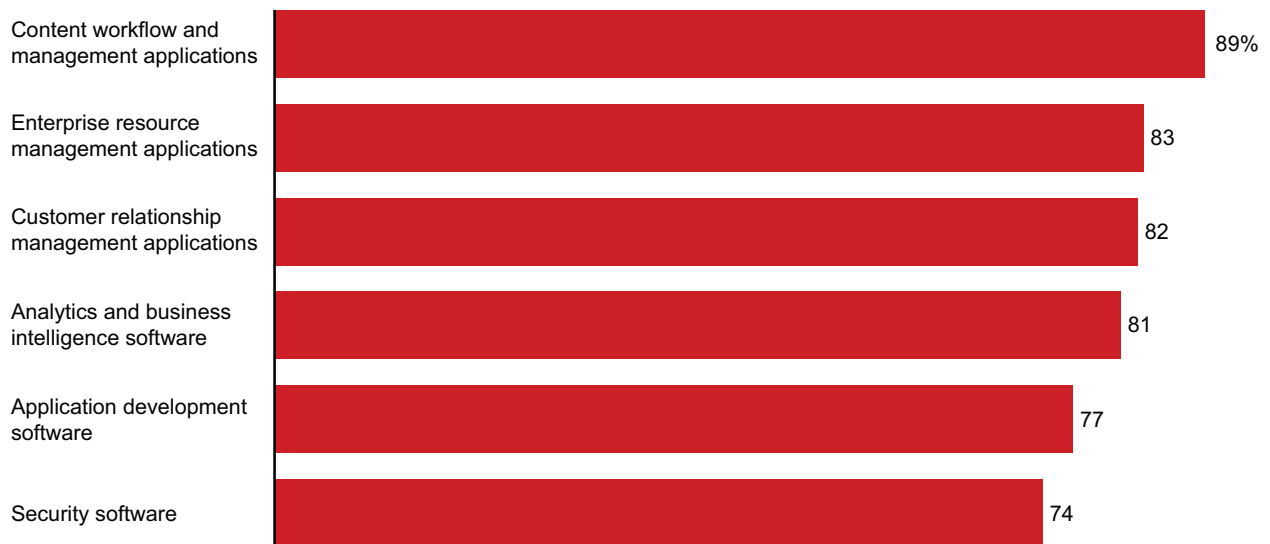
(see Figure 2). Seat-license software companies can respond by ensuring that the product still adds value as customers reengineer their processes; they can also adopt an alternative, consumption-based pricing model (for more, read the Bain Brief, “Is Consumption-Based Pricing Right for Your Software?”).

Developing an understanding of how customers are adopting AI and reengineering their processes can help identify other risks and opportunities. Nearly 40% of the companies we surveyed said that they are either evaluating or adopting foundation models or generative AI into their work. Most activity is in software development, knowledge work, and content creation aimed at helping companies synthesize data, create content, or assist in reasoning and planning. Rather than simply automating discrete roles (for example, an AI-powered chatbot), we’re seeing a complete reimagining of workflows and job roles. For example, AI could help a product manager create marketing content, thereby reducing the need for some downstream roles in product marketing and content authoring.

In the past, vertical software vendors focused on particular industries and relied on process expertise to maintain a competitive advantage. That edge could become harder to maintain as horizontal software vendors are able to use LLMs to interpret industry knowledge and develop industry features at low cost, using their scale and scope to beat niche players.

Figure 2: Generative artificial intelligence will have a greater effect on software categories that rely on seat-based pricing models

Percentage of revenue that top 10 independent software vendors accrued through seat-based pricing (business-to-business software)



Sources: Bain & Company; IDC; company websites

AI and product strategy

As software companies think about how AI will change their business, they should consider several important questions.

- How will generative AI change the customers' businesses, and what does that mean for the software product and business model? Automating process steps is simple, but how will customers radically reimagine their workflows?
- Will our AI-powered solutions be differentiated by a proprietary LLM? Or will we differentiate through the integration with other systems and data?
- How will improvements in R&D productivity affect the speed of innovation?
- Will LLMs and generative AI enable a new level of customization for users, reversing the trend toward standardization? Will users still interact with our application, or will it be intermediated by a new chat-based user interface?

These choices will help identify where differentiation will matter most, how to construct the user interface, and how to package and price products. LLM investment barriers to entry are dropping rapidly, and the open-source community continues to innovate in kind. Options to partner or build are expanding, and some customers might have preferences for or against models hosted by particular cloud service providers.

Some use cases are better served with narrower models rather than general foundation models such as GPT4. For example, Intuit is rolling out a generative AI operating system on which its next generation of applications will be built. The OS would be based on a narrow LLM targeting tax, accounting, cash, and personal finance tasks.

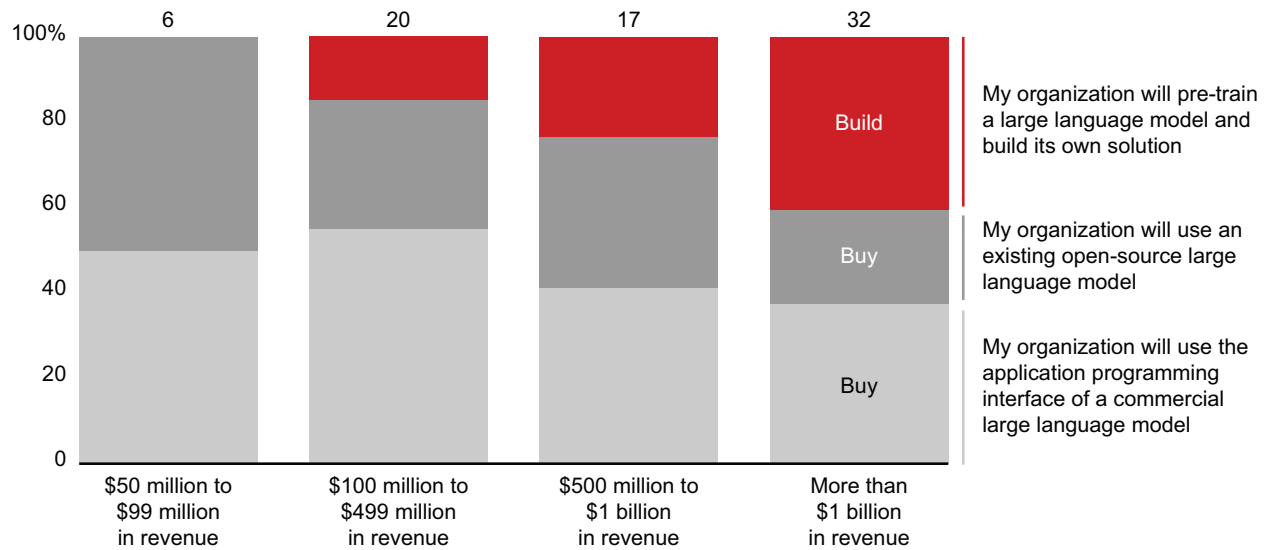
Although companies such as Salesforce and ServiceNow use LLMs from third-party vendors, they are also building their own LLMs. As expected, propensity to build and train an LLM increases with company size (see *Figure 3*).

Many customer concerns around data protection and access, personally identifiable information, audit trails, prompt grounding with proprietary data, and integration with other machine learning and automation technologies are served in platform layers, beyond the LLM. It's here that many software companies can differentiate themselves, leveraging established positions in customer architectures. For example, Salesforce is investing in its LLM Gateway architecture while accessing GPT4 and other LLMs through APIs, where they also have MuleSoft API management capabilities.

Generative AI will transform the way users interact with software. They no longer will have to interact through traditional user interfaces, and they can now do so with natural language via

Figure 3: Larger companies are more likely than smaller ones to build their own large language models, but even they are more likely to buy

Percentage of respondents



Source: Bain Tech Talent Survey, 2023 (n=75)

a chatbot. Software makers’ decisions about whether this is a simpler user interface for existing applications, a new user portal for all process interactions, or an established general purpose text interface (such as Slack or Teams) can shift to where the control point sits.

Software makers also have to decide how to package and price new AI functionality. Whether it’s a separate product, an add-on, or just embedded as an enhancement of the existing product, independent software vendors could monetize it with a price increase, or they might choose to treat this as continued innovation that pays for itself by retaining customers. But beware the gross margin impact of running computing-intensive features.

Generative AI is already having a huge impact on the software industry, offering both opportunities and threats to the established order. Software vendors must embrace the opportunities and not shy away from reinventing themselves to remain relevant and capitalize on this new technological development. Doing so requires understanding how customers will reengineer themselves around existing applications, and that will help software makers decide how to architect and differentiate new AI solutions.



Strategic Battlegrounds

Generative AI and Cybersecurity: Strengthening Both Defenses and Threats

Breakthroughs in technologies built on large language models will accelerate the arms race between hackers and companies.

By Syed Ali and Frank Ford

At a Glance

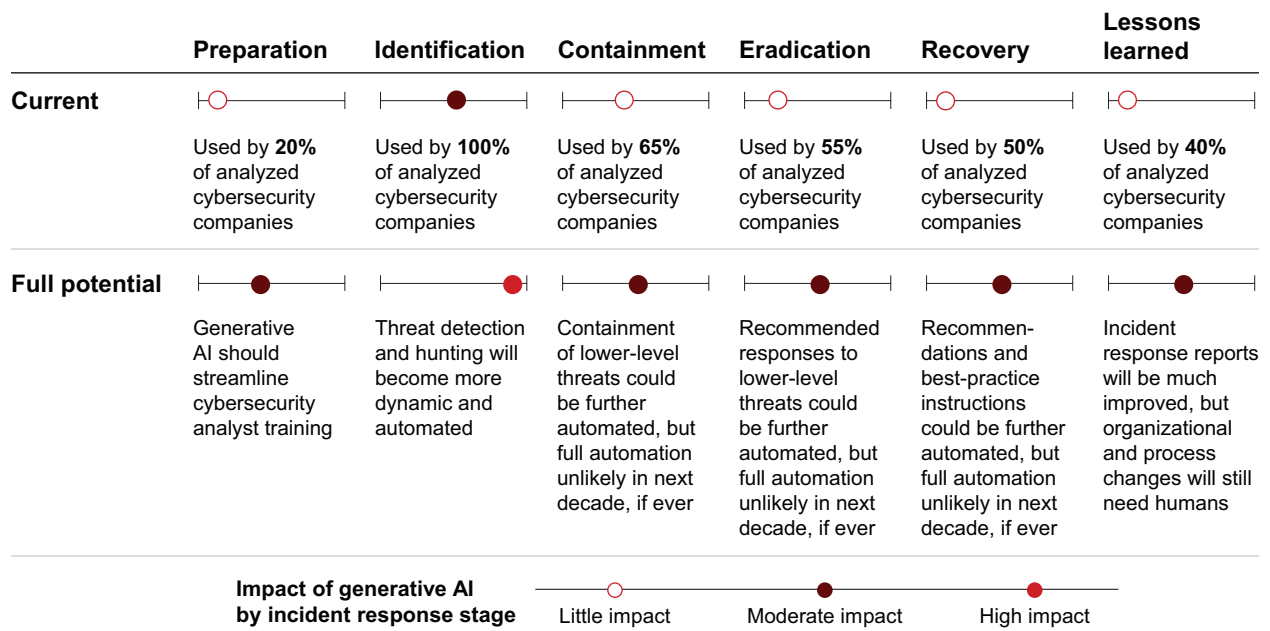
- ▶ Generative artificial intelligence (AI) should strengthen cybersecurity, particularly in threat identification, although it's unlikely to lead to full automation anytime soon.
- ▶ Bad actors are also exploring generative AI's potential to aid cyberattacks through innovations such as self-evolving malware.
- ▶ Through a range of moves today, both buyers and providers of cybersecurity services can take advantage of the new technology while remaining protected.

Only months after its public breakthrough, generative AI has shown the potential to transform cybersecurity products and operations. After the launch of ChatGPT and other products powered by large language models (LLMs), the cybersecurity industry is planning for generative AI to become a key tool. And that's despite the launch challenge generative AI faces in cybersecurity—namely, the sensitive and siloed nature of security data, which makes it hard to get high-quality, comprehensive datasets to train and update an LLM model.

So far, threat identification is the hot spot. When we analyzed cybersecurity companies that are using generative AI, we found that all were using it at the identification stage of the SANS Institute’s well-known incident response framework—the biggest uptake in any of the six SANS stages (preparation, identification, containment, eradication, recovery, and lessons learned). That fits our assessment that threat identification holds the greatest potential for generative AI to improve cybersecurity (see Figure 1). Generative AI is already helping analysts spot an attack faster, then better assess its scale and potential impact. For instance, it can help analysts more efficiently filter incident alerts, rejecting false positives. Generative AI’s ability to detect and hunt threats will only get more dynamic and automated.

For the containment, eradication, and recovery stages of the SANS framework, adoption rates vary from about one-half to two-thirds of the cybersecurity companies we analyzed, with containment most advanced. In these stages, generative AI is already narrowing knowledge gaps by providing analysts with remedy and recovery instructions based on proven tactics from past incidents. While there will be more gains through automation of containment, eradication, and recovery plans, full automation is unlikely over the next 5 to 10 years, if at all. The longer-term impact of generative AI in these areas is likely to be moderate and will likely always need some human supervision.

Figure 1: Threat identification holds the most potential for generative AI to improve cybersecurity—and that’s where industry adoption has been strongest so far



Notes: Percentages rounded; analysis is of cybersecurity companies that are using generative AI to enhance solutions
Source: Bain & Company

Generative AI is also being used in the lessons-learned stage, where it can automate the creation of incident response reports, improving internal communication. Crucially, the reports can be reincorporated into the model, improving defenses. For example, Google’s Security AI Workbench, powered by the Sec-PaLM 2 LLM, converts raw data from recent attacks into machine-readable and human-readable threat intelligence that can accelerate responses (under human supervision). But while the quality of generative AI-powered incident response reports should keep improving, human involvement is still likely to remain necessary.

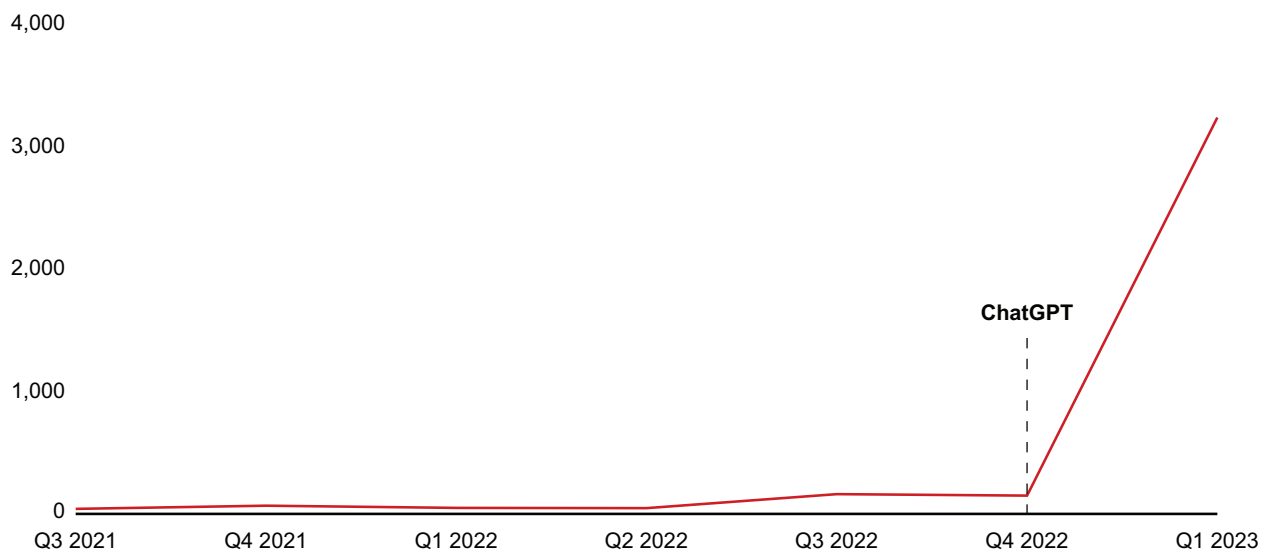
A double-edged sword

Of course, generative AI can also be used as a cyberattacker’s tool, giving them similar capabilities as defenders. For example, less experienced attackers can use it to create more enticing emails or more realistic deepfake videos, recordings, and images to send to phishing targets. Generative AI also allows bad actors to easily rewrite a known attack code to be just different enough to avoid detection.

Generative AI has certainly become a trending topic for malicious actors. Mentions of generative AI on the dark web proliferated in 2023 (see Figure 2). It’s common to see hackers boasting that they’re

Figure 2: The use of generative AI for nefarious purposes has become an increasingly popular topic on the dark web after the launch of ChatGPT

Number of dark web mentions of generative AI



Sources: Rapid7; Bain & Company

using ChatGPT. One hacker posted that he was able to use generative AI to recreate malware strains from research publications, such as a Python-based stealer that can search and retrieve common file types (.docx, PDF, images) across a system.

The threat from bad actors will only increase as they use generative AI to standardize and update their tactics, techniques, and procedures. Generative AI–assisted dangers include strains of malware that self-evolve, creating variations to attack a specific target with a unique technique, payload, and polymorphic code that’s undetectable by existing security measures. Only the most agile cybersecurity operations will stay ahead.

Actions to take now

Corporate leaders should:

- understand that generative AI won’t rid cybersecurity of its operational and technical complexities;
- make generative AI and cybersecurity a recurring agenda item for board and C-suite meetings; and
- avoid a narrow focus on controls or certain risks—cybersecurity demands a holistic approach.

Chief information officers/chief information security officers should:

- get security operations (SecOps) leaders to validate generative AI output, particularly threat-detection algorithms updated by generative AI;
- train new and junior SecOps employees to hunt threats with and without generative AI to avoid dependence; and
- where possible, avoid relying on a single vendor or generative AI model across the cybersecurity stack.

Cybersecurity companies should:

- hire the right mix of talent to bring generative AI capabilities into their products; and
- guard against generative AI–created false information (hallucinations) and external tampering with generative AI algorithms and models that might create backdoor vulnerabilities.

Generative AI will rapidly advance, and it’s essential that all stakeholders from cybersecurity providers to enterprises continuously update their specialist knowledge and strategy to take advantage—and stay protected.



Strategic Battlegrounds

Taking the Hyperbole Out of the Metaverse

The metaverse isn't dead, but it's time to take a more sober view of its future.

By **Chris Johnson, David Crawford, Nihar Naik, and Neha Verma**

At a Glance

- ▶ The metaverse is here, with immersive gaming platforms boasting hundreds of millions of monthly active users, and emerging metaverse technologies deployed across industries.
- ▶ Bain projects that the metaverse could reach a market size of \$700 billion to \$900 billion by 2030 and that the major winners will likely be determined in that time frame.
- ▶ While it's unclear how the competitive landscape will shift, five tech battlegrounds will shape the metaverse: virtual experiences, content-creation tools, app stores and operating systems, devices, and computing and infrastructure.

The debate over what the metaverse will ultimately become misses the more salient point: The metaverse is already here.

People imagine a future straight from the sci-fi novel-turned-movie *Ready Player One*, in which we would spend most of our time living in completely immersive virtual worlds. But when we break it down, the metaverse is a collection of immersive, collaborative, and interactive environments that span digital and physical worlds and enable us to create, exchange, socialize, and learn. And that part of the vision already exists.

Popular gaming platforms today—Fortnite, Roblox, and Minecraft—are becoming more interactive, enable users to create avatars and worlds within them, and deepen the level of immersion players experience by delivering increasingly photorealistic content. They’re also doing this on a massive scale. Each of the platforms mentioned has around 200 million monthly active users, on par with the respective number of subscribers of Amazon Prime and Disney+.

In the business world, a suite of emerging metaverse technologies that leverage virtual reality (VR) and augmented reality (AR) are already providing value. These include applications in areas of high risk (e.g., AR-assisted spinal surgery) and high expense (e.g., jet engine manufacturing) in which interacting with digital models can help improve care or save money.

While it’s challenging to predict exactly how the metaverse will look decades from now, it’s clear that the journey is well underway and there’s a real and growing economic opportunity. We project the metaverse could reach a market size of \$700 billion to \$900 billion by 2030. Furthermore, the next 5 to 10 years will likely determine the metaverse’s major winners (more on this below).

A multiyear tech boom and free-flowing venture capital fueled a lot of excitement about the metaverse over the past few years. Now, as executives map their strategies in a very different economic environment, we think framing the discussion through the following lenses will help determine where to focus their metaverse investments.

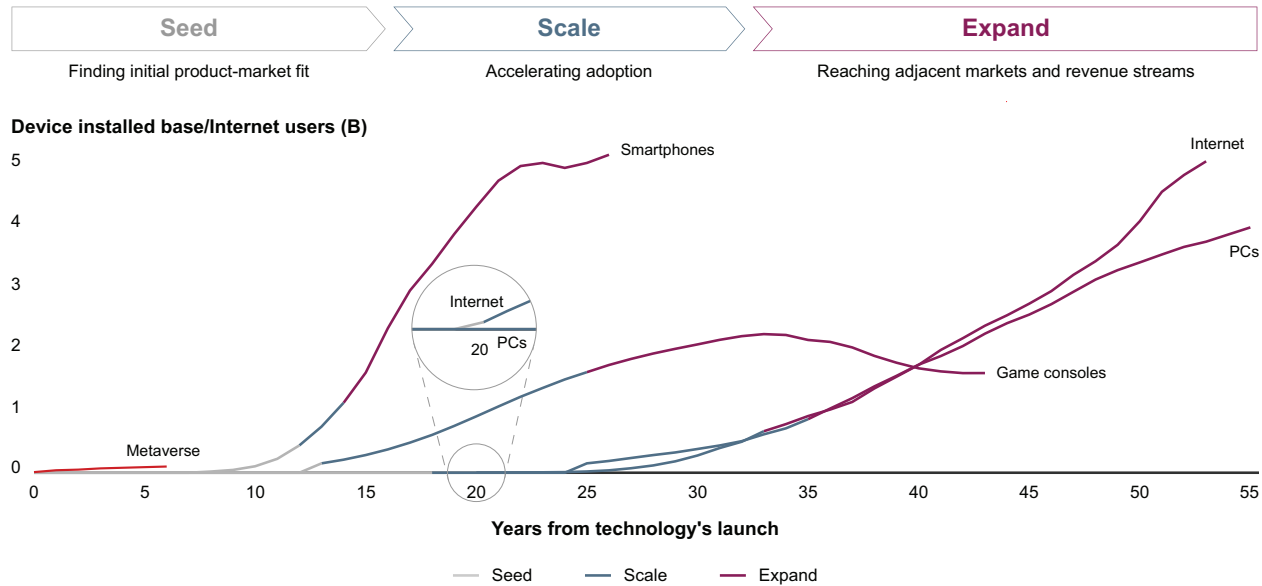
The metaverse will take years to reach full scale

The metaverse will likely remain in the first phase of development—what we call the “seed” stage of the platform development journey—for at least another 5 to 10 years (*see Figure 1*). Reaching scale requires bringing compelling, breakthrough use cases to market in a format that enhances user experiences. It took more than 10 years for smartphones and gaming consoles to each exit the seed stage and begin scaling up, while it took almost 20 years for the Internet and personal computers, respectively.

Nevertheless, it wouldn’t be surprising if the metaverse grew faster than other influential technologies, given how the pace of change has accelerated. And if a company waits for the metaverse to reach the scale phase before it enters the market, it’s likely already too late. Big market winners often emerge during the seed stage: think Microsoft and Apple in PCs, Nintendo in video games, or Apple’s iPhone in smartphones and iPad in tablets.

Today, a mix of metaverse strategies exist, from companies with a vertically integrated approach that spans multiple segments of the metaverse technology stack to those with a horizontal strategy that focuses on a single layer of the stack. It remains to be seen which will prove to be most effective as the market develops, and the shape of the ecosystem (vertical vs. horizontal) is likely to evolve over time. Meta has established an early lead among those focused on vertical integration, combining leading hardware, app stores, and virtual content in pursuit of widespread user adoption and engagement. The company’s vertical approach allows for tight coupling of hardware and content and, therefore, strong curation of the user experience.

Figure 1: The metaverse may take 5 to 10 years to begin scaling, based on the evolution of analogous technologies



Notes: Game consoles' user base declined as gaming PCs market grew; smartphones defined as mobile phones that have a high-level operating system with third-party native applications and connectivity; smartphone installed base decreased 3% during the Covid-19 pandemic, as second or third phones (e.g., company phones) were redundant with decreased mobility
Sources: Euromonitor; IMF reports; Gartner; Bain analysis

Another notable company with a vertical strategy is Apple. It entered the market in June with the announcement of a mixed-reality headset that combines AR and VR, uses Apple-designed chips and an Apple-designed operating system, and connects with Apple's existing app ecosystem.

Companies that have adopted a more horizontal approach include Nvidia and Epic Games. Rather than build end-to-end technology stacks, they supply silicon and content-creation tools, respectively, that are used by many companies in the metaverse ecosystem.

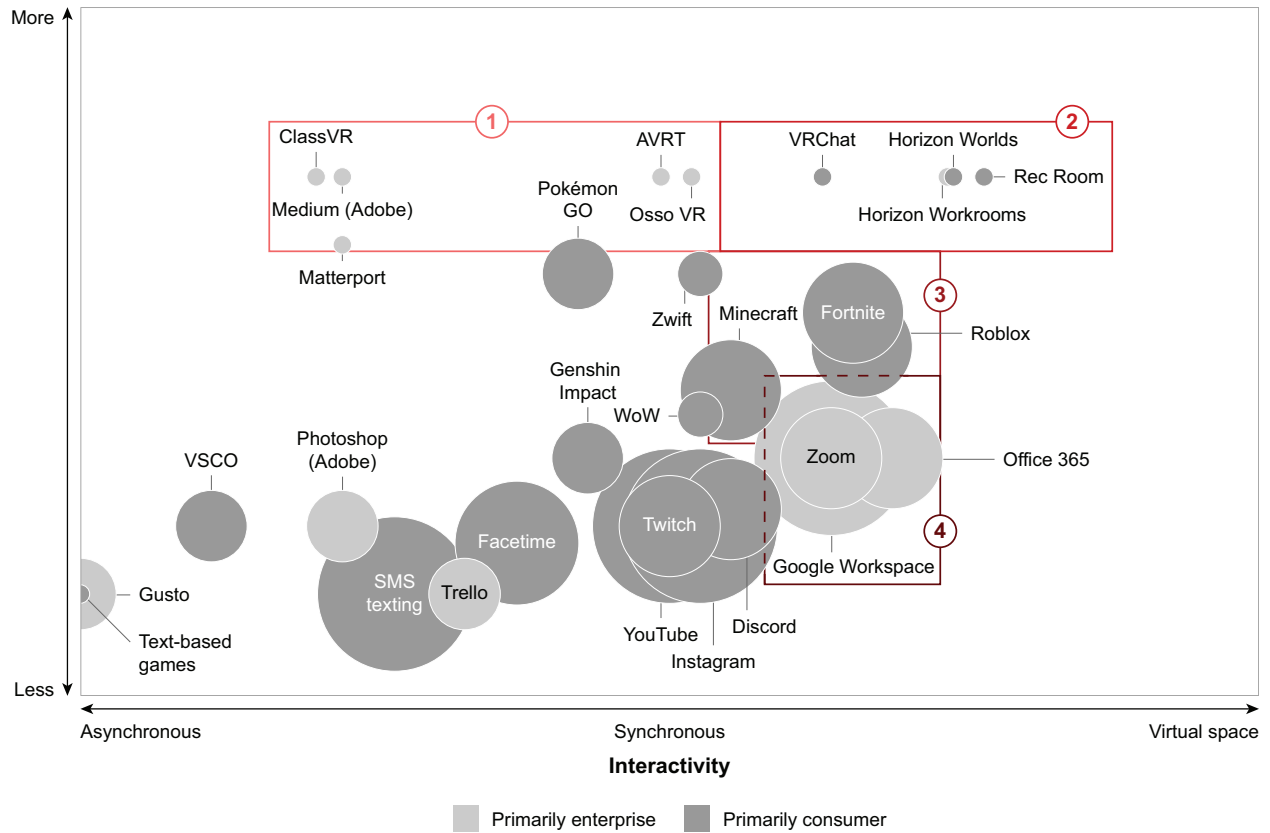
The metaverse will be plural

Today's consumer and enterprise applications will become increasingly immersive and collaborative, moving closer to the most aspirational vision of the metaverse by unlocking richer experiences and better functionality (see Figure 2). And while it's unclear how the competitive landscape will shift and potentially converge, it's unlikely to become one big platform dubbed "the metaverse."

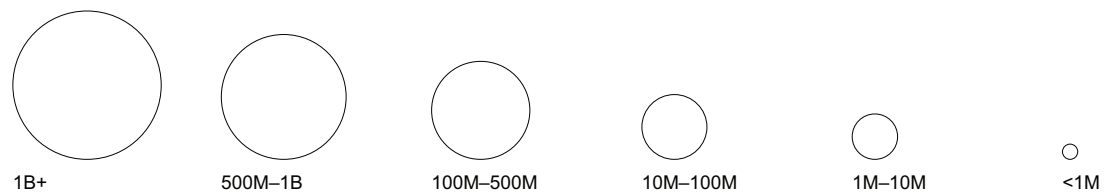
Although open standards initiatives have attracted the attention of major tech companies, including Microsoft and Meta, an industrywide shift to a truly interoperable metaverse likely won't happen anytime soon. Similar to today's Internet, private companies have strong incentives to maintain "walled gardens" and the companies' proprietary datasets within them so that they can effectively monetize and recoup the investments required to develop metaverse technologies.

Figure 2: Today’s consumer and enterprise apps already exhibit metaverse attributes and are evolving quickly

Immersion level



Monthly active users



- 1** **Niche use cases**
Smaller immersive platforms likely to remain focused on specific industry verticals
- 2** **Social destinations**
Metaverse-first worlds trying to achieve scale through a broad set of social, gaming, and productivity experiences
- 3** **Creative gaming**
Mature gaming worlds expanding to social use cases partly through user-generated content
- 4** **Virtual workplaces**
Enterprise companies racing to add new collaboration features

Notes: Immersion level determined by immersive nature of content (70% of weight) and physical and digital world blending (30% of weight); interactivity determined by user-to-user interactivity (70% of weight), with the remaining 30% split among the ability to create user-generated content and the presence of digital economies for consumer applications; enterprise applications weren't considered for the digital economies criteria given different monetization models; Google Workspace includes Google Meet (video conferencing) and has more monthly active users relative to its enterprise counterparts due to greater consumer adoption; Office 365 is bundled and includes Microsoft Word, PowerPoint, Excel, OneDrive, and Teams; text-based games include Choice of Robots, Reigns, Sorcery!, The Dreamhold, and others
Sources: Company websites; press releases; public company financial earnings calls; Bain analysis

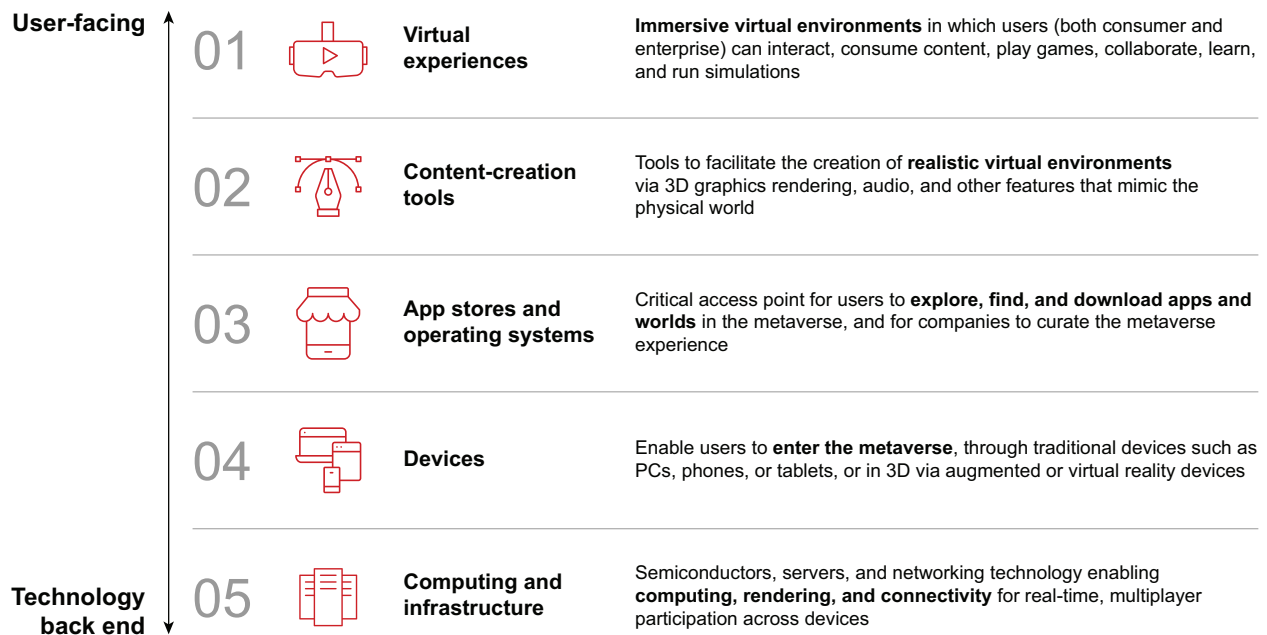
Rather, platforms with large user bases today may take steps to become increasingly immersive and engaging, while smaller, metaverse-like worlds will try to attract bigger user bases. The size of these walled gardens will depend on their ability to tap into network effects and spur user-generated content, kicking off a flywheel effect that accelerates the platform’s growth. These efforts won’t preclude open standards initiatives from making progress, but walled gardens will likely remain more prevalent for the foreseeable future.

Five battlegrounds are shaping the metaverse

Metaverse profit pools are likely to accrue across the technology stack at key control points (see Figure 3). In short strokes, here’s where the most consequential competitive dynamics are taking place.

- **Virtual experiences** (about 65% of metaverse projected market size in 2030): Although gaming is currently the leading consumer metaverse application, immersive fitness and entertainment could also be compelling in the medium term. On the enterprise side, innovative use cases are emerging, primarily in collaboration and productivity but also in digital marketing, employee training, education, and healthcare.

Figure 3: In the tech industry, there are five key metaverse battlegrounds



Source: Bain & Company

- **Content-creation tools** (about 5% of metaverse market size in 2030): There's a growing field of software tools that provide the building blocks, editing platforms, and interfaces for creating metaverse worlds and experiences. Many leading platforms offer simple drag-and-drop world-building features that are typically free and intended to cultivate user engagement, retention, and monetization. Generative AI will also transform the way content is created by making it easier to create avatars, in-world assets, and interactions with virtual characters. Meanwhile, developer tools continue to advance, both for consumers and enterprises.
- **App stores and operating systems** (about 10% of metaverse market size in 2030): We expect the metaverse to follow the smartphone model, with app stores serving as the primary access points for users to explore apps and worlds in the metaverse. The app store role will be even more crucial during the metaverse's seed stage, helping provide users with curated, high-quality experiences to keep them engaged with the platform and headset they use to access the metaverse; this need is amplified by the immersive nature of VR content.
- **Devices** (about 10% of metaverse market size in 2030): Significant technological barriers must be overcome before the arrival of comfortable, lightweight, standalone devices that allow for truly immersive experiences. To achieve mass adoption, metaverse content will need to work across all types of devices—including, for the foreseeable future, personal computers, gaming consoles, and smartphones. These device manufacturers may see their businesses benefit as some consumers opt for their higher-end product lines to unlock more immersive, collaborative experiences.
- **Computing and infrastructure** (about 10% of metaverse market size in 2030): Demands on computing power will continue to grow significantly. That will pressure hardware companies to develop higher-performing chips, servers, and networking technologies to render high-quality graphics and reduce latency. Improvements are already underway, including 5G network rollouts and advances in system-on-chip performance.

No one knows exactly what the metaverse's final destination will be, but all signs indicate it's going to be a journey well worth taking.

While executives can't ignore the metaverse, neither are we suggesting that every company pivot its entire strategy to focus on this sector. It's more about making targeted adjustments to existing roadmaps to ensure that the company moves in the same direction as its ecosystem of customers, partners, and competitors. No one knows exactly what the metaverse's final destination will be, but all signs indicate it's going to be a journey well worth taking.



Strategic Battlegrounds

The Untapped Value at the Intelligent Edge

The need to process data close to its source is creating a new computing architecture and a growing market.

By David Crawford, David Deming, and Bill Radzevych

At a Glance

- ▶ The market for intelligent edge computing is greater than previously understood, with as much as \$127 billion in spending on embedded silicon forecast through 2027.
- ▶ This increase reflects the rise in the intelligent edge paradigm, which puts computing resources close to data sources to reduce latency, power usage, and bandwidth costs.
- ▶ Succeeding at the intelligent edge requires strong capabilities to integrate software, digital hardware, and analog hardware since customers give higher satisfaction ratings to fully integrated solutions.

Edge computing—that is, moving processing from central data centers to regional and local computing clusters closer to the source—represents a major shift in technology. Because of constraints on power and latency, many applications benefit from data processing at the source—for example, close to sensors (see *Figure 1*). For these applications, a new architecture is emerging: intelligent edge devices.

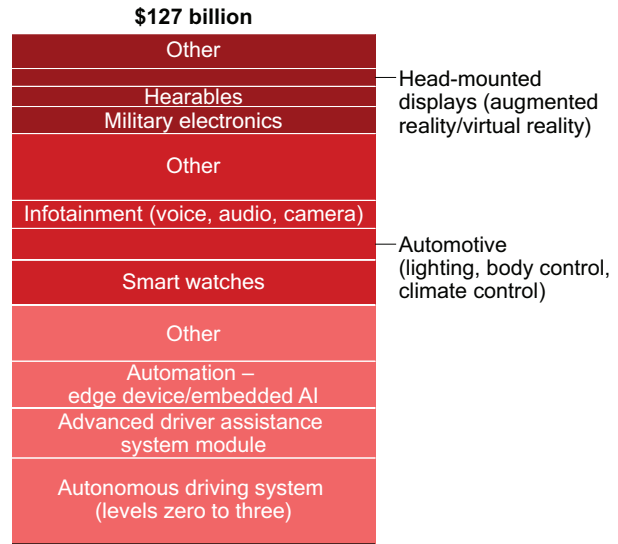
Sending vast amounts of data to regional or local cloud hubs for processing is inefficient at best and has the potential to overwhelm existing transport and computing architectures. Furthermore, much of the data generated is noise, and filtering and processing it right at the source can cut down

Figure 1: Power constraints, latency requirements, and limits on connectivity shift computing toward an intelligent edge paradigm

Primary drivers of intelligent edge computing

- Latency**
Decision making moving closer to the sensor improves latency
- Power/form factor**
Computing-enabled sensors optimize power consumption and reduce form factor
- Data volume reduction**
Computing at the edge sends out only useful data, significantly reducing the volume of data transmission

Market for embedded silicon in intelligent edge applications



Sources: Gartner IoT Semiconductors Forecast (worldwide third-quarter 2022); Bain & Company

dramatically on transport and processing requirements. Many applications also have a very low tolerance for latency because they are unable to wait for transfer times or delays, requiring resolution in real time. Even traditional edge processing nodes, including local data centers and on-premise gateways, are not efficient enough for the real-time feedback loops these modern devices require.

Intelligent edge devices represent a paradigm shift as they perform most data inference and processing directly at the device itself and offer distinct advantages in terms of latency, power consumption, and use of bandwidth. Noise-canceling headphones are a good example: They analyze sound signals in the surrounding environment and counter with opposite frequencies locally, reducing background noise without the need to transmit data to the cloud. Video surveillance is another example: Instead of sending a raw video pixel by pixel to a central processor, which would require tremendous bandwidth and central processing power, an intelligent edge camera can perform a first-order structuring of the data—for instance, looking for humans—and send this structured data to a central hub for decision making.

Not all devices will use this architecture, of course. For example, large medical datasets that search for genetic abnormalities require comprehensive processing and inference, and they need access to the massively parallel computational power offered in cloud architectures. Additionally, many smart building management systems take advantage of a central hub in the building to make decisions based on sensor data coming from all over the building.

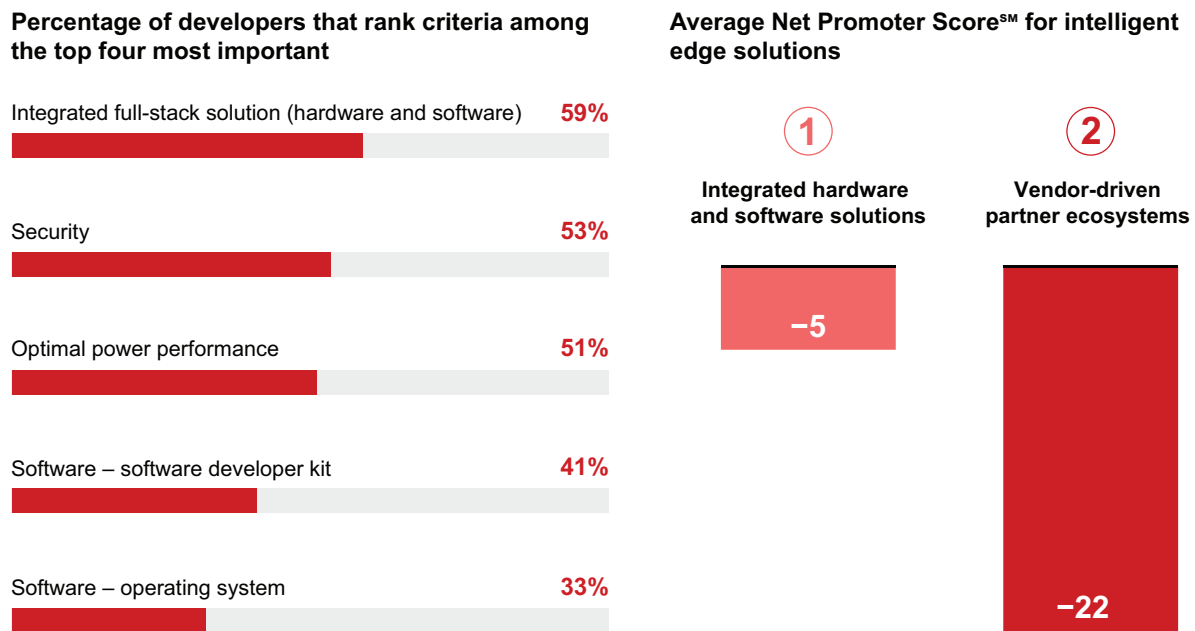
But for the devices at the intelligent edge, the market opportunity may be larger than previously understood. Bain’s analysis forecasts that by 2027, \$127 billion of the \$277 billion total market for embedded silicon could come from the intelligent edge. It’s a huge opportunity, but most ecosystem participants aren’t fully ready to address this market. Given how rapidly this space is evolving, companies need to react now to serve this market effectively.

Develop new capabilities

Tapping the intelligent edge opportunity requires new technical capabilities and business models.

First, companies will need to further develop their ability to integrate software with digital and analog hardware to deliver fully integrated solutions. Bain research finds that when customers choose solutions, integration of hardware and software is the most highly ranked purchase criteria and that customers award a higher Net Promoter ScoreSM for fully integrated products, though even here there is room for improvement (see Figure 2). Given their starting points, this will mean finding the right partnerships or acquisitions while also building up internal capabilities. But our research is clear: Delivering an integrated, end-to-end solution will produce the product most likely to win in these markets.

Figure 2: Developers prioritize integrated full-stack solutions



Note: Net Promoter ScoreSM is a service mark of Bain & Company, Inc., NICE Systems, Inc., and Fred Reichheld
 Source: Bain Intelligent Edge Survey (n=140)

These companies will also need to strengthen their abilities to assess and determine which solutions merit full integration and where it makes more sense to deliver parts of solutions, leaving integration to the customer or third-party integrators. As markets mature, customers may develop a preference for open solutions that they can more easily tailor to their needs or that fit better into their software ecosystem. Understanding the determining factor among digital, analog, or a combination can help shape the best offer for a given application and customer. Developing a better understanding of customers and their commercial needs will also be key. It's likely that as the market matures, customers will want more control over the elements of a solution.

Understanding the determining factor among digital, analog, or a combination can help shape the best offer for a given application and customer.

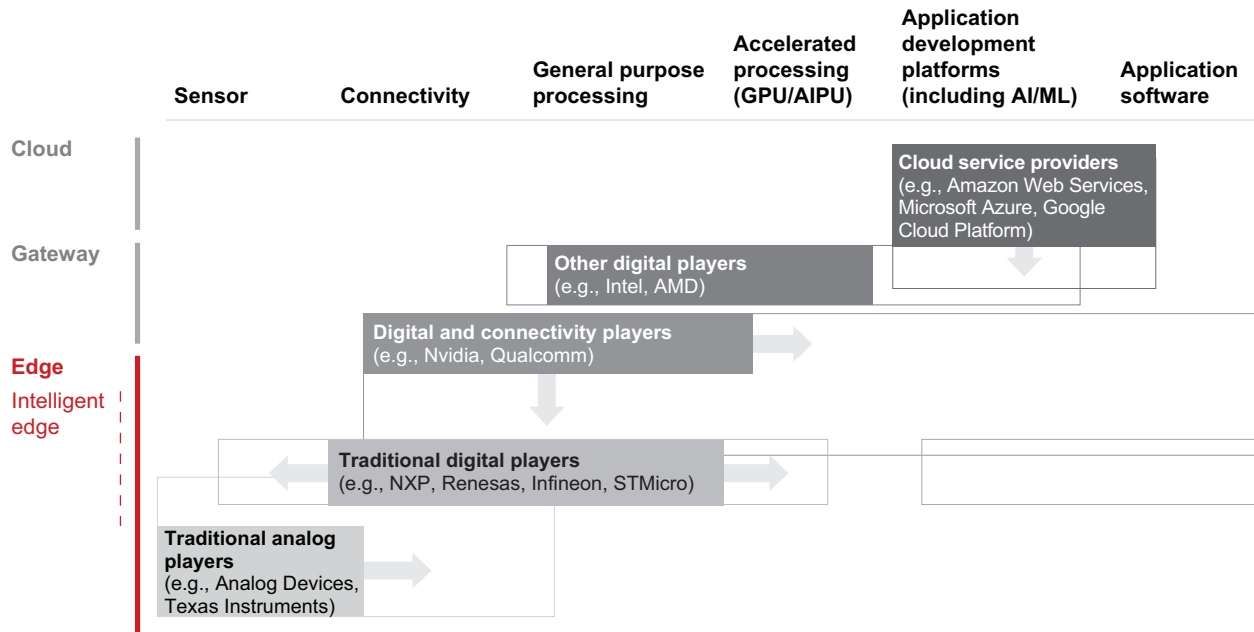
Capture opportunities

Given the importance of integration and the nascent nature of the solutions in this space, traditional lines of competition are blurring in intelligent edge computing. Most vendors do not provide full-stack solutions, so to win in this market, companies have to find partners across the edge solution stack. For example, application-specific solutions that integrate digital and analog components bring together microcontroller and analog players. Gateway players such as Nvidia and Qualcomm are investing in integrated computing and software solutions as well as developer-friendly tools (for example, Nvidia Jetson and Qualcomm Drive Data Platform). We see many participants in the market starting from their position of strength, pushing into adjacent segments, and blurring traditional lines of competition (see *Figure 3*).

Companies in different tech sectors have different avenues to success in the intelligent edge market.

- **Digital semiconductor:** Digital and connectivity players should continue to work toward the integration of analog components, strengthening the integrated software stack and building purpose-specific applications.
- **Analog players:** Anchor in analog strengths while leveraging the ecosystem and partnerships to build full-stack solutions and software capabilities.
- **Software:** Meet developers in their ecosystem of choice, and embrace growing industry standards and open-source offerings.

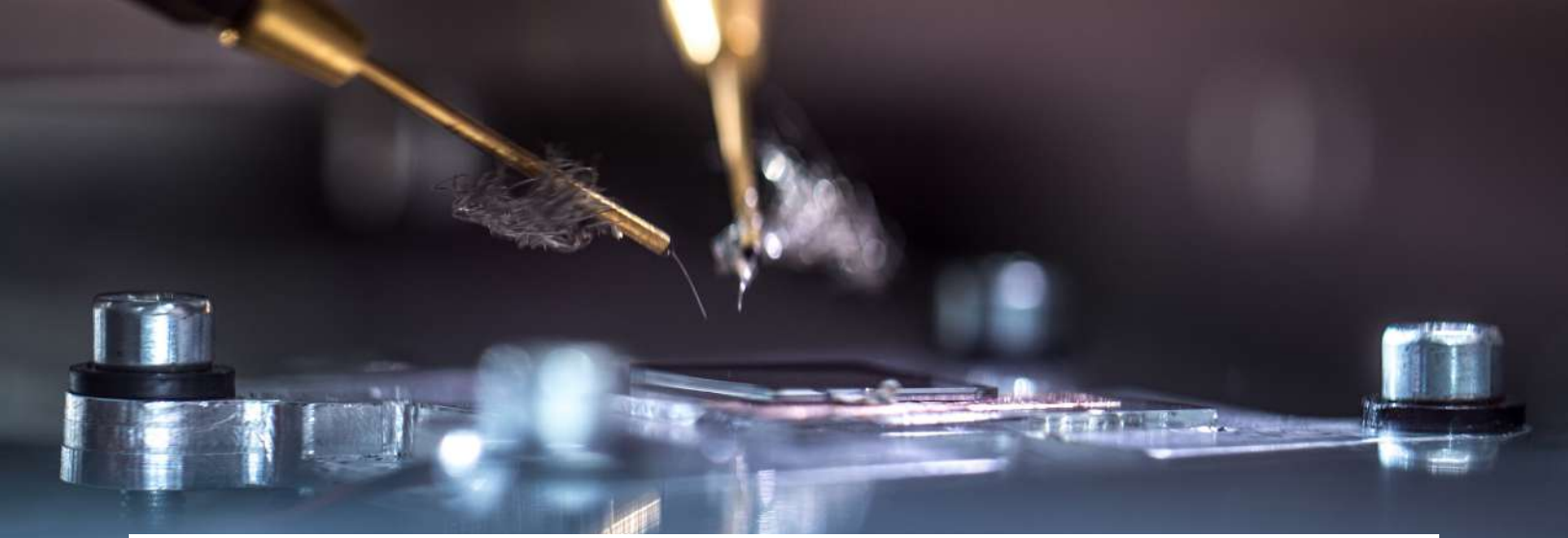
Figure 3: The intelligent edge requires more integrated solutions, pushing players to expand their capabilities



Notes: GPU stands for graphics processing unit; AIPU stands for artificial intelligence processing unit; ML stands for machine learning
 Source: Bain analysis

- **Original equipment manufacturers:** Focus on strategic issues and holistic use cases, and let vendors absorb the hardware and software complexity.
- **Hyperscalers:** Recognize where cloud-tethered solutions have limitations, and partner with hardware vendors—for instance, as NXP partnered with Amazon Web Services.

Intelligent edge devices represent a new computing paradigm that will enable a new class of devices that react in real time to the world around them, without needing the computing and connectivity requirements of the cloud or local data center processing. But success will also require a shift in capabilities and new linkages within the ecosystem. Vendors in this space should assess their readiness for this shift.



Strategic Battlegrounds

After the Chip Shortage, Fears of a Capacity Glut Are Overblown

The industry and its customers are adept at balancing long-term capacity and supply.

By David Crawford, Peter Hanbury, Anne Hoecker, and Michael Schallehn

At a Glance

- ▶ The semiconductor industry's post-pandemic rebound boosted capacity to the extent that some foresee an oversupply.
- ▶ But cyclical in the sector is normal, and it's actually been leveling out over time as the end markets for chips have broadened and suppliers have consolidated.
- ▶ Even so, supply-and-demand balance could remain bumpy in three areas that customers should monitor: bleeding-edge, leading-edge, and super-lagging chips.
- ▶ Companies can guard against the risks of imbalance by designing products for resilience and flexibility, taking advantage of moments of oversupply, and developing chip-specific strategies for mission-critical components.

Many manufacturers that depend on the semiconductor supply chain are breathing easier now.

As post-pandemic demand for PCs, smartphones, and consumer devices eased, capacity grew in the semi market. In fact, we've gone from a chip shortage in 2021–2022 to underutilization of capacity in some parts of the semi value chain. Some say this is a harbinger of a massive capacity glut, implying we no longer need to worry about securing our semiconductor supply chain. We disagree.

Cyclicality and brief periods of underutilization are normal features of the semiconductor business cycle. But cyclicality has actually dampened over the past couple of decades for three main reasons (see Figure 1).

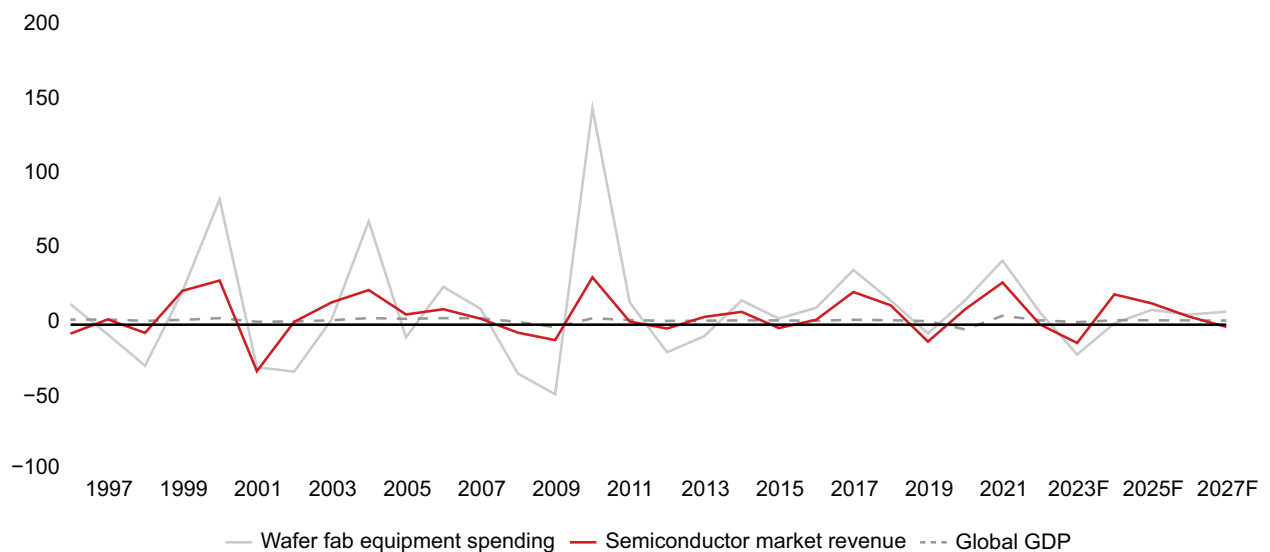
- First, the law of large numbers suggests that the broad set of end markets, each with different demand cycles, helps counter-balance demand.
- Second, although memory is the most cyclical part of the semi market, it now represents a smaller portion of total capex.
- Finally, fewer suppliers of logic and memory result in a less irrational supply.

Cyclicality is likely to continue, but structural or long-term overcapacity is unlikely for several reasons.

One is the underlying secular growth of the industry combined with the pragmatic nature of semiconductor manufacturers when it comes to building out capacity. Bleeding-edge fab shells (7-nanometer nodes and below) are not cheap, costing about \$2 billion and taking more than two years to build. Even greater expense lies in the equipment, which can run up to \$9 billion and take up to 18 months to qualify and ramp up. When downturns reduce expectations to fill capacity, manufacturers often hit pause before adding machinery to prevent periods of overcapacity. This creates large swings of

Figure 1: Cyclicality has moderated in the semiconductor market

Year-over-year percentage changes for selected semiconductor ecosystem metrics, global GDP included for scale (1996–2027F)



Note: F after year stands for forecast
 Source: Gartner Worldwide Capital Spending Forecast, second quarter 2023

cyclicality in the semiconductor equipment market as projects are started and then paused abruptly. As the market for electronics returns to its historic growth, demand for semiconductors grows, quickly consuming any overcapacity, which is why we rarely see semiconductor downcycles lasting longer than two years.

As the market for electronics returns to its historic growth, demand for semiconductors grows, quickly consuming any overcapacity, which is why we rarely see semiconductor downcycles lasting longer than two years.

Another factor that absorbs overcapacity is that chips can be designed on a range of technologies, and products can be adapted to take advantage of available supply, thereby rebalancing demand. This redesign process takes 12 to 18 months. So, although it didn't help alleviate the recent shortage, it does help prevent structural or long-term overcapacity.

Similarly, large government subsidies don't usually change this calculus. Although the US and EU are offering about \$100 billion in subsidies through 2030, this is only a fraction of the \$1 trillion in capex that the semiconductor industry plans to invest. Government subsidies might influence the location of fabs built, but they are unlikely to lead to structural overcapacity.

Since the market is growing, overbuilt capacity is generally consumed by market growth within a year or two, as we have seen in previous cycles.

Gauging supply, demand, and pockets of overcapacity

Although cyclicality is leveling out over time, pockets of overcapacity still occur for short periods (one or two years) and for certain technology nodes or regions.

The big question here is whether the semiconductor market remains a single global demand pool or splinters into competing blocs. A key indicator will be whether governments start to mandate where some chips are manufactured (domestically or via a trade partner). This would accelerate the splintering of semiconductor ecosystems and have a greater effect than subsidies on the global market for semiconductors.

We also see specific technologies in which the current plan to build out supply could lead to challenges—for example, the bleeding-edge foundry capacity being added by TSMC, Intel, and Samsung in the US, or the older technologies largely being built out in China and Taiwan.

Given these dynamics, we expect that the supply-demand balance will be bumpy over time by node and by region, especially in three key areas.

- **Bleeding-edge foundry:** If Samsung and Intel take some of TSMC's customers or if government subsidies broaden the base of semi suppliers (such as the new Rapidus group in Japan), this would make capacity expansion decisions significantly more complex and prone to miscalculation, with overinvestment in boom times and underinvestment in busts.
- **Leading-edge technologies:** In the Asia-Pacific region, many foundries (TSMC, UMC, SMIC, Samsung, GloFo) produce mid-tier mature nodes (28-nanometer to 90-nanometer nodes). The market for 28-nanometer nodes, in particular, is expected to see capacity grow at 12% annually over the next few years vs. 5% to 7% for 45-nanometer and 90-nanometer technologies. If significant capacity comes online at the same time, we could see overcapacity for these older nodes for a period of time.
- **Super-lagging edge fabs will remain a challenge:** There's a long tail of low-end chips, usually produced on 6- and 8-inch wafers, that serves a wide range of applications from industrial and defense to automotive and consumer devices. Similar to how low-cost labor makes producing a cost-competitive T-shirt in the US challenging, the economics of depreciated fabs producing low-end chips make it harder to get new lagging-edge fabs built in nearshore locations. About 60% of new super-lagging edge foundry capacity is expected to be built in China.

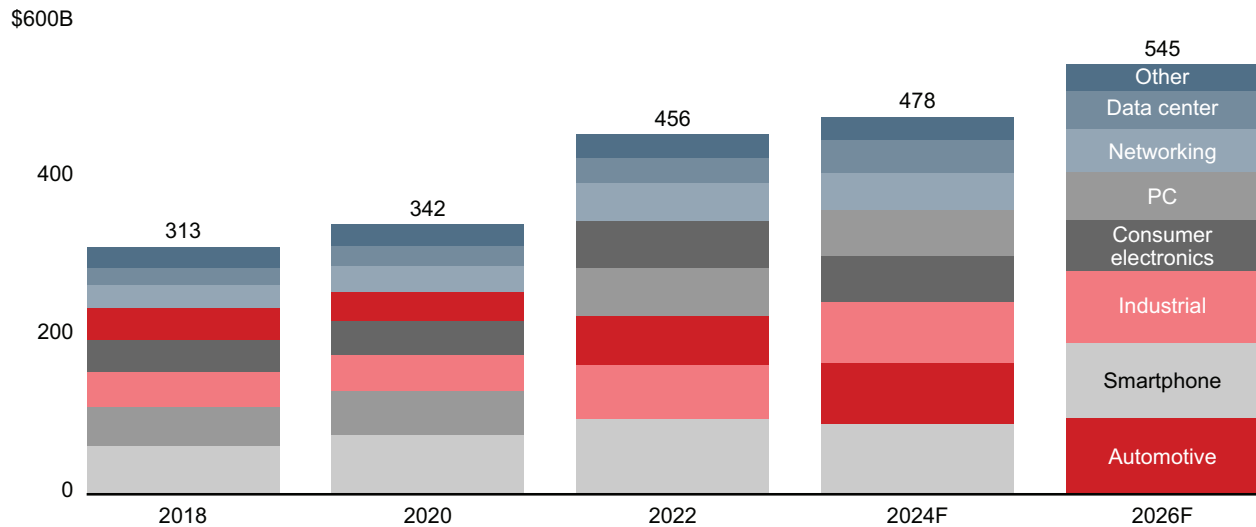
Companies that rely on semiconductors should continue to design for resilience and traceability.

What does all this mean for industries that rely on semiconductor chips? Customers still need to pay attention to the semiconductor supply chain.

- **Deepen your semiconductor capabilities.** The semiconductor market remains complex, with many moving pieces. Companies that rely on semiconductors should continue to design for resilience and traceability. Improving understanding and engagement with the semiconductor market is critical.
- **Leverage moments of oversupply.** Close monitoring of fab build-outs and demand can help identify pockets of oversupply in which players should secure capacity and take advantage of favorable pricing opportunities.

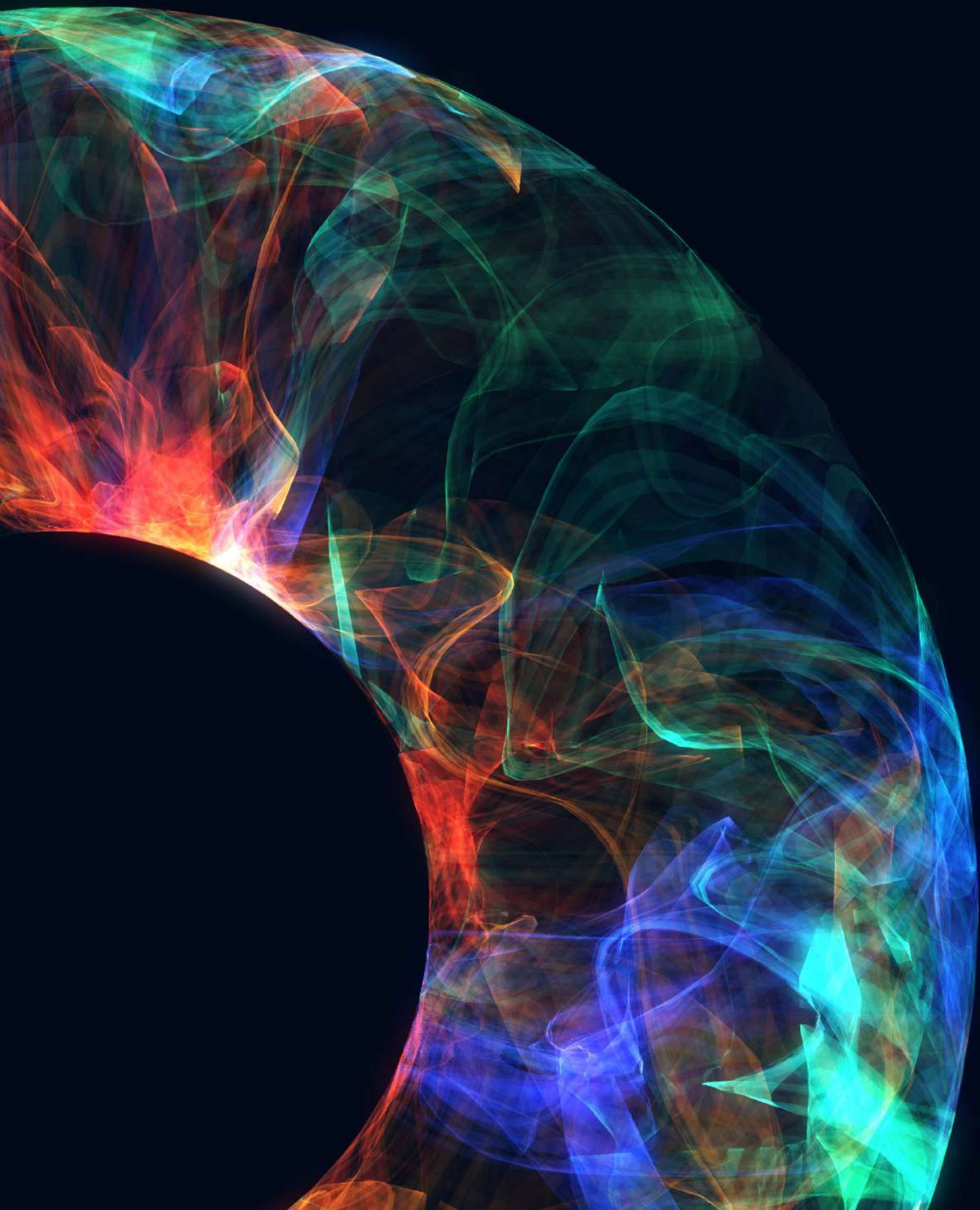
Figure 2: Applications beyond classic IT are growing faster

Worldwide semiconductor sales, excluding memory (in billions of US dollars)



Notes: F after year stands for forecast; consumer electronics includes tablets; accelerator cards have been included in data center segment, which includes logic, analog, discrete, opto, and sensors and excludes memory
 Source: Gartner Semiconductor Forecast Database, second quarter 2023

- Develop chip-specific strategies, part 1.** For example, in low-end chips, an area where multiple suppliers can be qualified, it’s important to monitor the entire market. Unexpected demand spikes in emerging areas (for example, electric vehicles) could create shortages of specialty chips. Semi vendors have historically focused on the classic IT market of computers and other tech devices. But automotive and industrial applications for semiconductors are expected to grow faster over the next few years (see Figure 2). Monitoring the balance of supply and demand and working with multiple suppliers can help guard against bottlenecks.
- Develop chip-specific strategies, part 2.** For mission-critical chips such as microcontroller units, companies should partner with silicon vendors to consolidate architecture to a single chip and secure supply for long periods, monitoring that specific supplier closely. This is especially true for customer-specific chips, such as application-specific integrated circuits and other application-specific chips, particularly if manufactured in small volumes by one provider.
- Think beyond semis.** Supply chain leaders are building resilience for all components in their devices. They are securing their supply of other must-have pieces such as motherboards and batteries that might be unexpectedly disrupted in another supply crisis.



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Operational Transformations

Digital Innovation: Getting the Architecture Foundations Right

Modern architectures help companies make better use of technology.

By John Beaumont, Brendan O'Rourke, Bala Parameshwaran, and Neil Mulholland

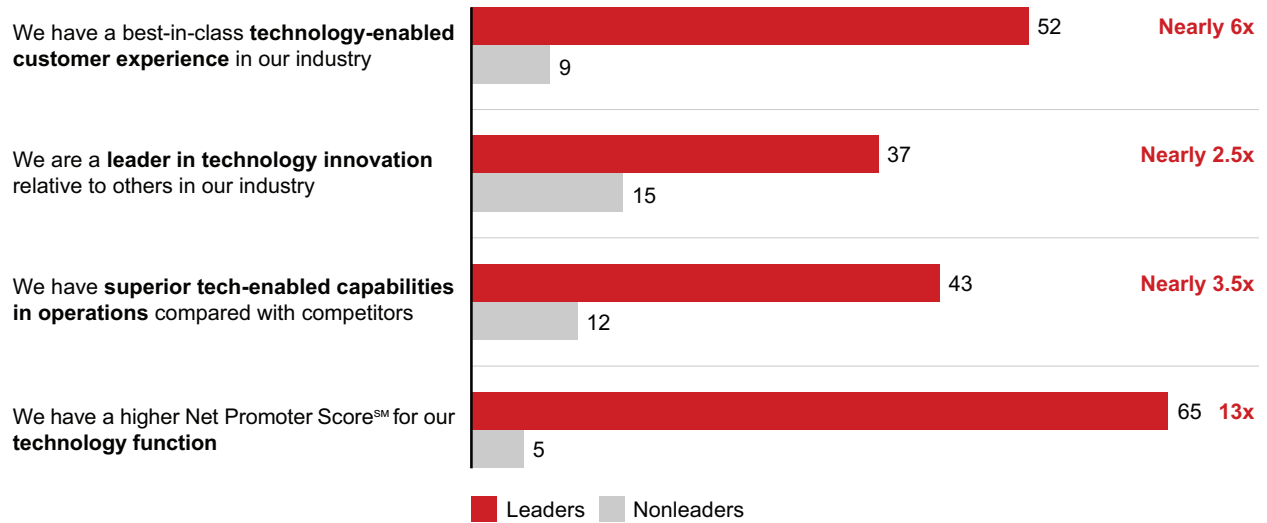
At a Glance

- ▶ Companies with modern technology architectures outperform their competitors with better customer service, more efficient operations, and stronger customer advocacy.
- ▶ Modern architectures are Agile (able to adapt rapidly), real-time (putting data where it's needed), and intelligent (personalizing experiences using artificial intelligence and machine learning).
- ▶ Only 13% of executives say that they are getting the business value they expected from their spending on technology.
- ▶ Developing a better understanding of the connection between architecture and business value can help companies get a better return on those investments.

Companies with modern architectures (Agile, real-time, intelligent) outperform competitors by delivering a better customer experience, more efficient operations, and stronger customer advocacy (see *Figure 1*). They can scale quickly to capture the benefits of technology innovations, which helps them become market leaders.

Figure 1: Modern technology architecture helps companies outperform on many levels

Percentage of respondents who strongly agree



Notes: Net Promoter ScoreSM is a service mark of Bain & Company, Inc., NICE Systems, Inc., and Fred Reichheld; Net Promoter ScoreSM represents actual score, not survey response
 Source: Bain Modern Architecture Survey, 2022 (n=339)

But to capture those benefits, enterprise architecture needs to continuously evolve. This evolution happens gradually, taking a decade or more for technologies to move from cutting edge to mainstream. This stately pace may lull some tech executives into believing that they have ample time to put off complex change. And while moving quickly doesn't guarantee success, we do see time and again that emerging leaders tend to adopt new technologies and architectural patterns early, which gives them time to climb the experience curve and achieve benefits well ahead of competitors.

Amazon's adoption in the early 2000s of cloud-based service interfaces, which exposed data and functionality across the organization internally and externally, is a famous example of this. Those early investments continue to pay off for the retail leader, which saw sales grow by 25% annually between 2016 and 2022, compared with a market average of 6%. Even today, only 14% of companies are using similar modern, service-oriented technologies.

More recently, some neobanks that moved quickly to adopt a mobile-first customer experience saw growth rates of 52% a year between 2019 and 2022. One of these, Monzo, has a competitive cost position that allows it to serve twice as many customers per employee than traditional banks. Both outcomes are enabled by modern architectures based on microservices.

Getting architecture right

Despite this clear record of success, only about 13% of executives surveyed said that they are getting the business value they expect for the amount they spend on technology. Most of these companies are constrained by their legacy technology and, in some cases, by a lack of understanding about what modern architecture is.

- **Agile:** Modular, service-oriented architecture that enables quick changes.
- **Real-time:** Utilizing event-based architecture to make data available when and where it is needed.
- **Intelligent:** Embedded, mature, structured artificial intelligence (AI) and machine learning (ML) capabilities to ensure highly personalized customer and employee experiences.

Modern architecture supports digital capabilities across the enterprise (from customer experience and intelligent engagement to the core business and operational systems) with data, security, integration, and cloud architecture. It's also critical for scaling emerging technology. For example, scaling AI applications across the enterprise requires access to data in a format that AI models can understand. This transformation of data requires modern data architecture and integration capabilities, connecting silos that might otherwise separate customer engagement and operational systems.

Modern architecture is critical for scaling emerging technology. For example, scaling AI applications across the enterprise requires access to data in a format that AI models can understand.

Commonwealth Bank of Australia (CBA) built a customer-engagement engine using AI and ML that enables its customer support function to suggest and personalize the best conversation to have with each customer in real time, whether they are in the branch, on the phone, online, or on a mobile device. Modern architecture enabled CBA to integrate data points from emergency sources and weather alert systems so that algorithms could monitor a situation in real time, which allowed the bank to support disaster recovery efforts during the Perth brush fires of 2021, offering personalized support to 80,000 clients. Those efforts paid off with a 6-point increase in its Net Promoter ScoreSM, which measures a customer's likelihood of recommending CBA to peers.

While the benefits of modernization are clear, companies don't need to be cutting edge everywhere, but they do need to apply the appropriate architectural patterns to the appropriate business processes. For example, Amazon Prime recently moved away from a microservices-based architecture

for streaming media. In considering the additional complexity of service-oriented architectures, the company decided that a “modular monolith” would deliver most of the benefits for much less cost.

Companies that make a successful transition to modern enterprise architectures get a few things right.

- They have a clear point of view on how architecture helps create business value, whether it is cost reduction, transformation, asset reuse, or risk reduction.
- They modernize the capabilities that matter; not everything needs to be gold plated.
- They enable agility, providing flexibility for innovation while standardizing less differentiated capabilities (for more, read the Bain Brief “A Modern Enterprise Architecture Is Essential for Scaling Agile”).
- They build and own their architecture capabilities rather than relying on outsourced talent.

Building a modern architecture requires ongoing experimentation and a commitment to investment over the long term.

Enterprise technology architecture isn’t something that most business leaders have had to think about, but they can’t afford to ignore it any longer. Together with the leaders of the technology function, they need to ask whether they have the right architecture to help them succeed. Building a modern architecture requires ongoing experimentation and a commitment to investment over the long term. But without it and its support for real-time data integration, Agile development, and new AI capabilities, companies cannot expect to maintain a competitive advantage in today’s markets.



Operational Transformations

The Talent Implications of Generative AI

AI will change how work gets done and the talent mix necessary to make it happen.

By Jay Bhatnagar, Jonathan Frick, and Arun Ganti

At a Glance

- ▶ Artificial intelligence (AI) will change the software industry, particularly the engineering and sales and marketing functions.
- ▶ Nearly two-thirds of software engineers say that they expect productivity gains of 20% or more, and many are already deploying AI coding assistants.
- ▶ About 39% of software companies said that the biggest barrier is the lack of technical skills, so an early investment in upskilling talent could offer a competitive edge.
- ▶ AI will also help automate sales to smaller businesses and consumers, allowing for smarter self-service.

Artificial intelligence (AI) promises to improve productivity across industries and business functions, with some estimating that about 20% of all work tasks could be completed faster and at equal quality with assistance from generative AI.

In the software industry, engineering and go-to-market (GTM) functions are among the areas most likely to benefit from AI over the next 18 months. The technology will change how work gets done and also the mix of talent and skills necessary to make it happen.

Because these productivity gains are accessible to every company, they are unlikely to make technology companies structurally more profitable. Firms will instead likely feel the competitive pressure to use productivity gains to build new product—and build it faster, in order to keep up with or outcompete the market. While a small portion of AI productivity gains may flow to the bottom line, most is likely to be reinvested in the business (see *Figure 1*).

Firms will likely feel the competitive pressure to use productivity gains to build new product—and build it faster, in order to keep up with or outcompete the market.

Figure 1: More than 90% of engineering and go-to-market executives expect gains from AI to be reinvested back into the business

Percentage of respondents (n=30)



Source: Bain Tech Talent Survey, 2023

More productive engineering teams

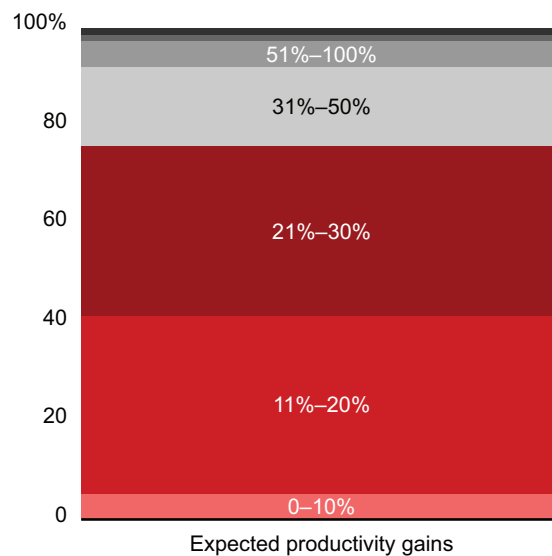
Software engineers see potential for generative AI in comprehending, developing, testing, and documenting code, as well as improving data quality and building user stories that articulate how a feature will provide value. About 57% of the software engineers we surveyed said that they anticipate 20% or better productivity gains from generative AI use cases over the next two years (see *Figure 2*).

To take advantage of AI and its productivity potential, companies will need to integrate commercial large language models (LLMs)—or in certain cases develop their own LLMs. About 39% of those surveyed said that the biggest barrier to benefiting from AI is a lack of technical skills—especially AI language model training, engineering chains of AI model prompts, machine learning model testing and operations, and data engineering of unstructured data assets. Some of these skills are new capabilities, so an early investment in helping employees develop these skills should be a near-term focus for companies.

As companies seek out the necessary capabilities, their talent mix is likely to shift. They will need more engineering talent for AI and machine learning, particularly with experience building or integrating LLMs. Since these are comparatively new skills, scarcity is likely to continue for some time, underlining the importance of upskilling the existing workforce. The outlook for other engineering roles may remain the same as or less than today (see *Figure 3*).

Figure 2: Nearly 60% of software engineers expect AI to improve productivity by more than 20% over the next two years

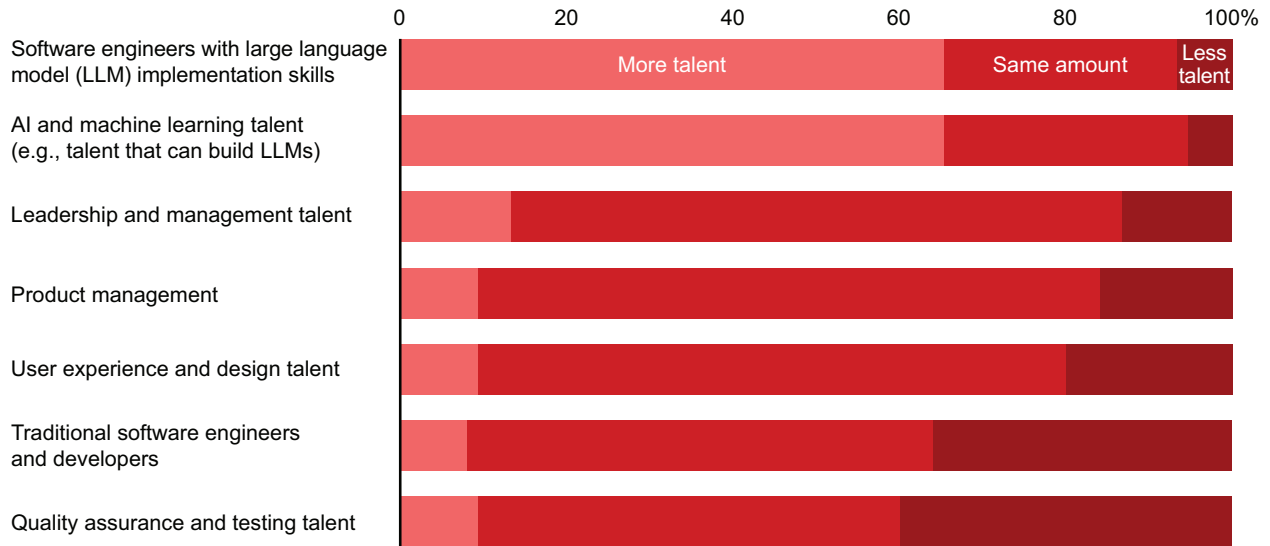
Percentage of respondents (n=75)



Source: Bain Tech Talent Survey, 2023

Figure 3: Engineering leaders expect the talent mix to shift over the next two years

Percentage of respondents (n=75)



Source: Bain Tech Talent Survey, 2023

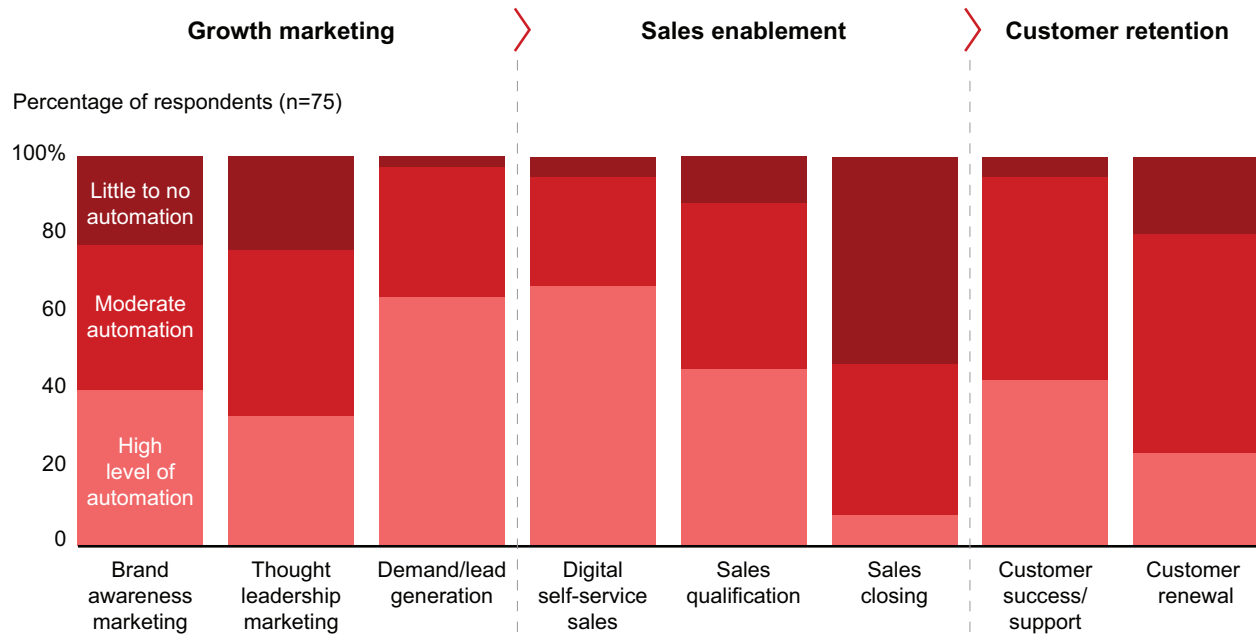
More automated sales and marketing

Generative AI will change the way that companies market and sell their products and services as it enables significant automation across every step of the customer life cycle. In particular, demand and lead generation, digital self-service sales, customer success, and other support activities all have the potential to benefit from the types of automation that generative AI enables (see Figure 4).

Demand and lead generation, digital self-service sales, customer success, and other support activities all have the potential to benefit from the types of automation that generative AI enables.

Among the GTM executives we surveyed, 64% believe that consumer sales will see a significant amount of automation over the next two years, partly because they are less customized. Automation in business-to-business sales will vary by segment, but 40% of GTM executives see lots of potential

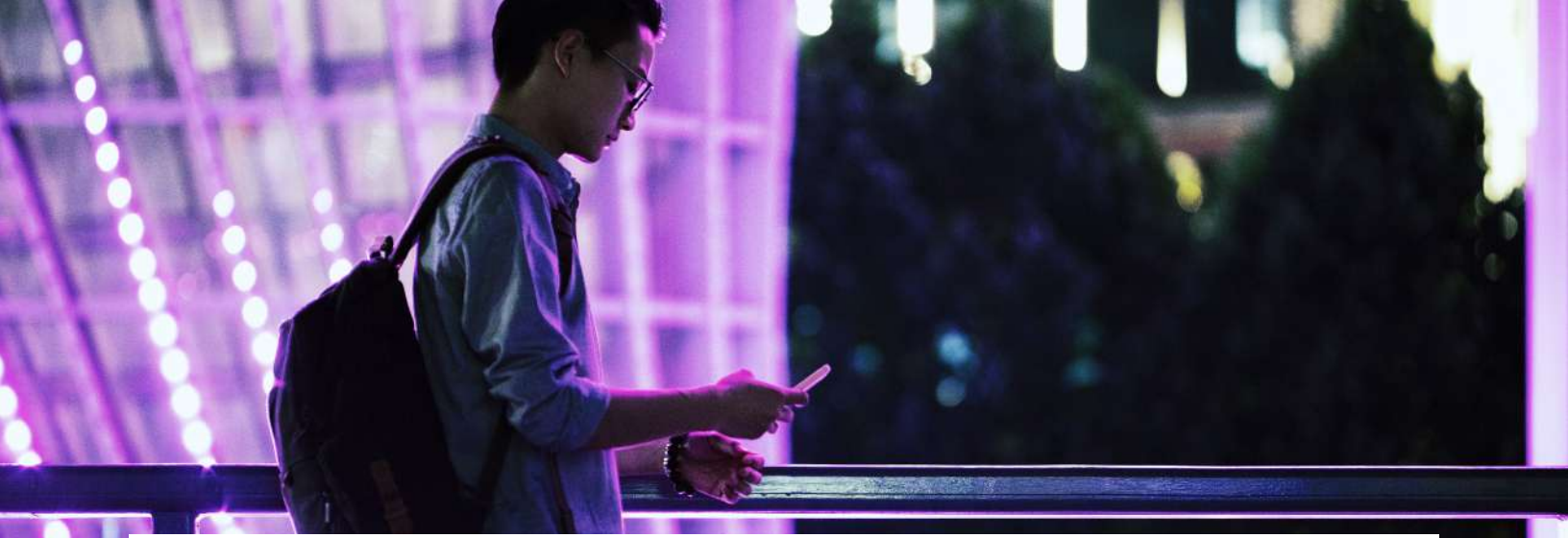
Figure 4: Marketing executives foresee a high degree of automation across the customer life cycle



Source: Bain Tech Talent Survey, 2023

for automation in sales to small and medium businesses. More complex sales at the midmarket and enterprise levels are less ideal for automation, although one-third of the GTM executives surveyed expect to see high levels of automation here, too. More than half of the GTM executives we surveyed believe that generative AI may enable them to serve some customers with a lower-touch or self-service model, ultimately reducing the number of customers served by a more manually intensive, bespoke enterprise effort.

No company can afford to sit back and watch how its competitors and vendors deploy generative AI. The rapid adoption of this technology is changing the basis of competition, and senior leaders should be acting now to understand its strategic implications. Most companies will need to invest significantly in talent to take advantage of generative AI, hiring new engineers and improving the capabilities of their current workforce. Executives will also need to decide how to distribute resources across key areas such as security, data platforms, and experimentation teams, and they will need to find the right balance of investment across customer-facing uses and internal productivity. Making key decisions now will help firms find, train, and retain the talented people they will need to support the evolving generative AI-enabled business model.



Operational Transformations

How Enterprise Sales Can Supercharge Product-Led Growth

For software companies that rely on self-service products, adding an effective enterprise sales motion can maximize revenue.

By Rohan Narayan, Rishi Dave, and Justin Murphy

At a Glance

- ▶ Software firms with a primarily product-led growth strategy increased their revenue in 2022 about twice as fast as those with little to no focus on product-led growth.
- ▶ Effectively integrating enterprise sales with product-led sales motions can accelerate revenue growth, but many companies struggle with this.
- ▶ Leading companies define thoughtful, data-based triggers for staff to engage with customers.
- ▶ Leading companies also develop clear strategies to foster collaboration among product, customer success, sales, and marketing teams.
- ▶ And finally, leading companies allocate resources intelligently and dynamically across product- and sales-led activities.

Despite the recent reset of technology sector valuations, product-led growth (PLG) software companies continue to outperform.

PLG has caught fire in software markets. It focuses on enabling end users to discover, try, buy, and scale up their usage in a self-service manner. Many companies adopt a PLG strategy from day one and add traditional sales-led commercial motions over time. Meanwhile, sales-led software companies can add a PLG motion or take a hybrid approach by applying the PLG model or capabilities to select parts of their product and customer portfolios—for example, relying on a sales team for the initial sale, then shifting to PLG self-service for renewals or expansions.

Firms that rely primarily on PLG increased revenue in 2022 nearly twice as fast as companies with limited or no PLG focus, and PLG companies are almost three times as likely to have gained market share over recent years (see Figure 1).

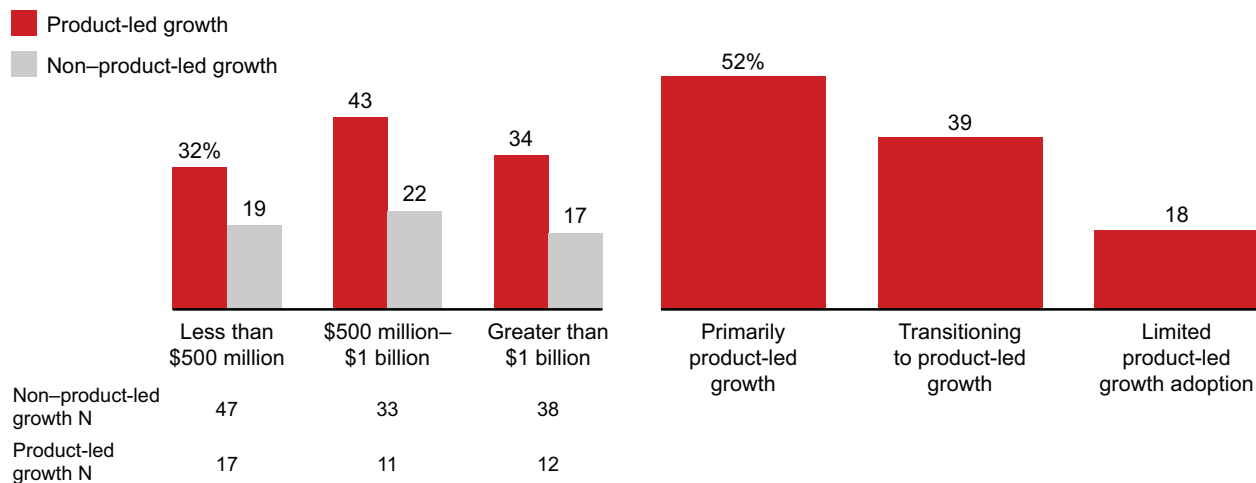
Furthermore, investors reward PLG companies with higher valuations, especially at higher revenue growth rates (see Figure 2). This remained true in 2022 despite the market correction.

PLG works best in markets where product configuration and deployment time are usually quick; end users can make purchasing decisions; the product is sticky, with usage growing over time; the potential customer base is broad, with lots of free users who can convert to paid users; and the product has features that entice users to upgrade to the next, higher-priced tier. (Read more in the January Bain Brief “What It Really Takes to Develop Product-Led Growth.”)

Figure 1: A product-led growth strategy produces faster revenue growth and greater market share

Median annual revenue growth, 2022 vs. 2021

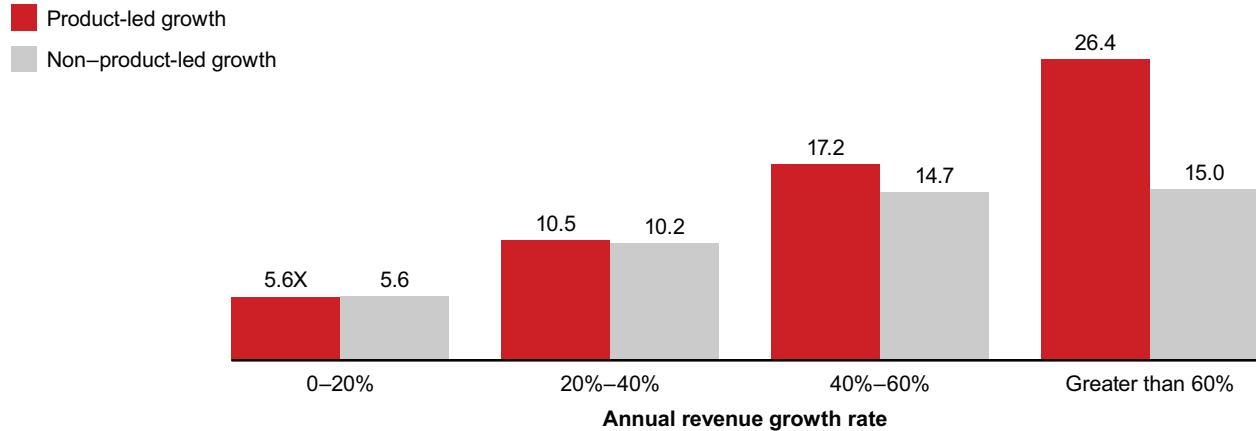
Percentage of respondents reporting market share gains of 3 points or more, 2020 and 2021



Notes: Companies categorized as product-led growth (PLG) or non-product-led growth based on OpenView 2022 PLG Index; survey respondents grouped into PLG adoption categories based on self-reported percentage of companies' revenue from PLG, with limited PLG adoption corresponding to less than 25% revenue from PLG, transitioning to PLG is 26% to 75% of revenue from PLG, and primarily PLG is 76% or more revenue derived from PLG
 Sources: S&P Capital IQ (n=158 public software companies in revenue growth chart, data retrieved on May 16); OpenView 2022 PLG Index; Bain product-led growth survey, September–October 2022 (n=179); Bain analysis

Figure 2: Investors have rewarded primarily product-led companies with higher multiples at comparable revenue growth rates

Median enterprise value-to-revenue multiple for companies with revenue between \$250 million and \$1 billion, 2017–2022



	0–20%	20%–40%	40%–60%	Greater than 60%
Non-product-led growth N	112	88	21	10
Product-led growth N	6	33	24	14

Note: Includes enterprise value multiples from last five years unless company didn't have publicly available financial data or didn't report revenue between \$250 million and \$1 billion for a given year
 Sources: S&P Capital IQ (n=104 public software companies, data retrieved on May 16); OpenView 2022 PLG Index; Bain analysis

But in markets suited to PLG, what’s surprising is how many companies continue to struggle with the key to unlocking its full potential: enterprise sales. Nearly every PLG company adds an enterprise sales team at some point along their growth journey, but figuring out when and how best to integrate it—that is, maximizing value creation without undermining operational efficiency—often separates leaders from laggards in PLG.

Breaking through the ceiling

It may seem counterintuitive to integrate a live person into a business model tied to self-service. Nevertheless, getting end users to discover, sign up for, and engage with a product on their own can be challenging, especially if the product is complex or all its benefits aren’t obvious.

Plus, once PLG companies reach a critical mass of users, they often hit a revenue ceiling that’s tough to break through. As customer spending on an individual software vendor grows, the extra scrutiny and required budget approval by senior leadership can become roadblocks. And in some cases, larger customers may continue using suboptimal packages delivered via self-service that don’t provide the benefits required for large-scale deployment, leaving value on the table for both the software vendor and customers.

A dedicated sales team can help PLG companies move beyond one-off software purchases within enterprises and land bigger deals across the customer's organization. It makes a huge difference having a salesperson proactively pitch to purchasing decision makers, address enterprise-grade requirements that an individual departmental buyer might overlook (e.g., cybersecurity and resilience), and coordinate the sales contract process required for larger spending levels. Sales, customer success, and support teams can also unlock new avenues of growth for both customers and vendors by helping end users scale up product usage beyond what they could do alone.

It makes a huge difference having a salesperson proactively pitch to purchasing decision makers, address enterprise-grade requirements that an individual departmental buyer might overlook, and coordinate the sales contract process required for larger spending levels.

One PLG company increased its annual revenue growth rate by more than 5 percentage points in the two years after it launched an enterprise sales team. The company's PLG motion supports bottom-up growth through customer success staff who serve as the frontline salesforce, targeting the most active users likely to convert others within their organization. And the enterprise sales motion supports top-down growth by engaging the largest, most promising accounts and providing centralized support for large-scale product integrations.

Integrating enterprise sales and self-service

Many companies have difficulty seamlessly marrying enterprise sales with a product-led sales motion. The product, customer success, sales, and marketing teams share ownership of the customer journey and touch the same customer experiences, so without well-defined connection points and an operating model that effectively integrates the distinct functions, companies will have trouble maximizing growth. Leading companies focus on three things.

- **Defined triggers for a person to engage with a customer:** Twilio brings in enterprise salespeople when an annual contract value reaches \$100,000, and Dropbox does so when at least 3% of a customer's employees already use its product. Some PLG companies take a more nuanced approach by passing along different accounts at different times based on the customer's firmographic characteristics and behavior within the self-service platform. Sometimes, a customer's first engagement point with a live person is with the enterprise sales team, while at other times, it could be customer success or even customer support, depending on the situation's needs.

- **Clear collaboration strategies:** Product, customer success, sales, and marketing teams that support PLG can sit in different departments or in a single one. Several best practices apply to either model—namely, outlining distinct responsibilities across functions; transparently setting shared goals, metrics, and incentives; and establishing Agile ways of collaborating at the pace needed for PLG.
- **Appropriate resource allocation:** Leading companies thoughtfully tune their allocation of resources across product- and sales-led growth capabilities (including the mix of talent between the two motions) based on the strategic role PLG plays in their overall go-to-market approach.

Implications for key players

For entirely product-led companies, choosing the right time to add an enterprise sales motion is crucial. About 61% of PLG companies launch an enterprise sales team by the time they reach \$50 million in annual revenue, according to a 2022 Bain survey.

There are usually clear indicators that enterprise sales could spur growth—for example, dips in converting enterprise users from free to paid subscriptions, having a low share of customers' wallets, having a user base skewed toward small and midsize companies, or struggling to scale up the number of end users in segments with large potential for growth.

For enterprise sales-led companies transitioning to a PLG strategy, it's important to recognize this is a major organizational transformation with long investment payback periods. Therefore, it requires strong C-suite sponsorship and a shift in mindset across the organization.

For investors, even in a tougher market, there are still strong opportunities in PLG if they can tailor their typical deal diligence approach to this sector's distinct needs and characteristics. The investors that consider enterprise sales integration and effective cross-team collaboration when evaluating a PLG asset have a chance to achieve greater success in this increasingly attractive sector.



Operational Transformations

How Your Revenue Can Grow Faster Than Your Salesforce

Successful companies move beyond cost-cutting tweaks to raise commercial productivity year after year.

By **Jordan Lee, Peter Henle, and Jens Friis Hjortegaard**

At a Glance

- ▶ With sales and marketing being a major operating expense in the tech sector, companies with growth aspirations need to raise and sustain their commercial productivity.
- ▶ Bain research on 1,254 companies worldwide from 2017 through 2021 found that the average company had flat productivity in any given year, but 5% of the firms realized productivity gains in at least three of the four years.
- ▶ These productivity leaders do things differently than the rest of the pack with their go-to-market model, support for sales reps, and efficiencies in sales and marketing support.
- ▶ Leaders also organize for productivity by assigning a clear executive owner and tying targets into their planning cadence.

Software, hardware, and other technology companies have found themselves in a tough position for most of 2023. After the recent years of rapid growth in which they felt free to add sales and marketing capacity, the economic tailwinds died down, stranding the tech sector in the doldrums. To placate investors and reset, many companies announced major layoffs and other cost-cutting measures.

But cost-cutting alone isn't a viable response. Sales and marketing executives still aspire to grow the business, and they realize there's no longer an option of adding capacity at a high cost. Their go-to-market model must become much more productive.

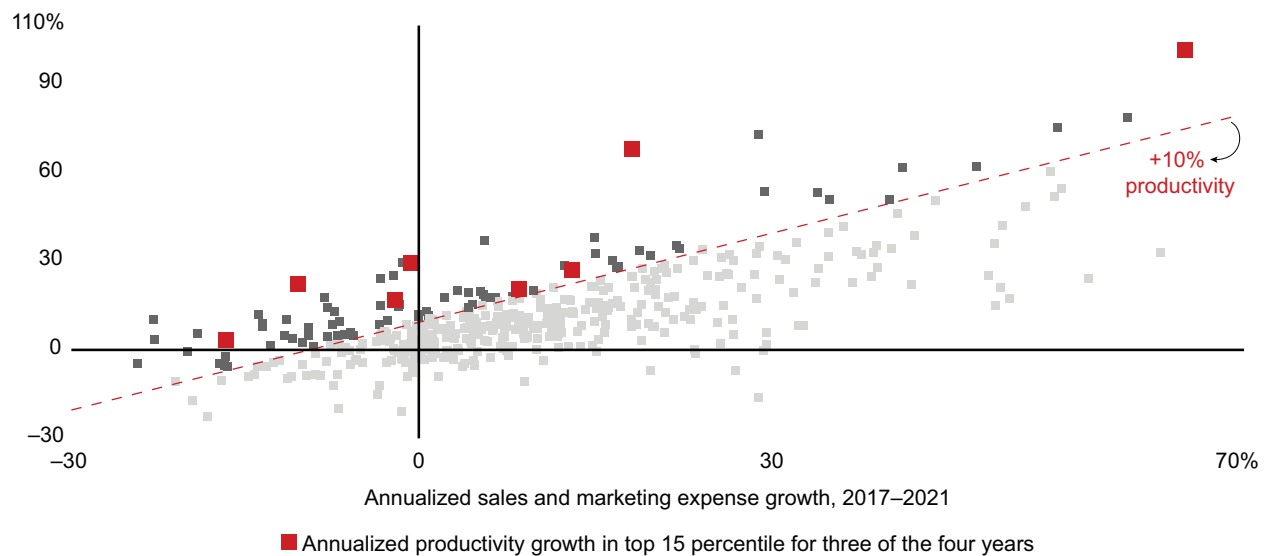
To that end, we recently focused our research on commercial productivity, which measures the revenue (or gross profit) returned per dollar of commercial cost, and then evaluates how much faster revenue grows relative to growth in sales and marketing expenses. Given that in software and some other tech sectors the largest operating expenditure typically is sales and marketing spending, greater commercial productivity is essential to survive, not just thrive.

As described in the *Harvard Business Review* article "3 Strategies to Boost Sales and Marketing Productivity," we analyzed 1,254 public business-to-business companies worldwide from 2017 through 2021. The average company had flat commercial productivity in any given year, with revenue growing at the same rate as sales and marketing expenses. Some 19% of companies improved commercial productivity more than 10% in any given year, but most eventually dealt it back. Only 5% of companies were able to realize commercial productivity gains in three out of the four years (see Figure 1).

These elite companies—the sustained productivity leaders—achieved a meaningfully higher annual total shareholder return than their peers, with a 12% difference, on average.

Figure 1: An elite group of companies have consistently improved commercial productivity

Annualized revenue growth, 2017–2021



Notes: Analysis for 458 software, hardware, and IT companies; excluded operating subsidiary companies
Source: Bain analysis of S&P Capital IQ data

The *Harvard Business Review* article describes how, over a period of years, commercial productivity leaders systematically pursue levers in three areas:

- **They refine their go-to-market model.** The leaders assess how to deploy sales and marketing capacity against the opportunities that will generate the highest returns. This involves rebalancing account assignments based on customers' expected future spending, creating the most suitable territories for each seller.
- **They turn every sales rep into an elite player.** One tactic is creating data-informed sales plays—that is, a coordinated set of activities with target accounts. Another is consistent coaching to improve both rookie and veteran performance. And a third is creating a revenue intelligence database to guide reps on the most effective use of their time.
- **They identify efficiencies in sales and marketing support.** The leaders use automation tools to simplify processes, improve the accuracy of quotas for individual reps, reduce spans and layers in the organization, and scrutinize non-selling and non-quota-carrying roles.

Veteran leaders tie productivity targets into annual and multiyear planning so that the effort expands beyond the sales group.

There's an organizational dimension to the productivity leaders as well. They assign a clear owner of commercial productivity, often with a dedicated role. Veteran leaders tie productivity targets into annual and multiyear planning so that the effort expands beyond the sales group. Many enlist a commercial operations team for modeling sales and marketing capacity, communicating with the finance group, and creating go-to-market blueprints that are continually revised.

Instead of commercial leaders making reflexive cuts or referring to last year's levels, a commercial productivity framework allows them to make healthy trade-offs between top-line and cost savings actions. That perspective serves them well at any stage of the economic cycle.



Operational Transformations

Decarbonizing Technology Supply Chains

Most tech companies have set ambitious targets, but only half are on track to meet them.

By Peter Guarraia, Josh Hinkel, Velu Sinha, and James Baird

At a Glance

- ▶ In technology, most emissions are Scope 3, resulting from upstream supply chains or downstream use of products, which are harder for companies to control than Scope 1 (operations) or Scope 2 (energy use) emissions that are under their direct control.
- ▶ Using more renewable energy in data centers helps many software companies reduce their Scope 2 emissions.
- ▶ Bringing supply lines closer to customers can reduce upstream Scope 3 emissions, while redesigning products to use less energy helps reduce downstream Scope 3 emissions.
- ▶ Companies should adopt a holistic perspective so that they can take a long-term strategic approach to emissions and other sustainability issues.

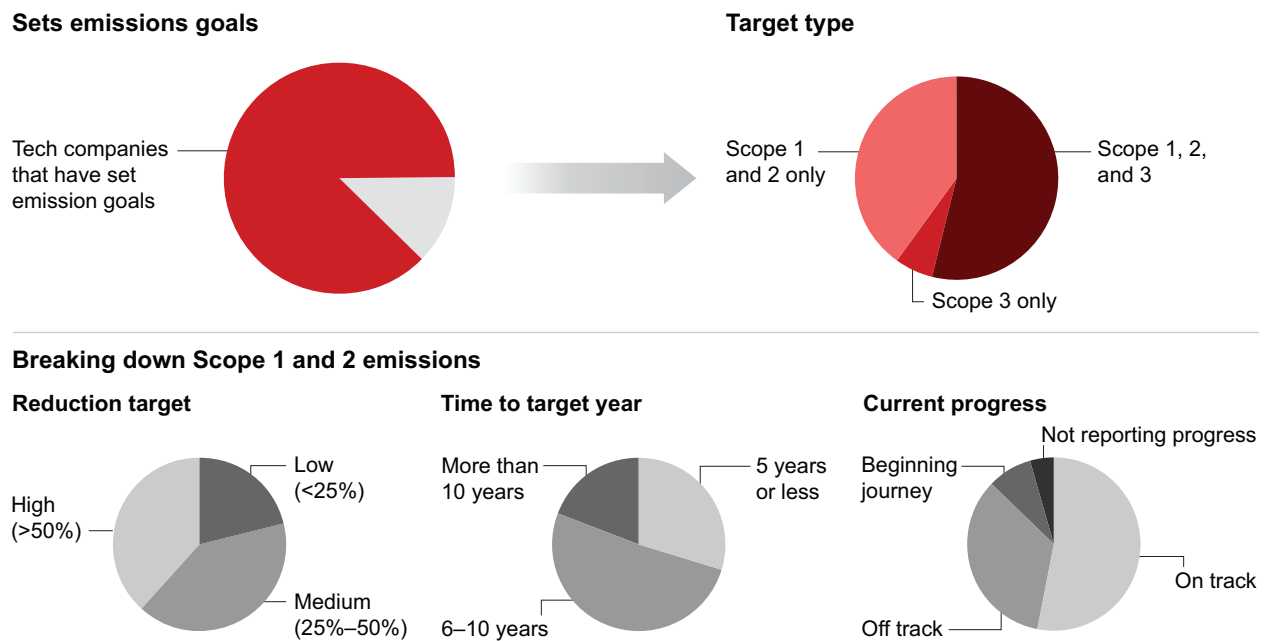
Sustainability and decarbonization efforts increasingly are top priorities for technology companies as customers, shareholders, and regulators all push for more sustainable products and services. In response, most tech companies are setting ambitious goals to reduce emissions, but only half report

being on track to reach their goals (see Figure 1). Most emission reduction goals focus on Scope 1 (direct emissions from a company’s activity) and Scope 2 (emissions from purchased electricity, heat, and steam), which companies have more control over. Scope 3 emissions come from the upstream supply chain and flow downstream to customer use.

Why is reducing emissions so hard? First, most emissions are Scope 3, which are more difficult to control. Also, reductions compete with other strategic priorities. For example, PC makers need to find sustainable solutions to extend the life of their products without jeopardizing long-term sales.

The ambitions may be clear, but the devil is in the execution. Improvement initiatives require complex coordination across manufacturing, operations, engineering, and R&D teams, as well as customers. Regulations differ across locations. Even with offset purchases as part of the strategy, companies might find it hard to source enough renewable power in some markets. Launching, tracking, and following through on implementation requires senior sponsorship and commitment—and a willingness to tackle cross-organizational and cross-regional challenges.

Figure 1: 90% of tech companies have set decarbonization targets, but results are mixed



Sources: CDP (self-reported data), n=57; Bain analysis

Successful measures

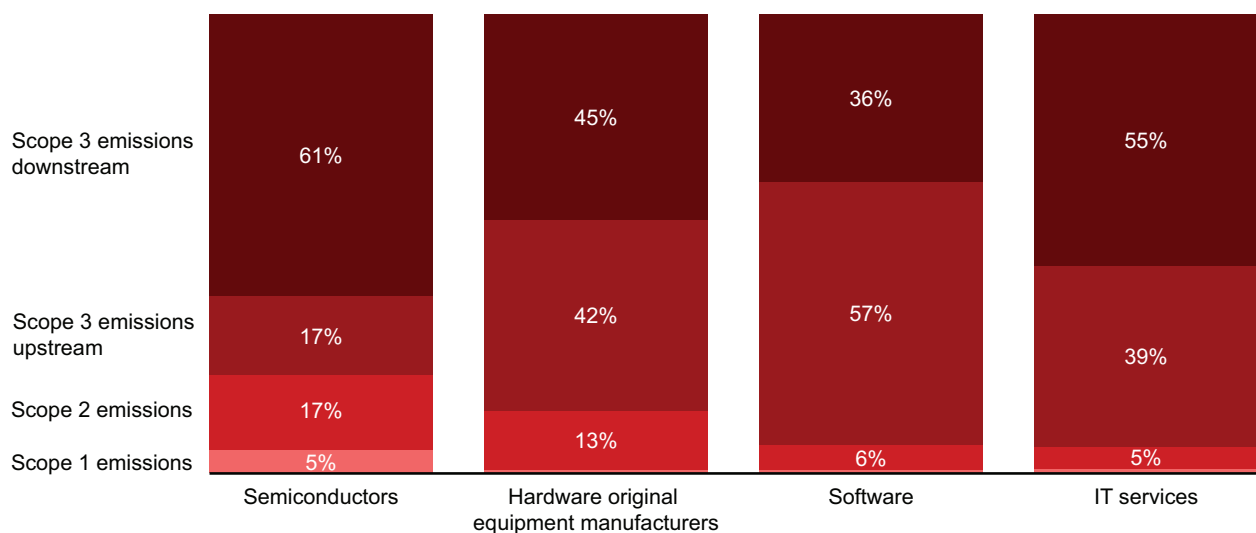
The causes of carbon emissions vary by subsector (see Figure 2). Emissions in semiconductors derive mostly from Scope 3 downstream usage, but the sector also has the largest Scope 1 and Scope 2 emissions. Hardware manufacturers’ emissions result from Scope 3 downstream electricity usage and the upstream supply chain for materials and minerals. The software industry’s emissions come from customers using their products (Scope 3 downstream) as well as the goods and services that software companies buy to make their products (Scope 3 upstream).

While specific solutions may look different for hardware and software companies, all tech companies are embedding the impact of carbon into decision making around supply chain footprint, day-to-day operations, and product life cycles. Across subsectors, tech companies are finding ways to reduce carbon emissions.

- **Data centers:** Many companies are using more renewable energy in their daily operations. For example, Microsoft committed to using 100% renewable energy by 2025 for electricity in its data centers and buildings, and it says it reduced Scope 2 emissions by 30% to 35% from 2021 to 2022. Some are reducing emissions by developing new, more energy-efficient ways to cool servers. Intel recently formed a partnership with specialty chemical maker Lubrizol to design and

Figure 2: Most emissions are Scope 3, which are difficult to track and abate

Percentage of overall reported emissions (2021, total emissions, in metric tons of carbon dioxide equivalent)



Notes: Percentage totals may not add up to 100% because of rounding; semiconductors category includes electric components; hardware includes communication equipment; software includes web-based software
 Sources: CDP (self-reported data), n=1,193; Bain analysis

create immersion-cooling fluid solutions that don't void the warranty on Intel microarchitectures. Immersion-cooling technology could reduce the energy required to cool servers in data centers by more than 30% vs. traditional air-cooling solutions.

- **Optimizing the supply chain:** As companies evaluate bringing suppliers closer to end markets, many are looking not only at economic costs but also at their carbon footprint to help decide who to source from and where to locate new manufacturing sites. Bringing suppliers closer to customers can reduce emissions in transportation and energy consumption when the destination uses cleaner or renewable energy sources. For example, one major tech company is shifting some of its production from Asia to North America not only to help guard against future supply chain disruptions but also to increase sustainability and responsiveness by locating closer to more customers, which reduces transportation-related emissions and delivery time.

Bringing suppliers closer to customers can reduce emissions in transportation and energy consumption when the destination uses cleaner or renewable energy sources.

- **Redesigning products:** Companies are redesigning their products so that they consume less energy or cleaner energy in order to reduce downstream Scope 3 emissions. For example, Apple's Clean Energy Charging setting, which limits charging to periods when lower carbon-emission electricity is available, helps Apple reduce downstream Scope 3 emissions in the US.
- **New business models that balance financial and emissions trade-offs:** New business models are proving to be a win-win for decarbonization efforts and for technology companies' financials. For example, companies that adopt hardware-as-a-service models could extend the life of products or make them modular to lengthen times between replacement. This could allow them to generate revenue for longer on each asset while also reducing their carbon footprint by manufacturing less hardware.

"No regret" actions

A phased approach helps companies bridge the gap between sustainability goals and results.

The first step is gaining a better understanding by mapping the major sources of carbon emissions in the supply chain. This can reveal opportunities for reductions. For example, choosing a renewable energy source for the company's and suppliers' energy needs is often low-hanging fruit, achievable during the early stages of decarbonization.

Next, companies should adopt a long-term, holistic perspective and develop new business models that strengthen competitive advantages. By strategically addressing emission sources, embracing innovative business models, and making thoughtful strategic choices, companies can succeed financially while becoming more sustainable. Although most customers are still not willing to pay much of a green premium for sustainable products, they are becoming more conscious of their environmental impact and are actively seeking out eco-friendly options.

Finally, tech companies face increasing pressure from regulators to disclose and reduce Scope 1, 2, and 3 emissions as part of their financial reporting. The EU's Corporate Sustainability Reporting Directive and the US Security and Exchange Commission's new reporting rules are among the measures that will help ensure that companies develop sound climate strategies for reducing emissions and that they comply with disclosure requirements.

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